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Indigenous Fruit Trees of Tropical Africa: Status, Opportunity for Development and Biodiversity Management

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Abstract

Tropical fruit trees constitute important biological resources in the global agrobiodiversity context. Unlike the tropical fruit trees of American and Asian origin, indigenous fruit trees (IFT) of tropical Africa have scarcely achieved the status of international recognition in commodity markets and research arena outside Africa. This paper presented a critical review of the status of IFT in the Tropical African sub-regions (of West Africa, Central Africa, East Africa, Southern Africa and the Indian Ocean Islands) in relation to the introduced naturalised fruit trees from tropical America and Asia, threats to the diversity and sustainable use of IFT, analysis of the opportunities and challenges of developing IFT, as well as targets for crop improvement of the rich IFT of Tropical Africa. Domestication programme via relevant vegetative propagation techniques for priority IFT of the sub-regions was examined and advocated, in addition to the adoption of complementary conservation strategies, including Field GeneBanks in the management of the continent's IFT diversity.

Keywords

Biodiversity, Conservation, Crop Improvement, Domestication, Indigenous Fruit Trees, Introduced Species, Tropical Africa

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1. Introduction

Fruit trees constitute important biological resources in many agroecological systems and forest ecosystems all over the world. The assertion is evident by the fact of these tree species long time economic and ecological impacts in nature. Fruits are full of nature's rich essential nutrients, antioxidants and health benefits for ready use by humans (and other animals) without alternation in most cases, unlike vegetables and other edible agricultural/horticultural produce that may require necessary pre-treatments, like heating, sometimes before consumption [1]-[3]. The tropics, more than any other region of the world, is endowed with great diversity of fruit tree species that have provided humans with basic food and nourishment for ages since the domestication of beneficial wild plants (crops species). Tropical continents of the world possess rich variety of fruit trees with about 1000 species identified in Americas, 1200 species in Africa and 500 species in Asia [4] [5]. Although only relatively few fraction of these diversities are marketed worldwide, the diversities are nature's inestimable assets for the livelihoods of local people throughout the tropical regions.

In contrast to the noted diversity of fruit trees, only 10 annual cereal grains, pulses and oil seeds dominate 80% of the world agronomic fields. At present, wheat, rice and maize cover half of the world's croplands, while adding other annual gains and pulses accounts for up to two-third of all arable land in the world [5] [6]. Also despite the fact that more than 90% of fresh fruit produce are consumed locally, the importation demand for tropical fruits has been on steady increase globally in the past few decades. According to FAO [7], there is a great potential for growth of the fruit produce in the international markets due to the increasingly health consciousness and much hyped nutritional awareness about the consumption of more fresh fruits as well as vegetables in people's diets.

1.1. Indigenous Fruit Trees (IFT) of Tropical Africa

According to the authors [6] in PROTA report, Tropical Africa comprised of 48 countries which are distributed across the various sub-regions of the continent, namely West Africa (16 states), East Africa (9 states), Central Africa (10), some part of Southern Africa (7) and the Indian Ocean islands (6) including Madagascar (**Table 1**). Others described Tropical Africa as Sub-Saharan Africa excluding South African republic and the few countries enmeshed in it [9].

These sections of the continent are diverse in their climate, soil, topography and vegetation, which invariably influence the array and distribution of African floristic diversity. Tropical Africa sub-regions are home to many valuable fruit tree species whose potentials have not been fully realized. A good number of these fruit species have remained rather of local importance, and are yet to be domesticated. However, tangible economic produce are been harvested from their wild and or protected volunteer stands in home gardens, farmlands and forest reserves [10] [11]. Following PROTA reports [12] [13], Tropical Africa has 477 edible fruit and nut species (including both indigenous and introduced naturalised ones) grown across its landscape. Attempts to identify and compile some of these local fruit commodity species that had their roots in Tropical Africa sub-regions, with regards to the species origin and natural distributions are shown in **Table 2**. The list in **Table 2** should not be seen as exhaustive, since some of the IFT also yield other valuable products like timber and medicine for which they are sometimes treated as more of forest trees or medicinal plants than orchard species.

1.2. Status of IFT in Tropical Africa

According to the National Academy of Science [14], fruit production in Africa at present has been dominated by such species introduced from tropical Americas and Asia. These introduced species, including Banana, *Citrus* spp, Mango, Papaya, and Pineapple among others (**Table 3**) have also constituted bulk of international trade on tropical fresh fruit produce and processed fruit products. These and other adapted exotic tropical fruit crops which were already improved through horticultural selection and breeding, arrived on the African continent centuries ago and increasingly displaced the indigenous fruit species that had fed African for millennia. Moreover these introduced species received the support of colonial powers who wanted familiar crops that were highly economical to cultivate. Consequently, most of these introduced fruit species rather than the indigenous species were grown and established in orchards and plantations for large scale production and distribution. Thus, the IFT known to the local people continued their downward spiral of dwindling cultivation and knowledge without research investment and improvement. In fact, until recently, most of the researchers in horticultural crops

Table 1. Countries of Tropical Africa and their respective sub-regions.

Sub-regions	Member countries
West Africa	Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Niger, Nigeria, Mali, Mauritania, Senegal, Sierra Leone, Togo
Central Africa	Burundi, Cameroon, Central Africa Republic, Chad, Congo, Sao Tome and Principe, Democratic Republic of Congo, Equatorial Guinea, Gabon, Rwanda
East Africa	Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan, South Sudan, Tanzania, Uganda
Southern Africa	Angola, Botswana, Malawi, Mozambique, Namibia, Zambia, Zimbabwe
Indian Ocean Islands	Comoros, Madagascar, Mauritius, Mayotte, Reunion, Seychelles

production in Nigeria for example still inadvertently show preferences for detailed research work on introduced fruit species over the indigenous species, according to a recent survey [15].

The fact about Tropical Africa indigenous fruit trees (IFT) diversity and economic potential is something one would never readily recognized by looking at fresh fruits local markets in most parts of the continent, or even consulting most college recommended text books on tropical agriculture and horticulture, for instance: [1] [5] [16]-[23]. The reasons for this insidious neglect of the continent's IFT economic resources may not be far-fetched. Most African native fruit species have not been brought up to their full potential in terms of quality breeding and selection, scale of production and distribution, value addition and availability. In terms of geographical spread and distribution, relatively few of them have moved beyond Africa's shores, unlike similar tropical fruit species from other continents.

2. Exploring and Exploiting the Under-Tapped Treasures of IFT

2.1. Threats to Diversity and Sustainable Use of IFT

Historically, the protection of IFT/wild fruit species in many countries of Africa has been carried out by local farmers in their community forest reserves, traditional home gardens, protected volunteer stands of such important plant species in farmlands, market squares and village squares. Until recently, organised orchards and plantations of IFT were rather rare and only few exceptional ways used in the perpetuation of IFT kinds in some African communities. Due to little or nil formal research development and investments for improvement, many of the IFT still retain their natural massive size that would make group planting and management in orchards/ plantations setting difficult [14] [15] [24] [25].

Various other factors have contributed as threats to survival and sustainability of IFT in the Tropical African sub-regions. In the first place, local populations in the sub-regions are heavily dependent on forests, which provide them with firewood, timber and food (nuts, fruit, mushrooms and honey). They use wild fruit and nut species as food, as well as for their medicinal properties, in handicrafts and to dye home-made products. Indiscriminate and illegal logging of IFT stands in the remaining forested areas and farmlands for varied reasons have in no small measure contributed to the depletion IFT local population and distribution in many Tropical African rural communities. Such uncontrolled tree felling may be due to domesticate needs as fuel woods, charcoal production, livestock feeds, land clearing of site for building construction and or intensive agricultural activities, especially crop production.

As earlier pointed out, the insidious domination and preference of other introduced tropical fruit tree species over the African IFT by most researchers and investors have impeded the expected developmental needs of the continent's many IFT. For most of the IFT, standardised agrotechniques for the propagation, protection, production, value added products and improved processing are nearly lacking or at best just at rudimentary stage when contrast to similar crop species from Tropical America and Asia. However, where such standardised agrotechniques might have been locally developed, they often remained as prototypes in relevant national research centres and government ministries yet to be commercialized. A SWOT (Strength, Weakness, Opportunity and Threat) analysis (**Table 4**) of Tropical African indigenous fruit trees' (IFT) opportunities, potentials, limitations and threats captured and summarized the prevailing situation.

2.2. Domestication of Indigenous Fruit Tree (IFT)

Tree domestication has been explained by various authorities in agroecology, agroforestry, agronomy and plant

Table 2. List of some scantly researched indigenous fruit trees/shrubs of Tropical African origin.

Common name	Botanical name[1]	Family name	Species origin
1. African breadfruit	*Treculia africana*	Moraceae	W, C, E
2. Ackee	*Blighia sapida*	Sapindaceae	W, C
3. Butter fruit	*Dacryodis edulis*	Burseraceae	W, C, E
4. Baobab	*Adansonia digitata*	Bombacaceae	W, C, E
5. Monkey kola (yellow)	*Cola lepidota*	Malvaceae	W, C
6. Monkey kola (white)	*C. pachycarpa*	,,	,,
7. Monkey kola (red)	*C. lateritia*	,,	,,
8. Magic plant	*Synsepalum dulcificum*	Sapotaceae	W, C
9. African walnut	*Plukenetia conophora*	Euphorbiaceae	W, C
10. Black plum/Mbembe	*Vitex doniana*	Labiatae	W, C, E, S
11. -	*V. payos*	,,	C, E, S
12. Tamarind	*Tamarindus indica*	Fabaceae	W, C, E, S
13.Velvet tamarind	*Dialiumgu ineense*	Fabaceae	W, C, E
14. African oil bean	*Pentaclethra macrophylla*	Fabaceae	W, C, E, S, I
15. Sheabutter	*Vitellaria paradoxa*	Sapotaceae	W, C, E
16. Irvingia nut	*Irvingia garbonensis*	Irvingiaceae	W, C, E
17. African star apple	*Chrysophyllum albidum*	Sapotaceae	WC, E, S
18. Incense tree	*Canarium schweifurthii*	Burseraceae	W, C, E
19. Gum vine	*Landolphia kirkii*	Apocynaceae	W, C
20. -	*Uvariodendron connivens*	Annonaceae	E, S
21. -	*Sacoglottis gabonesis*	Humiriaceae	E, S
22. -	*Maesobortyabarteri*	Euphorbiaceae	E, C, S
23. Ebony	*Diospyros mespiliformis*	Ebenaceae	WC, E, S
24. -	*Chytranthus talbotii*	Sapindaceae	W, C
25. -	*Salvadora persica*	Salvadoraceae	W, C
26. -	*S. australis*	,,	W, C
27. Marula	*Sclerocarya birrea*	Anacardiaceae	W, C, E, S
28. African walnut	*Coulae dulis*	Olacaceae	W, C, S
29. Imbe	*Garcinia livingstonii*	Gultiferae	W, C, E, S
30. Medlar	*Vangueria apiculata*	Rubiaceae	C, E, S
31. -	*V. rotundata*	,,	C, E, S
32. Monkey orange	*Strychnos cocculoides*	Strychnaceae	W, C, E, S
33. Wild loquat	*Uapaca kirkiana*	Euphorbiaceae	W, C, E, S
34. Sugar plum	*U. heudelotii*	,,	W, C, E, S
35. Sweet Detar	*Detarium senegalense*	Fabaceae	W
36. Detar	*D. microcarpum*	,,	W
37. Tree grape	*Lannea microcarpa*	Anacardiaceae	W, C, E, S
38. Aizen	*Boscia senegalensis*	Capparaceae	W, E
39. Balanite	*Balanites aegyptiaca*	Balanitaceae	W, E
40. Carissa	*Carissa macrocarpa*	Apocynaceae	W, C, E
41. Kei apple	*Dovyalis caffra*	Flacourtiaceae	S
42. Custard apple	*Annona senegalensis*	Annonaceae	W, C, E, S
43. Ginger bread plum	*Parina riexcelsa*	Chrysobalanaceae	W, C, E, S
44. Gum vine	*Saba lanceolata*	Apocynaceae	W, C
45. Icacina	*Icacina oliviformis*	Icacinaceae	W, C
46. -	*Trichoscypha ferruginea*	Anacardiaceae	W, C, S
47. -	*Azanza garckeana*	Malvaceae	E, S
48. Bird plum/wild date	*Berchemia discolor*	Rhamnaceae	E, S
49. -	*Ximenia caffra*	Olacaceae	W, C, E, S
50. -	*Grewia tembensis*	Tiliaceae	W, C, S
51. -	*G. caffra*	Tiliaceae	W, C, S

[1]Note: some genus have more than one species of primary use as fruit, although not all are listed; [2]W—West Africa; C—Central Africa; E—East Africa; S—Southern Africa; I—Indian Ocean Islands.

Table 3. Some adapted introduced tropical fruit species from outside Africa.

Common name	Botanical name	Family name	Species origin
Avocado pear	*Persea americana*	Lauraceae	Central America
Banana	*Musa* spp	Musaceae	South East (SE) Asia
Cashew	*Anacardium occidentalis*	Anacardiaceae	South America
Coconut	*Cocosnu cifera*	Arecaceae	Pacific South/Central America
Carambola	*Averrhoa carambola*	Oxalidaceae	Indonesia
Custard apple	*Annona squamosal*	Annonaceae	South America
Date palm	*Phoenix dactylifera*	Arecaceae	Persian Gulf
Fig	*Ficus caria*	Moraceae	SE Asia
Grape citrus	*Citrus paradise*	Rutaceae	West Indies
Lemon	*C. limon*	"	SE Asia
Lime	*C. aurantifolia*	"	"
Orange	*C. sinensis*	"	"
Shaddock	*C. grantis*	"	"
Tangerine	*C. reticulate*	"	"
Tangelo	*C. reticulate* × *C. paradisi*	"	"
Tangor	*C. reticulata*× *C. sinensis*	"	"
Guava	*Psidium guajava*	Myrtaceae	West Indies America
Grapevine	*Vitis vinifera*	Vitaceae	Russia (Asia)
Passion fruit	*Passiflora edulis*	Passifloraceae	South America
Mango	*Mangifera indica*	Anacardiaceae	South Asia
Pawpaw/Papaya	*Carica papaya*	Caricaceae	Central America
Pineapple	*Ananas comosus*	Bromeliaceae	South America
Sour sop	*Annona muricata*	Annonaceae	Central America
Sweet sop	*Annona squamosal*	"	South America
Star apple	*Chrysophyllum cainito*	Sapotaceae	Central America
Breadfruit	*Artocarpus atilis*	Moraceae	Polynesia (Asia)
Jackfruit	*A. heterophyllus*	"	S. Asia
Mulberry	*Morus alba*	"	China-Japan
Hog plum	*Spondia mombin*	Anacardiaceae	Tropical America

breeding [26]-[30]. However, common among the varied definitions is that domestication entails settling a species (whether plant or animal) as a member of a household; to cause to feel at home or naturalized. Thus, domestication in this context is an anthropogenic change in the genetics of a plant to conform to human needs and agroecosystem [6]. By extension therefore, domesticating underutilized IFT/wild fruit trees involves accelerated and human-induced evolution to bring species into wider cultivation through a farmer-driven and or market-led process. This is an iterative procedure involving the identification, production, management and adoption of desirable germplasm. Strategies for individual species vary according to their functional use, biology and target environment. Remarkably, domestication of any plant species consists of selection and management by humans, and

Table 4. SWOT analysis of opportunities and challenges of Tropical African IFT.

Internal factors	Strength (+ve)	Weakness (−ve)
	- Area of origin/natural distribution - Local preference/consumption of produce - Form part of traditional home garden farming system - Hold high cultural value among the local people - Viable revenue generator for rural resource poor farmers - Available local/regional markets	- Grossly under-researched - Relatively poor and inefficient production technology - Near absence of improved propagation agrotechniques - Most harvest still derived from wild/volunteer stands - Slow rate of natural regeneration - IFT information are poorly documented or in grey literatures
External factors	**Opportunity (+ve)**	**Threat (−ve)**
	- International market/export prospects as novel crops - Potentials diversification of products and markets - Recognition as candidates for agroforestry multipurpose trees for the sub-regions - Recent recognition by Bioversity International—NUS, ICUC, ICRAF - Recent works of PROTA documentation/Publications - Satisfy needs for crop diversification	- Over exploitation of available *in situ* stands on farms and in forests - Depleting tree stands in the wild due to deforestation - Inadequate deliberate replanting scheme and organised orchards - Poor marketing outlets and low pricing of IFT produce - Preference of African researchers for introduced naturalized species over IFT

Note: NUS—Neglected and Underutilised Species/Bioversity International Rome; ICUC—International Centre for Underutilised Crops, Colombo Sri Lanka; ICRAF—International Centre for Research in Agroforestry (now known as World Agroforestry Centre), Nairobi Kenya; PROTA—Plant Resources of Tropical Africa, Wageningen, the Netherlands.

is not only about breeding *per se*, but definitely an aspect of whole species improvement. Domestication, in this perspective, aims at promoting the cultivation of IFT with economic potentials as new cash or novel crops, and provides incentive to subsistence farmers to grow such trees that contribute toward achieving poverty reduction, enhancement of food and nutritional security [25] [31]-[33].

Deliberate tree improvement programme (involving specific domestication interventions) for useful characters has been advocated for some highly promising IFT of Sub-Saharan sub-regions. This is to encourage local farmers to continue their age long practice of on-farm conservation and sustainable exploitation of IFT alongside their field crops [8] [34]-[36]. The long period that it takes before enjoying tangible benefits from tree-based agriculture is one of the reasons why some farmers see it as deterrent to planned cultivation of such economic IFT species. However, domestication via standardised vegetative propagation (like budding, stem cuttings and layering) can play significant role in ensuring that trees start producing quality fruits in a shorter period [28] [37]-[39]. Farmers and nursery managers must be able to have access to superior stocks for multiplication and distribution, if they are to capitalise on the benefit of such IFT cultivation.

2.3. Vegetative Propagation for Domestication of Indigenous Fruit Trees (IFT)

Vegetative propagation refers to the regeneration of selected plants from vegetative organs such as roots, stems, leaves, buds and even single cells/tissues; and it offers a wide range of benefits for any domestication programme of IFT, as well as in general Plant Genetic Resources (PGR) conservation efforts. By capturing the genetic variation of trees in natural stands, researchers are able to select for desirable traits found in wild tree populations. Ultimately, the aim is to produce large number of improved propagules for resource poor farmers and reforestation programme [40] [41]. The concept of vegetative propagation is that an exact copy of the genome of a mother plant is made and continued in new individuals (clones). This is possible in plants unlike animals or humans, for several reasons. Firstly, every living cell of a plant is initially totipotent, meaning that it contains all the genetic information needed to regenerate the entire plant. Furthermore, cell division continues to occur during the normal growth and development of most plants. Thirdly, cells can reform a meristem, which divides and produces the missing part [42]. Thus clones (*i.e.* all individuals produced by vegetative propagation from a single or original stock plant), are genetically identical, unless rare somatic mutations (chimeras) occur and are perpetuated. Whereas propagation by seeds provides opportunity for variation and evolutionary advancement, vegetative propagation aims at the identical reproduction of plants with desirable features such as high productivity, superior quality or high tolerance to biotic and or abiotic stresses, and as such plays a very vital role in perpetuating a preferred trait [36] [43].

According to author [37], the most important vegetative propagation techniques for trees are the regeneration by stem or root cuttings, grafting and budding, as well as various methods of marcotting (layering) and micropropagation procedures. Rooting of stem cuttings is the most common vegetative propagation technique used by gardeners and nursery managers. For this purpose, a portion of a stem with a leaf and axillary bud is cut from the parent plant and then set in an environment where humidity is high. After few weeks in such humid environment, roots may form on the cutting, and a new independent plant can then develop from the stem section. Most high success record regeneration of tree plants by cutting is done with materials from seedlings or from coppice shoots, because these parts of the plants are young with less lignification, and tend to grow vigorously. On the other hand, grafting and budding are techniques that join parts of plants together in such a way that they unite and continue their growth as a single plant. These techniques are used to perpetuate clones that cannot be conveniently reproduced by other vegetative propagation methods. Grafting is often used to multiply mature material that is difficult to root as cuttings. It is mainly applied in multiplication of high value fruit and ornamental woody species [38] [42].

Marcotting, a form of layering, is one of the oldest methods of vegetative propagation, although it still has relevance in present day plant multiplication, domestication and conservation efforts. It involves the development of roots on a stem while the stem is still attached to the parent plant. The rooted stem is then detached to be new plant growing from its own roots. Unlike in grafting, the need of compatible seedling rootstock is unnecessary in layering, which is an added advantage. As rooting from cuttings of mature tree plant materials is known to be difficult, layering and grafting are preferred for the vegetative propagation plan in IFT domestication programme [37] [41].

Finally, micropropagation, also referred to as tissue or *in vitro* culture, is a relatively new vegetative propagation technique, which uses a plant's potential to regenerate a complete new plant from single cells or small amounts of living tissue through the cultivation of these in aseptic and controlled environments. Since this technique requires a substantial investment in infrastructure, equipment and materials, its application is mostly justified in the case of high value plants where traditional vegetative propagation methods are considered unsuccessful. The method also allows for the production of virus-free plant materials and large amounts of new plants issued from a limited amount of initial material [42] [44].

Evidently, vegetative propagation leading to the domestication and conservation of IFT offers exciting opportunities for research and sustainable development of Plant Genetic Resources (PGR). Reasons for vegetative propagation options include: maintenance of superior genotype, problematic seed germination and storage behavior, shortening time to first flowering and fruiting, controlling phases of tree development, combining desirable characteristics of more than one genotype into a single plant stand, uniformity of plantations/orchards, among others [28] [41]. For instance, time to first fruiting have been reduced through vegetative propagation in Bush mango [*Irvingia gabonensis* and *I. wombolu*] from 7 years to 3 years; Bush butter tree [*Dacryodis edulis*] from 5 years to 2 years; Baobab [*Adansonia digitata*] from 10 years to 4 years; and inSheanut [*Vitellaria paradoxa*] from 20 years to less than 5 years [37] [45].

2.4. Major Targets in the Improvement of Tropical African IFT

Most Tropical African IFT have so far been grown in traditional ways as homestead shade trees, nurse trees; in community protected sacred forests, wild and volunteer stands on farms, market squares, village squares and forest areas. A good number of these species are scarcely grown deliberately by the farmers, who most times depended on wild saplings they came across for transplanting and regeneration of their choice local fruit trees. Knowledge and technical know-how of propagation and nursery management of the IFT are more or less lacking. Scientifically planned selection and breeding programmes have not been largely undertaken to select promising pomological traits (such as fruit size, shape, flavor, taste, suitability for processing into juice, wine and other beverages, resistance to biotic and abiotic stresses) among the various landraces of species. High production technologies such as high density planting system, pruning, efficient rootstocks cultivars and plant protection schedules have not been standardized. Faced with these several challenges, there is need to initiate focused tree improvement programme that would address essential pomological needs of the continent's IFT to bring it them at par with similar commodity crops from tropical America and Asia. Hence, the following major general targets for improvement are enumerated, although there may be other species specific needs relevant to the consumers and or markets.

***Screening and selection of priority species for domestication*:** Specific screening plots for priority species identified by local farmers in the sub-regions should be established as well as on-farm trials to determine farmers' preferred niches for IFT.

***IFT phenology, physiology and propagation study*:** Initiation of detailed research works on the IFT phenology, physiology and profitable propagation options for priority species in the various localities.

***Varietal selection for superior fruit quality among the landraces*:** Quality of fruit will always be a major objective of fruit tree improvement programme. Pulp taste, aroma and texture, fruit size and shape are main pomological attributes of fruit quality.

***Development of robust rootstock that is resistant or tolerant to biotic stress*:** Efficient and resistant cultivars and rootstocks are primary requirements for modern fruit production which can be achieved by undertaking sound science based improvement programme. Common objectives of rootstock improvement for fruit trees include ease of propagation, graft compatibility, high yield, control of scion vigour, longevity, adaptation to wide environmental conditions, resistance to diseases and pests.

***Enhanced productivity*:** This involves selection and breeding of promising cultivars with greater economic yield per unit area and cultivars with reduced tree size for ease of management.

***Value addition of IFT produce*:** Involves development and commercialization of enhanced processing techniques and value added products from fresh produce for market diversification of IFT. This would boost the resource poor farmers' expected revenue and encourage them to embark on deliberate cultivation of IFT.

3. Managing Tropical African IFT Genetic Resources

In Situ and *ex Situ* Conservation Approaches

There are two complementary approaches for conservation of IFT, namely *in situ* and *ex situ*. The *in situ* conservation involves maintaining genetic resources in the natural habitats where they occur, whether as wild and uncultivated plant communities or crop cultivars in farmers' fields as components of traditional agricultural systems. The aim of *in situ* conservation is to protect habitats of target species so that a population of that species can steadily persist [46]. Its target is for the protected areas to allow for multiple uses, and to allow the system to preserve rare, endangered and threatened species. In these systems, there is need to increase the geographic distribution of target species, improve population structure, and influence the dynamics and genetic variability within and between populations. Also, identification of threats to targets species in the wild and suitable mitigation actions as well as species recovery programmes need to be implemented. *In situ* conservation of cultivated and exploited wild species is mostly concerned with the on-farm maintenance of landraces, forage, fruit trees and agroforestry species [47] [48].

The *ex situ* conservation on the other hand involves conservation outside the native habitat and is generally used to safeguard populations in danger of destruction, replacement or deterioration. Samples from such species are stored in centralized banks away from the origin. Methods employed in *ex situ* conservation include field gene banks, seed storage banks, botanical gardens, arboretum, research centres and laboratories, DNA and pollen storage banks, and world heritage sites [49]. Other advanced biotechnological approaches include *in vitro* conservation and cryopreservation. These biotechnological approaches have been succinctly discussed by the authors [50].

According to author [46], the current level of development in conservation options for tropical fruit tree genetic resources, including African IFT, had necessitated the need for Field GeneBanks (FGBs) as important tool in the conservation and use of fruit tree genetic resources. Many important varieties of agronomic crops, horticultural crops and forestry trees are either difficult or impossible to conserve as seeds, due to inability of some species to naturally set seeds and as such are propagated vegetatively, or that the seeds are recalcitrant. Most of the IFT species are not exempted from this tendency, and hence are preferably conserved in FGBs along with other complementary conservation strategies [51]. The FGBs offer easy and ready access to conserve bulky plant genetic materials for research and use. Moreover a number of plant species, including many IFT of Tropical Africa, have not had alternative methods of conservation fully developed for them. However, FGBs have its own challenges too: requires more space due to natural large size and evergreen nature of IFT species, relatively expensive to maintain in the long run, risk of damage by natural disasters, pestilences, neglects among others.

4. Conclusion

Indigenous fruit species of Tropical Africa face enormous challenges in modern time rapidly advancing horticultural and food industrial sector. Yet the IFT are very important for the economic, health and social welfare of resource poor farmers in most rural and urban communities of the continent. Encouraging the domestication and conservation of IFT species in the agroecosystem can provide highly sustainable production systems that conserve soil fertility, micronutrients and biodiversity, as well as guarantee food security, climate change adaptation and mitigation. Although future outlook of IFT in the continent indicates great potentials as shown in the SWOT analysis earlier mentioned, a lot needs to be done from home front in order to shore up the relevance and production value chain of IFT at the global and regional commodity markets. In this connection, hitherto much emphasis and dominance of introduced adapted fruit species among many National Agricultural Research Centres (NARCs) list of mandate crops in Tropical African sub-regions should be re-considered for rather increasing focus and investment on exploiting the untapped rich treasuries of African IFT *vis-à-vis* developing improved agrotechniques and varietal selection for the species. The Plant Resources of Tropical Africa (PROTA) programme, World Agroforestry Centre and International Conference on Neglected and Underutilised Species (NUS) under the auspices of Bioversity International are by their various activities championing international campaign on re-awakening interests of all relevant stakeholders, including the academia, researchers, policy makers and industrialists on NUS generally and IFT in particular.

References

[1] Rathore, D.S. (2003) Role of Genetic Resources in Improvement of Tropical Fruit Species. In: Chaudhury, R., Panday, R., Malik, S.K. and Mal, B., Eds., *In Vitro Conservation and Croypreservation of Tropical Fruits Species*, IPGRI Office for South, Asia New Delhi/NBPGR, New Delhi, 17-25.

[2] Kulnlein, H., Erasmus, B. and Spigelski, D., Eds. (2009) Indigenous People Food Systems. FAO and Centre for Indigenous People's Nutrition and Environment, Rome, 251-281.

[3] Lapeña, I., Turdieva, M., Noriega, I.L. and Ayad, W.G. (2014) Conservation of Fruit Tree Diversity in Central Asia: Policy Options and Challenges. Bioversity International, Rome, 251 p.

[4] Paull, R.E. and Duarte, O., Eds. (2011) Tropical Fruits. 2nd Edition, CAB International, London, 1-10.

[5] Sthapit, B., Rao, V.R. and Sthapit, S., Eds. (2012) Tropical Fruit Trees Species and Climate Change. Bioversity International, New Delhi, 15-26, 97-125.

[6] Jaramillo, E.H., Sensi, A., Brandenberg, O., Ghosh, K. and Sonnino, A. (2011) Biosafety Resourcebook; Module (b): Ecological Aspects. Food and Agricultural Organisation (FAO), Rome, 10-49.

[7] FAO (2010) Statistical Yearbook 2010. http://www.fao.org/fileadmin/templates/ess/ess_test_folder/publications/yearbook_2010/c11.xls

[8] Grace, O.M., Borus, D.J. and Bosch, C.H., Eds. (2008) Vegetable Oils of Topical Africa. Conclusions and Recommendations Based on PROTA I4: Vegetable Oils. Plant Resources of Tropical Africa (PROTA) Foundation, Nairobi, 84 p.

[9] Newman, J.L., Mehretu, A., Shillington, K. and Stock, R. (2009) Africa. Microsoft® Encarta® 2009 [DVD]. Microsoft Corporation, Redmond, 2008.

[10] Okigbo B.N. (1997) Neglected Plants of Horticultural and Nutritional Importance in Traditional Farming Systems of Africa. *Acta Horticulturae*, **53**, 131-150.

[11] Meregini, A.O.A. (2005) Some Endangered Plants Producing Edible Fruits and Seed in Southeastern Nigeria. *Fruits*, **60**, 211-220.

[12] Bosch, C.H., Siemonsma, J.S., Lemmens, R.H.M.J. and Oyen, L.P.A. (2002) Plant Resources of Tropical Africa Basic List of Species and Commodity Grouping. PROTA Programme, Wageningen, 7-12.

[13] Siemonsma, J.S., Schmelzer, G.H. and Rodrigues, W. (2004) PROTA 2004 Annual Report. Plant Resources of Tropical Africa (PROTA), Wageningen University and Research, Wageningen, 5-7.

[14] The National Academies (2008) Lost Crops of Africa: Volume 3. Fruits. National Academies Press, Washington DC, 381 p. http://www.nap.edu/catalog/11879.html

[15] Ogbu, J.U. and Ibekwe, H.N. (2013) Characterization and Distribution of Indigenous Plants Research in Horticultural Society of Nigeria (HORTSON) Publications. *Nigerian Journal of Horticultural Science*, **18**, 35-41.

[16] Cobley, L.S. and Steele, W.M. (1976) Introduction to the Botany of Tropical Crops. 2nd Edition, Longman, London.

[17] Purseglove, J.W. (1978) Tropical Crops: Monocotyledons Vol. 1 & 2. Longman Group, London, 607 p.

[18] Purseglove, J.W. (1984) Tropical Crops: Dicotyledons Vol. 1 & 2. Longman Group, London, 719 p.

[19] Youdeowei, A., Ezedinma, F.O.C. and Onazi, O.C. (1986) Introduction to Tropical Agriculture. Longman, London, 344 p.

[20] Opeke, L.K. (1987) Tropical Tree Crops. Spectrum Books, Ibadan, 327 p.

[21] Yayock, J.Y., Lombin, G. and Owonubi, J.J. (1988) Crop Science and Production in Warm Climates. Macmillan Publishers, London, 307 p.

[22] MacDonald, I. and Low, J. (1990) Fruits and Vegetables. Evans Brothers Ltd., Nairobi, 137 p.

[23] Matthew, I.P. and Karikari, S.K. (1990) Horticulture: Principles and Practices. Macmillan Publishers, London, 202 p.

[24] Muok, B.O., Owuor, B., Dawson, I. and Were, J. (2000) The Potential of Indigenous Fruit Trees: Results of a Survey in Kitui District, Kenya. *Agroforestry Today*, **12**, 13-16.

[25] Mithofer, D. (2005) Economics of Indigenous Fruit Tree Crops in Zimbabwe. Ph.D. Thesis, Department of Economics and Business Administration, University of Hannover, Hannover, 250 p.

[26] Simon, T. (1997) Tree Domestication—Better Trees for Rural Prosperity. *Agroforestry Today*, **9**, 4-5.

[27] Altieri, M.A. (2000) Agroecology: Principles and Strategies for Designing Sustainable Farming Systems. Hayworth Press, New York.

[28] Leakey, R.R.B. (2000) Tree Domestication. The Overstory #31. http://www.agroforestry.net/overstory/overstory31.html.

[29] Pauku, R.L. (2005) Domestication of Indigenous Nuts for Agroforestry in the Solomon's Islands. Ph.D. Thesis, James Cook University, Cairns, 381 p.

[30] Akinnifesi, F.K., Leakey, R.R.B., Ajayi, O.C., Sileshi, G., Tchoundjeu, Z., Matakala, P. and Kwesiga, F. (2007) Indigenous Fruit Trees in the Tropics: Domestication, Utilization and Commercialization. CAB International, Wallingford, 28-49. http://dx.doi.org/10.1079/9781845931100.0000

[31] Jaenicke, H. and Hoschle-Zeledon, I. (2006) Strategic Framework for Underutilized Plant Species Research and Development with Special Reference to Asia and the Pacific, and to Sub-Saharan Africa. International Centre for Underutilized Crops, Rome, 33 p.

[32] Dawson, I.K., Guarino, L. and Jaenicke, H. (2007) Underutilized Plant Species: Impact of Promotion on Biodiversity. Position Paper No. 2. International Centre for Underutilized Crops (ICUC), Colombo.

[33] Leakey, R.R.B., Nevenimo, T., Moxon, J., Pauku, R., Tate, H., Page, T. and Cornelius, J. (2010) Domestication and Improvement of Tropical Crops for Multi-Functional Farming Systems. Contemporary Crop Improvement: A Tropical View. 14*th Australasian Plant Breeding Conference* (*APBC*) *and the* 11*th Congress of the Society for the Advancement of Breeding Research in Asia and Oceania* (*SABRAO*), 10-14 August 2009, Cairns, 57.

[34] O'Neil, G.A., Dawson, I., Sotelo-Montes, C., Guarino, L. and Weber, J.C. (2001) Genetic Conservation of Tropical Trees. *Biodiversity and Conservation*, **10**, 837-850. http://dx.doi.org/10.1023/A:1016644706237

[35] Dawson, I., Harwood, C., Jamnadass, R. and Beniest, J. (2012) Agroforestry Tree Domestication: A Primer. The World Agroforestry Centre, Nairobi, 148 p.

[36] Halewood, M., Baidu-Forson, J.J., Clancy, E. and Vodouhe, R.S. (2014) Cooperating to Make the Best Use of Plant Genetic Resources in West and Central Africa: A Regional Imperative. Bioversity International, Rome, and CORAF/WECARD, Dakar.

[37] Jaenicke, H. and Beniest, J. (2002) Vegetative Tree Propagation in Agroforestry. ICRAF, Nairobi, 1-30, 75-82.

[38] Verheij, E. (2006) Agrodok 5 Fruit Growing in the Tropics. 3rd Edition, Agromisa Foundation & CTA, Wageningen, 35-40.

[39] Scrase, R. (2009) Focus on—Domesticating Wild Trees in Botswana. *New Agriculturist Online Journal*. file:///E:/newag/focus/focusitem795.html

[40] Tchoundjeu, Z., De Wolf, J. and Jaenicke, H. (1997) Vegetative Propagation for Domestication of Agroforestry Trees. *Agroforestry Today*, **9**, 10-12.

[41] Verheij, E. (2004) Agrodok-19 Propagating and Planting Trees. 2nd Edition, Agromisa Foundation, Wageningen, 15-53.

[42] Hartmann, H.T., Kester, D.E., Davies Jr., F.T. and Geneve, R.L. (2007) Plant Propagation: Principles and Practices. 7th Edition, Prentice-Hall Inc., New Delhi, p 293-603.

[43] Acquoah, G. (2004) Horticulture: Principles and Practices. 2nd Edition, Prentice-Hall Press, New Delhi, 316-356.

[44] Chadha, K.L. (2009) Handbook of Horticulture. Indian Council of Agricultural Research (ICAR), New Delhi, 76-82.

[45] Jamnadass, R.H., Dawson, I.K., Franzel, S., Leakey, R.R.B., Mithöfer, D., Akinnifesi, F.K. and Tchoundjeu, Z. (2011) Improving Livelihoods and Nutrition in Sub-Saharan Africa through the Promotion of Indigenous and Exotic Fruit Production in Smallholders' Agroforestry Systems: A Review. *International Forestry Review*, **13**, 338-354. http://dx.doi.org/10.1505/146554811798293836

[46] Rao, V.R. and Sthapit, B.R. (2012) Tropical Fruit Tree Genetic Resources: Status and Effect of Climate Change. In: Sthapit, B., Rao, V.R. and Sthapit, S., Eds., *Tropical Fruit Trees Species and Climate Change*, Bioversity International, New Delhi, 97-128.

[47] Rao, N.K. (2004) Plant Genetic Resources: Advancing Conservation and Use through Biotechnology. *African Journal of Biotechnology*, **3**, 136-145.

[48] Rathore, D.S., Srivastava, U. and Dhillon, B.S. (2005) Management of Genetic Resources of Horticultural Crops: Issues and Strategies. In: Dhillon, B.S., Tyagi, S., Saxena, S. and Randhawa, G.T., Eds., *Plant Genetic Resources*: *Horticultural Crops*, Narosa Publishers, New Delhi, 1-18.

[49] Oldfield, S. and Newton, A.C. (2012) Integrated Conservation of Tree Species by Botanic Gardens: A Reference Manual. Botanic Gardens Conservation International, Richmond, 56 p.

[50] Ahuja, M.R. and Ramawat, K.G. (2014) Biotechnology and Biodiversity. Sustainable Development and Biodiversity. Vol. 4, Springer International Publishing Switzerland. http://www.springer.com/series/11920

[51] Engelmann, F. and Engels, J.M.M. (2002) Technologies and Strategies for *ex Situ* Conservation. In: Brown, A. and Jackson, M., Eds., *Managing Plant Genetic Diversity*, CAB International /IPGRI, Wallingford, 89-104.

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