CLIMATE CHANGE, FOOD SECURITY, NATIONAL SECURITY and ENVIRONMENTAL RESOURCES

GLOBAL ISSUES & LOCAL PERSPECTIVES

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Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous climate change, food security, national security and environmental resources issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which climate change, food security, national security and environmental resources issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue climate change, food security, national security and environmental resources necessary in policy making process that will stimulate increase in food production and environmental sustainability.

Climate Change, Food Security, National Security and Environmental resources: Global issues and Local Perspectives is organized in four parts. Part One deals with Climate Change with Six Chapters, Part Two is concerned with Food Security with Nine chapters, Part Three deals with National Security with Five Chapters, while Part Four pertains Environmental Resources, has Five Chapters.

Ahmed Makarfi / Eteyen Nyong

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Chapter 17

Conservation of Forest Resources in Nigeria: Case Study of Indigenous Forest Food Plants Species

Okonkwo, H. O, Nsien, I. B., and Akomolede, L. A.

Abstract

Indigenous forest food plants species (IFFPs) are the most intimate food plant species of the traditional rural farming households of the tropics and very important to the household economy in nutrition security and supplementary income generation. However traditional IFFPs management systems are presently inadequate vis-à-vis the growing demand for IFFPs products and deforestation. There is therefore an urgent need to develop IFFPs in the country to harness the inherent potentials of job creation, on-farm biodiversity increase, income, etc. IFFPs provide opportunities for novel crop and new product development that can catch the interest of youths to conserve the species. To achieve this greater research effort need to be directed towards IFFPs development in the country. The review emphasis the traditional role of IFFPs in the rural household economy, highlights the traditional management system of IFFPs, the place of IFFPs in the contemporary society, the inadequacy of traditional IFFPs management system, the benefits of IFFPs development, and the state of IFFPs research in Nigeria; furthermore, the participatory IFFPs domestication strategy of ICRAF and vegetative propagation of IFFPs are recommended as strategies to increase the benefits and conservation of the species.

Keywords: IFFPs, nutrition-security, income-generation, biodiversity increase

Introduction

Indigenous forest food plants species **(**IFFPs) are a diverse array of wild plant species with strong local relevance and appeal throughout their natural range (Sthapit *et al.*, 2016). IFFPs are indigenous food plants with strong cultural, religious, traditional or nutritional relevance but are sourced from the wild or undomesticated/uncultivated when compared to domesticated/cultivated

field crops like yam or maize and of which benefits and use are only known and appreciated within the native range (Leakey, 2019). Their importance stems from the traditional key and essential role they play within the local rural and even urban livelihoods (Okonkwo *et al.*, 2018). I actually prefer to see IFFPs as trado-cultural plant species because of their long traditional/cultural ethnobotanical history in their native areas. We often see a bond or relationship between the people and these plant species. They are the closest to the people than other wild plants species. As a matter of fact from these plants one can notice a gradation in the occurrence of plants species as we move from the traditional farming homestead/settlements in a typical rural area towards the forest. Plants that are most useful to the people are normally planted closest to the home.

The conclusion is drawn from the fact that IFFPs constitute the most of plant species found in the most intimate farming systems of the tropics, the homegarden (Okafor *et al.*, 1987). IFFPs actually are the reason homegardens are important. Homegardens are the domestication ground/cradle of IFFPs. The much touted healthy eating of the local farming populations is due to their high consumption of IFFPs. Local people have therefore over time built trado-cultural association with IFFPs and developed diverse uses for them. In the south-east of Nigeria a IFFPs like *Dacryodes edulis* has a powerful place in the food culture of the people (Table 1). The local pear is usually consumed together with maize. How these cultural behaviour came about we can only guess is due to the fact that the tree normally will fruit during maize harvest season. *Irvingia species* is another IFFPs with strong cultural appeal in the south-east. The species used as soup thickener is highly valued in the region with a high trade value.

IFFPs are more or less overlooked yet their presence is ubiquitous and hardly does an average Nigerian live without them. They have supported household nutrition and food security for as long as anyone can possibly remember. They constitute the fruits, vegetables, spices, and herbs that we grew up knowing and that we see every day in our local markets and especially village markets (Okonkwo *et al.*, 2018). Yet they are often looked upon as common and the sophisticated ones see them as the preserve of the *uncivilized* and often attempt to make a switch from them as soon as they can afford processed foods. Not only are IFFPs neglected by even the indigenous owners whose forefathers raised with proceeds and products from these

species, IFFPs generally speaking have received very little attention from the scientific world and this has earned them the name Cinderella species (Leakey, 2019).

IFFPs are classified among non-timber forest products (NTFPs) (Dadegnon *et al.*, 2015) alongside other forest products like medicinal plants, wildlife, etc. IFFPs often produce a diverse array of products. For example, *Garcinia kola,* is an indigenous IFFP known for the medicinal and trade value of the seeds, but the tree bark and root have been reported to be reputed for medicinal potency among local people living within the natural range of the species (Okonkwo *et al.*, 2014). The multiple benefit characteristic of many IFFPs earned the species the appellation *multipurpose trees.* Nutritional and medicinal values are not the only reason many IFFPs are described as multipurpose species: many IFFPs trees wood are of high timber quality. An example is *Allanblackia floribunda* and *Garcinia kola* wood which are reported to be locally valued for durable and strong timber (Okonkwo, 2013). In more recent times IFFPs have acquired more usefulness in keeping with their multipurpose character in the areas of carbon sequestration, on-farm biodiversity increment (Gouwakinnou, 2011), and soil nutrient replenishment in agroforestry systems (Batish *et al.*, 2008). Therefore in this review we assessed the traditional role of IFFPs in the rural household economy, highlight the traditional management system of IFFPs, the place of IFFPs in the contemporary society, the inadequacy of traditional IFFPs management system, the benefits of IFFPs development, and the state of IFFPs research in Nigeria; furthermore, the participatory IFFPs domestication strategy of ICRAF and vegetative propagation of IFFPs are recommended as strategies to increase the benefits and conservation of the species.

Table 1. Some common IFFPs in Nigeria.

Botanical name	Common name	Family
Allanblackia floribunda	Allanblackia	Coriacea
Dacryodes edulis	Butter fruit	Burseraceae
Irvingia gabonensis	Sweet bush mango	Irvingiaceae
Irvingia wombulu	Bitter bush mango	Irvingiaceae
Cola parchycarpa	White monkey kola	Malvaceae
Cola lepidota	Yellow monkey kola	Malvaceae

Cola lateritia	Red monkey kola	Malvaceae
Pentaclethra macrophyla	African oil bean	Fabaceae
Treculia Africana	Bread fruit	Moraceae
Chrysophyllum albidum	Star apple	Sapotaceae
Parkia biglobosa	Oil bean	Fabaceae
Pterocarpus millbreadhii	-	Fabaceae
Plukenetia conophora	African walnut	Euphorbiaceae
Adansonia digitata	Baobab	Bombacaceae
Vitellaria paradoxa	Shea butter	Sapontaceae
Annona muricata	Sour sop	Anonnaceae
Artocarpu saltilis	Bread fruit	Moraceae

Sources: (Awodoyin *et al.*, 2015)

Why IFFPS: The Traditional Role of IFFPS in the Rural Household Economy

Traditionally IFFPs are the chief sources of anti-oxidants, vitamins, minerals, and fibre for the rural farming household: they supply the vegetables, fruits, nuts, etc. that provide the essential life maintaining nutrients to the household (Okonkwo, 2017). They therefore support rural food security by way of nutrition or diversification of diet which is very essential to maintaining a healthy family workforce. This is probably why many IFFPs are cultivated within the most intimate of the rural farming systems, the homegarden (Okonkwo, 2015): to facilitate quick and easy access to opportunity for rich diets for the family. Vegetables and spices used to prepare soup eaten with the carbohydrate laden cassava mills are readily sourced from the backyard garden(Harris *et al.*, 2003). This is probably why some authors called homegardens or kitchen garden (Okonkwo, 2017) due to the role that IFFPs play in household food security. IFFPs rich homegarden means rich and diversified diet. For example in Vietnam and Indonesia it was discovered that vegetables and fruits sourced from the homegarden make up to 50% of the diet of the household (Okonkwo, 2015).

IFFPs also play gap filling roles during the hungry season of the year when the regular staples like cassava, yam and cocoyam are in short supply (Okonkwo *et al.*, 2018). The hungry season usually is the planting season during which the staples are being cultivated, unavailable and

expensive (Amadi, 2014). IFFPs fill this food scarcity gap through the supply of fruits and vegetable. Acoording to Okonkwo, (2017) this role of IFFPs is essential to forestalling the collapse of the rural household economy. This is the reason people living rural and farming communities are healthy and not always down with sicknesses and diseases that come with westernization of diets. IFFPs are able to play this role due to their diversity hence there is always a IFFPs in season at any particular point in time in the year (Okonkwo, 2015). In summary therefore it is safe to say that while farm-fields supply the household with carbohydrate rich food required for energy, IFFPs bring the diversity that is essential for healthy living.

Another important role that IFFPs play in the rural household economy is supplementary income supply (Okonkwo, 2015). Proceeds from the sale of excess IFFPs production is normally ploughed into buying the shortfall in household food supply. Income from IFFPs trade was also used to purchase inputs for the field crop farms away from the homestead. Ownership of diverse IFFPs stands actually makes a wealthy household in the rural household. IFFPs bring a boost to the household asset, diversify livelihood strategy and subsequently the outcomes (Okonkwo, 2015). Asset poverty has been fingered as the bane rural poverty in developing tropical countries. When you tinker with the asset status of the rural household you bring about a change in their livelihood outcome. Looking at IFFPs it is obvious that they were actually the game changer in the asset status of rural household. I therefore propose that to improve rural livelihood and create wealth IFFPs need to be developed. A lot of improvement can be brought to rural life if IFFPs are developed and returned to them (Amadi, 2014).

IFFPs play a key and important role in the rural economy. Aside from trade in the regular staples such as yam, cocoyam, and maize. IFFPs products trade is the second largest economic activity of the rural people. Rural/urban IFFPs product trade has been a source rural livelihood diversification (Okonkwo, 2017). It increases the portfolio of livelihood strategies available to the populations and subsequently an improvement in the livelihood outcome they reap (Okonkwo, 2015). Many rural people engage full time in IFFPs trade (Adams *et al.*, 2019). Matter of fact the value chain of many popular IFFPs products employ and engage several people. Take for example IFFPs product like *Irvingia gabonensis/wombulu* seed trade which is both international and local generating several jobs and supporting many households (Okonkwo, 2017). The problem is many IFFPs product trade are unrecorded and unsupervised (Stoian, 2000). They operate within the

sphere of trade we can call *grey* market or trade. Despite the paucity of research attention (Adams *et al.*, 2019) on the species they continue to play these roles in the rural farming communities within the natural range of the species and highly valued for the contribution they make to livelihoods outcome. The value chain of many IFFPs we see in the urban centres and cities already employs many and provides alternative income sources for locals (Okonkwo, 2017). Efforts need to be made to fully document the contributions IFFPs make in the areas of rural wealth creation, employment generation, nutrition security, and livelihood diversification.

Traditional Management System of IFFPS: IFFPs traditionally are planted and maintained within the *backyard garden* or *homegarden* close to the home and particularly the kitchen (Okonkwo, 2015). This is why most IFFPs, can be found in the traditional forest homegardens typical of rural farming households (Ogbu *et al.*, 2007). Few stands of food trees can often be found away from the homegardens at village squares or around the homestead nonetheless the homegarden always hold the highest reservoir of IFFPs (Okonkwo, 2017). So the traditional homegarden that has well been described by several authors e.g.(Nair, 1993) are the traditional management systems of IFFPs.

Farmers and rural households plant and manage IFFPs within homegardens using family labour (Nair, 1993). Traditionally therefore homegardens are biodiversity hotspots of IFFPs. Farmers even select to improve their cultivated varieties through exchange of elite germplasms(Leakey, 2019). Most IFFPs are therefore partially domesticated although it remains to determine the degree of progress each IFFPs has made in the transition from wild to domesticated. There is therefore ample local knowledge on most IFFPs among people living within the natural range of the species. It is on these premise that it is been advocated by some authors e.g. (Leakey, 2018)that any effort to domesticate IFFPs must begin with ethnobotanical studies that will take into consideration the contribution that indigenous people have made to the domestication of the species. This has led to the advent of the participatory domestication approach to the development of IFFPs (Leakey, 2017) which entails starting the domestication process on the platform of local knowledge and marrying this with science in the process in a collaborative and interactive way. The approach is bottom up as against the usual top down approach of many scientific studies. It makes the process the peoples own and ensures that the result is immediately

applied to improve local livelihood and wellbeing (Leakey, 2019). Furthermore efforts are already being made to document and encourage good indigenous IFFPs management practices and possibly improve on them to bring about sustainable production and management in Asia (Sthapit *et al.*, 2016). Similar efforts need to be made in Nigeria to sustainably produce, manage and develop our IFFPs.

IFFPS in Contemporary Society: The Need for Food Plants: Globally there is a growing need to increase food production vis-à-vis the increasing world population. Food security is fast becoming a global challenge against the backdrop of growing world population, climate change threat, deforestation, soil degradation, and failing mono-cropping systems(Harris *et al.*, 2003). Not only is there a growing urgent need to grow more food but also the need to diversify production to bring about healthy diets and healthy populations. It is on record that of the thousands of edible species on earth just about 0.5% are presently cultivated and utilized (Leakey, 2019). IFFPs present opportunities to increase the number and diversity of cultivated crops. Society like ours so blessed and rich in a diversity of IFFPs can draw upon this opportunity to make money, create jobs and grow the economy. IFFPs present to us opportunity to give to the world the next generation of novel crops. Many of our IFFPs can conveniently compete with western fruits in terms of nutrients and attractiveness. We must not let this God given opportunity slip by.

More and more people are becoming health conscious and the incidence of debilitating diseases like cancer, cardiovascular diseases etc. has become worrisome. Lifestyle and eating habits have been fingered as the major culprit in these issues (Okonkwo, 2017). Phytochemical analysis of some IFFPs has shown that many of them hold the solution to the many health challenges facing the world today. For example *Allanblackia species* (*Allanblackia floribunda* is indigenous to Nigeria of the nine species within the genus) seed oil has a rare combination of two unique qualities of low trans-fat (Ofori *et al.*, 2015) and high melting point (Munjuga, 2016) coupled with a reputation for lowering plasma cholesterol. As a result there is a high demand for the oil in Europe for the making of margarine and cosmetic products. A tonne of *Allanblackia* oilis sold for as much as USD 650 in Europe which is same as for refined palm oil. Equally important to mention is the medicinal value of *Allanblackia species* bark concoction which is reported to be effective in the treatment of cough, cold and sore throat (Munjuga, 2016). *Garcinia kola* seeds

have been reported to contain phytochemicals that fight several diseases such even ebola, cough etc.(Okonkwo *et al.*, 2014). IFFPs therefore are going to be part of the solution to the growing global health concerns.

Majority of IFFPs are trees and therefore are excellent candidates for agroforestry (Leakey, 2017). The traditional IFFPs agroforestry system is the homegarden. However it remains to consider developing such systems for commercial purposes. This will require development of high yielding and early fruiting cultivars and landraces. IFFPs can be important agroforestry products if well developed. Improved planting materials of IFFPs are already in high demand and need will only continue to grow as people strive to develop healthy eating habits.

The other potential tied to this is the carbon sequestration potential of IFFPs agroforestry which can be exploited to generate foreign exchange by designing them as carbon projects. Carbon projects are long term projects. IFFPs carbon projects will yield multiple income and create wealth. This an area that is begging for attention and if developed will help reduce poverty and unemployment in the country.

IFFPs provide opportunities for biodiversity and forest conservation (Sthapit *et al.*, 2016). Many IFFPs have recalcitrant seeds (i.e. seeds have short storage life) which means that the only way to conserve them is by the maintenance of field gene-banks (Mosquera-Losada *et al.*, 2019). There is therefore an urgent need to conserve many of the species. For example *Garcinia kola* has been labelled vulnerable in the wild (Okonkwo *et al.*, 2014). The need to rescues many of the IFFPs from the wild before they go extinct from deforestation is urgent. Development of field gene-banks of the species will both conserve forest and biodiversity. Field gene-banks are to be established after provenance evaluation of the genetic relatedness of the populations within the natural range of the species in the country. This is going to help in understanding the genetic structure of the species and provide guidance in the collection of germplasm for gene-bank establishment and genetic conservation of the species.

The Inadequacy of Traditional IFFPs Management System: More and more people are turning to fruits, vegetables, nuts, etc. which all come from IFFPs as the global awareness of the health benefits of these food species continues to grow. The local demand for fruits has led to increase in the nations' fruit importation budget. Traditional IFFPs can fulfil and even surpass the health benefits of these imported varieties. There is only a paucity of information on the native IFFPs due

to poor or little research attention (Lockett *et al.*, 2000). Nonetheless the local demand is already beyond supply and hence the need to go beyond the traditional production practices of IFFPs. The traditional IFFPs production system is low input and low income generating. The system cannot meet the growing demand for the product of these species. If our society will eat and live healthy these food species need to be developed.The high rate of deforestation and biodiversity loss means that if we do not develop these species we might risk losing them(Olajuyigbe, 2018). For example about 30 000 species are threatened with extinction globally (Iucn, 2019) (Table 2) while there is no information on the status of many indigenous IFFPs due to poor research attention. This highlights an urgent need to assess the status of these species in the wild in Nigeria as a country.

This is exacerbated by the growing human population in the country which all boil down to the fact that the present production system is grossly insufficient for the realities of today. Intense efforts must be made to domesticate the species. Research on the species must incorporate aspects such as production systems, selection for improvement, breeding, development of appropriate vegetative propagation technology for each IFFPs species, provenance/genecological studies, field gene-bank establishment, population genetics, etc to be able to develop these species and make them global products. The apples we import were sometimes ago wild and undeveloped in their native countries and people picked them up and made them global products today (Okonkwo, 2017).

Table 2: IUCN status of some IFFPs

Species	IUCN red list status	Threat
Irvingia gabonensis	Near threatened	Logging and wood harvesting
Garcinia kola	Vulnerable	Logging and wood harvesting
Pterocarpus mildbraedii	Vulnerable	Logging and wood harvesting
Plukenetia conophora	No information	No information
Irvingia wombulu	No information	No information
Dacryodes edulis	No information	No information
Cola lepidota	Least concern	No information
Parkia biglobosa	No information	No information
Cola parchycarpa	No information	No information
Cola lateritia	No information	No information

Source: (IUCN, 2019).

Benefits of IFFPS Development: The benefits of IFFPs development are many. By development I mean increased research attention, use, and production of IFFPs in the country. IFFPs development will require domestication, selection, breeding, conservation, and commercialization of the species. Below are some of the benefits inherent in IFFPs development in the country.

Opportunity for job and rural wealth creation: As I have earlier pointed out IFFPs product collection and trade is one of the important rural livelihood activities. IFFPs development has the potential to generate employment through the creation of a portfolio of IFFPs farming alternatives and systems that interested individual can venture into to make money. There is also employment generation in the value chain from the farm through processing and to the final consumer. IFFPs development will also help diversify rural economy thereby engaging the youths and providing alternative sources of income.

Opportunity for on-farm biodiversity increase: IFFPs development holds the promise of on-farm biodiversity increase which is important to pollination, diversification of income both in time and space. On-farm biodiversity conservation is going to become important in the future vis-à-vis the growing rate of deforestation in the country. Diversification of cultivated crop is also important to household nutrition and food security.

IFFPs Research in Nigeria

Research to domesticate and improve IFFPs though has been championed by ICRAF globally, under the auspices of *agroforestry food tree species* however local research efforts in this direction in Nigeria is still very low. Elsewhere in Asia(Sthapit *et al.*, 2016) efforts are on to develop indigenous IFFPs while the same cannot be said of Africa or Nigeria in particular.

There is therefore an urgent need to build research capacity, collaboration and investment in the country geared towards IFFPs development. Research gaps abound in indigenous IFFPs research in the country. The population distribution and status of most IFFPs in the country is unknown. Therefore it is difficult to make a statement on the extent of the wild populations of IFFPs in the country. Yet this information is important vis-à-vis the deforestation rate in the country. Little is also known about the reproductive biology of most IFFPs that are particularly indigenous to the country. This makes it difficult to determine the reproductive behaviour of most IFFPs and the resultant genetic variability. Moreover the high cost of genetic analysis in the

country makes it difficult to determine the relatedness of the cultivated and wild populations in the country. Yet this very important to genetic conservation of biodiversity and germplasm management of IFFPs in the country. There is also gaps in the knowledge of the behaviour of most IFFPs in a plantation environment which is important to the mass propagation of the species in the country.

IFFPs research actually is supposed to have an institute in the country dedicated to it in order to make serious progress in the development. Otherwise institutes like FRIN will have to set aside a station dedicated to research and development of IFFPs in the country. Finally there is the need to raise voices among policy makers for forestry research generally and IFFPs research in particular in the country. This is very important to generate interest and funding for forestry and allied subjects research in the country since government funding is channelled towards areas where the noise is coming from. The loudest voice gets to be heard among the policy makers and in Nigeria in particular the most connected is taken most seriously. It is therefore time that the academia begins to send men to the hallowed chambers of the national and state assembly and to hold key positions in government so as to ensure forestry research funding otherwise our cries and research findings will never see the light of the day.

The Participatory IFFPs Domestication Strategy of ICRAF

The strategy used by ICRAF in IFFPs domestication in the various countries they are working is the participatory domestication strategy (Leakey, 2017; Leakey, 2018) which involves working with local and indigenous people to first identify IFFPs of interest to them for domestication and subsequently to develop vegetative propagation methods to capture elite genes and to mass propagate them. Recently genetic diversity studies are being included in the project to aid germplasm management and genetic biodiversity conservation.

The concept of *socially modified organism* (SMO) being championed by (Leakey, 2017) is based on the participation of local people in the development of improved cultivars of IFFPs from their wild relatives using vegetative propagation methods. The participatory domestication method is quite useful in bringing immediate improvement to IFFPs of commercial value such as *Irvingia species, Dacryodes edulis,* etc. as it is capable of boosting incomes and trade by way of

improved yield and shorter gestation period. Farmers are quite interested in the domestication of species of commercial value and almost all IFFPs have the potential for commercialization.

Therefore with participatory domestication IFFPs can be mass propagated in Nigeria while at the same time conserving biodiversity and forests when properly organised working with local and indigenous communities especially those that are still agriculturally inclined. However where communities are inclined towards urbanizations and interest in agriculture is waning as is the case in Nigeria then IFFPs domestication will have to be packaged as a novel money spinning business to sell. To gain the interest of youths in IFFPs cultivation there must be the promise of good money generation. Therefore IFFPs domestication in Nigeria will have to take the route of *product development* where through research IFFPs are brought to a point where proceeds from them can equal that from the imported apple business, then they are introduced to the public through demonstration farm plots.

The difference between the two methods is that in the case of the participatory method pathway local's help to bear the cost of nursery maintenance and propagation while in the product development pathway the scientist works behind the scene and only comes to the public with the finished product. Therefore the type of society will determine the acceptance of the participatory domestication pathway and hence for a society like Nigeria where the population is geared towards urbanization and youths are apt to jump into anything that can generate quick money a different method will have to be adopted.

The Importance of Vegetative Propagation to IFFPs Domestication: Vegetative propagation methods are very important to the domestication of IFFPs in the tropics and has been used by several authors to capture elite genotypes of wild species (Asaah *et al.*, 2012; Leakey, 2017). Vegetative propagation is usually useful where propagation from seed is difficult or takes long as is the case of many IFFPs with recalcitrant seeds. Vegetative propagation is also used to capture promising or elite genotype for cultivar development which has been the case in the story of the domestication of IFFPs (Asaah *et al.*, 2012). This makes vegetative propagation very important to bring improvement to a cultivated species within a short period of time. For this reason vegetative propagation is being adopted in IFFPs domestication as the first step to improvement before proper breeding is done to further develop elite genotypes.

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Conclusion: IFFPs are going to increasingly become important in the coming years vis-à-vis the clamour for healthy eating and natural, growing populations and the need to diversify diets. There is therefore an urgent need to develop indigenous IFFPs by way of domestication and improvement. Traditional management systems can no longer meet the growing demand for IFFPs products and the way of development and commercialization is sure to set IFFPs on a pedestal to become a tool for poverty alleviation, wealth creation, rural empowerment and forest biodiversity conservation.

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