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Research article

Socioeconomic factors affecting households' use of indigenous forest management practices in managing non-wood forest products: evidence from forest communities in Nigeria derived savannah

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ABSTRACT

Although indigenous forest management practices have been used effectively by local people in the management and conservation of forest resources, these practices are eroding, causing negative consequences on the welfare of the people and their forests. To stem the erosion of the indigenous practices and instead stimulate, preserve, or improve their use, this study determines the socioeconomic factors that drive the household's use of the practices in the management and conservation of plant species of non-wood forest products (NWFPs). The study was carried out in Nigeria derived savannah. Data was collected from 200 randomly selected households in 10 randomly selected forest communities. Multivariate probit model was used to estimate the socioeconomic factors that influence the simultaneous use of indigenous forest management practices by households. Given multiple use of the practices, the result shows that the indigenous forest management practices used by the households are selective weeding (82.98%), controlled harvesting (82.45%), enrichment planting (75.53%), fire breaks (76.06%) and indigenous protective mechanism (45.74%). The majority (71.28%) of the respondents said they managed bush mango (*Irvingia gabonensis* and *wombulu*) using the practices, while the lowest proportion (21.28%) managed bush buck (*Gongronema latifolium*). The result of the multivariate probit model shows that virtually all the indigenous forest management practices are positively and significantly associated and are thus, complements. However, local protective mechanisms and controlled harvesting, local protective mechanisms and selective weeding, and local protective mechanisms and enrichment planting are not significantly associated. Farming occupation significantly increases the likelihood of simultaneous use of controlled harvesting, enrichment planting, and fire breaks as indigenous forest management practices in the management and conservation of NWFP. On the other hand, age significantly reduces the likelihood of the use of controlled harvesting and selective weeding. The study recommends the provision of support for young people who are more likely to be involved in the indigenous forest management practices; support to farmers who simultaneously use the practices, for example, through the provision of credit facilities; and a proper definition of user rights in community forests.

1. Introduction

Indigenous also referred to as traditional forest management practices are forest management practices, skills, know-how, innovations, among others, accumulated and handed down from generation to generation, and used by different cultural and ethnic groups to manage their resources that they depend on (Berkes et al., 2000; Camacho et al., 2015; Parrotta et al., 2016). Indigenous practices are practices that are unique to a given society. Indigenous people have effectively used these practices for natural resource management, especially forests product management, for many years (Boafo et al., 2016) and are necessary for sustainable use and conservation of biodiversity (United Nations 1992). Forests, in this case, include "all resources that can produce forest products, namely, woodland, scrubland, bush fallow and farm bush and trees on farms, as well as ecosystem dominated by trees" (Arnold, 1998). Indigenous forest management practices include some agroforestry

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systems (Warren and Pinkston, 1998); systems of controlled utilization or selective harvesting of trees, enrichment planting or purposeful propagation with domesticated or wild species, selective weeding, and the protection and maintenance of trees in sacred forests for ritual purposes (Wiersum, 1997; Forest Facts.Org, 2017). While indigenous forest management practices may not conform to the conventional model of scientific forestry, they have been used effectively by local people in managing forests and conserving forest resources for many years. They are used in both communally owned and family/individually owned forests. Indigenous people often modify and adjust these practices in such a way as to adapt to changes they observe in their forests (Alangui et al., 2013). The use of these indigenous management practices is strengthened through village social and economic structures, traditional political structures, and governance mechanisms.

Although local people employed these practices in forests and NWFPs management, they are now being eroded in Nigeria and other developing countries (Collings, 2009), causing negative consequences on the welfare of the people and their forests (Ouedraogo et al., 2014). The erosion of these practices may be due to a variety of reasons. Some of these are socioeconomic issues, for example, poverty, the rapidly increasing population, and the influx of migrants, increasing the demand for agriculture and forest products and putting a lot of pressure on forest resources (Camacho et al., 2015). Parrotta et al. (2016) argue that a small number of rural households are involved in traditional forest management practices since development programs focus more on promoting simplified and intensified agricultural production and other land and resource use. They aim to optimize the yield of a narrow range of crops and forest products to meet the demands of state actors and national or international markets.

The erosion of indigenous practices predisposes deforestation and loss of biodiversity, especially loss of non-wood forest products (NWFP). In fact, due to deforestation and forest degradation, there has been a sharp decline in the availability of NWFP in developing countries, and this is putting more pressure on the available ones and pushing forest-dependent people to travel long distances to collect them (Jalonen et al., 2018). The loss of forest resources equally limits their role in the sustenance of forest-dependent livelihoods. Udeagha et al. (2016) reported that 91.5% of forest users complained that an NWFP, *Irvingia* fruits and kernels, have decreased in abundance over the years, thus affecting their livelihoods. NWFPs are depleted at an unprecedented rate due to demand pressure from the rising human population and deforestation, especially as a result of land clearing for agriculture and forest degradation. The challenge imposed by deforestation and forest degradation is that it reduces the number of standing NWFPs trees and negatively impacts on the livelihood opportunities available to communities and households that depend on forests (Food and Agricultural Organization (FAO), 2016). Besides, weak management and conservation of forest resources, especially for NWFPs coupled with open access forestry and indiscriminate use of unsustainable and poor harvesting methods, have exacerbated the depletion of NWFP species (Muimba-Kankolongo et al., 2015; Sunderland and Ndoye, 2017). Many NWFPs are harvested using techniques (for example, uprooting or peeling off all the bark) that accelerate their depletion and impinge on their sustainability (Muimba-Kankolongo et al., 2015; Sunderland and Ndoye, 2017).

NWFPs referred to here are "goods of biological origin other than wood, derived from forests, other wooded lands, and trees outside forests" (FAO, 1999). Plant species of NWFPs are grouped into eight categories. These are "food; fodder; raw material for medicine and aromatic products; raw materials for colorants and dyes; raw materials for utensils, handicrafts and construction; ornamental plants; exudates and other plants products" (FAO, 2010). Given the evidence in the literature (Arnold et al., 1994; FAO, 1995; Sharma, 1995; Ambrose-Oji, 2003; Millennium Ecosystem Assessment (MEA), 2005; Ogbazghi and Bein, 2006; Ezebilo, 2010; Chukwuone and Okeke, 2012; FAO, 2015; and Forest Facts.Org, 2017; Jalonen et al., 2018; Nguyen et al., 2020) on the importance of NWFP in sustainable forest management, biodiversity conservation and livelihood sustenance, there is need to find ways to manage them sustainable in order to stem their depletion. This is also critical because forest management is becoming increasingly difficult due to persistent poverty, growing demand internationally for forest products, and climate change (Jalonen et al., 2018). Besides, research regarding NWFPs management, which had a boost in the nineties and early part of the millennium, received little attention in recent times, even as their depletion persists. Sustainable management and conservation of NWFP, although it can be achieved through cultivation (Chukwuone, 2009; Sunderland and Ndoye, 2017), can equally be achieved by building on and enhancing indigenous/indigenous management practices. As echoed by Mkapa (2004), the risk due to the failure of the development approach will be considerably reduced if government and development agencies understand and build on the indigenous knowledge and practices of the people and communities. Jalonen et al. (2018) argues that there is a need for a deeper understanding of indigenous knowledge and its use by the indigenous people to design effective forest management practices and formalize it in the rural communities.

Therefore, to manage and conserve NWFPs sustainably and equally stem the erosion and loss of indigenous knowledge and practices for forest management, it is important to understand the characteristics that drive their use among households in forest communities and thus evolve policy mechanisms to enhance their use. This is equally important since evidence has shown that science and technology cannot provide all the answers and solutions needed to deal with the loss of forest and forest resources (Mkapa 2004). In addition, some research has provided some indigenous practices used in forestry and natural resource management (Camacho et al., 2015; Parrotta et al., 2016). However, there is a paucity of research on socioeconomics drivers of indigenous forestry and natural resource management practices. This information is needed to guide policymakers and development practitioners on how to promote indigenous forest resource management, given the benefits of forest resources management by local people, as documented in Paudel (2018). This study, therefore, estimates the socioeconomic factors that influence the use of indigenous forest management practices by households in managing plant species of NWFPs.

The study focuses on Nigeria, particularly the derived savannah ecology. Nigeria is a typical case where the rate of forest loss is alarming, and forest management seems to be weak and slow in responding to forest and forest product depletion challenges. Although Nigeria has one thousand forest reserves recorded in the International Union for Conservation of Nature (IUCN) World Data Base on Protected Areas, most of these reserves have been degraded and deforested due to poor management (Usman and Adefalu, 2010). The condition has resulted in a contradiction ITTO (2006) described as "non-forested forest reserves." The IUCN Red List shows that the country has a total of 380 threatened species, of which plants are the highest, accounting for 211 (IUCN, 2019). Nigeria is equally one of the countries that had the most significant forest reduction between 2010 and 2015, with a loss of 410,000 ha (4.5% of 2010 forest area) (FAO, 2015). The derived savannah region which currently contains mainly scattered trees and grasses (although there exist some traces of forest in low-lying areas with surface water accumulation) was initially the less humid part of the high forest; however, this status was lost as a result of land clearing for agriculture, overgrazing, bush burning and hunting which happened over a long period (Federal Ministry of Environment, 2015). Also, different species of NWFPs, for example, medicinal plants such as Prunus (a cure for prostate cancer), are all being overharvested due to market demand. The condition has deteriorated to the point that even afang (*Gnetum* spp.), a vegetable delicacy used in many homes in Nigeria in soup making, are now imported from Cameroon (Chemonics International Inc 2008).

Considering the situation of forest depletion and NWFP loss and need to strengthen indigenous forest management practices, we pose the key questions: what are the indigenous forest management practices used by the people, and what is the regularity of use? What are the socioeconomic, forestry-related, and institutional factors that determine the

simultaneous use of different indigenous forest management practices in managing and conserving NWFPs in forests by households? The objective of this study is, therefore, to estimate the determinants of household's use of indigenous forest management practices in managing and conserving plant species of NWFPs in forests in some forest communities in Enugu State, a part of Nigerian derived savannah. Our contribution to literature is our focus on finding variables and strategies that could be exploited in designing effective policies to facilitate and encourage the use of indigenous forest management practices in forest and NWFP management and conservation. Currently, studies on determinants of indigenous/indigenous forest management practices are lacking. Recent studies focused mainly on estimating the determinants of households' participation in collective action as regards community-based forest management generally (Naik, 1997; Agarwal, 2009; Coulibaly-Lingani et al., 2011; Akamani and Hall, 2015) and NWFP cultivation (Chukwuone, 2009; N'Danikou et al., 2015), with none dwelling on the use of indigenous practices in NWFP management and conservation. We introduced some forest activity variables, for example, conflicts in the use of forest resources and perception regarding the increase or decrease in the availability of NWFP, which has not been used in previous studies from the perspective of determinants of indigenous forest management. Besides, the findings of the study will facilitate policy initiatives for strengthening the implementation of Community-Based Forest Resources Management, especially in developing countries. We focused on NWFP management in forests, which include ecosystems dominated by trees, farm bushes, and trees on farms (Arnold, 1998). The rest of the paper is organized as follows: section 2 dwells on the conceptual framework, section 3 is the methodology, section 4 presents the result, section 5 is on the discussion while section 6 concludes.

2. Conceptual framework

The concept of indigenous (local) knowledge is the basis for explaining the use of indigenous forest management practices in NTFP management and conservation. Indigenous knowledge is defined as knowledge accumulated by local or indigenous people over generations of dwelling in a given environment and renewed by each generation to guide their interaction with their environment (Rÿser, 2011; Nakashima et al., 2012; Karki and Adhikari, 2015). The concept of local or indigenous knowledge and its role in sustainable forest resource management and biodiversity conservation was clearly stated in article 8(j) of Convention on Biodiversity (CBD) (UN, 1992), and has been part of academic and policy discussions for some time (Nakashima and Roué, 2002). Easton (2004) identified three different ways of understanding the concept of Indigenous knowledge. The first approach considers it as an inheritance from the past. The second approach describes it as a representation of an alternative way of thinking, typical of African cultures. The third definition considers indigenous knowledge as a means to express what people know and create new knowledge from the intersection of their capacities and development challenges. Local people have applied this knowledge over the years to manage forests and sustain their livelihoods without infringing on the ecosystems ability to provide for future generations. Thus, Saway (2003) argues that the critical step towards the destruction of forests is by isolating indigenous and local people from the forests. Fadhilia et al. (2016) equally argue that conventional forestry management practices often undermine or compromise the livelihoods of indigenous people resulting in conflicting interaction between the people and their forests. Given the importance and advantages that can be gained from local or indigenous knowledge in forest management, there have been calls to strengthen local communities' involvement in the management of forests (Camacho et al., 2015; Parrotta et al., 2016).

Indigenous management practices reflect local indigenous knowledge of the people. Thus, as part of their livelihoods strategy (Reyes-García et al., 2008), and to optimize the benefits from forests, especially NTFPs, indigenous/local people carry out a variety forest management practices, and it is seen as a critical activity in community forestry (Pokharel, 2017). Some of the indigenous practices which can involve silvicultural and management or horticultural practices (Wiersum, 1997), include planting some species, fire protection, introduction of new species, mulching, pruning, removal of undesirable species, among others (Campbell et al., 1993; Lian and Kuwahara, 2007; Kosoe et al., 2015; Pokharel, 2017). The essential silvicultural components of the indigenous management system developed by Daret of Balai West Kalimantan Indonesia for the management of NTFPs include, selective weeding around durain (*Durio zibethinus*) and illipe nut (*Shorea* spp) tree during harvest season to facilitate the location and collection of fruits; enrichment planting with rattan palm, medicinal plants, fruit trees, and bamboo, and with wood species that are transplanted; occasional selective, low density harvesting of wood species (Reis, 1995). Camacho et al. (2015) described traditional practices for forest stand management by the “Ifugaos” to include weeding, selective cutting, fencing, planting of species, among others. Wiersum (1997) generally grouped indigenous management practices to comprise controlled utilization, forest stand maintenance and protection and deliberate propagation of either domesticated or wild species.

Although scanty, some previous studies indicated conditions necessary to stimulate, preserve, or improve indigenous forest management practices. Wiersum (1997) observed that local people would be less likely to be interested in forest protection and tree planting if forest resources are in abundance but would limit indigenous management practices to defining user rights. However, indigenous management practices may be focused on biologically-oriented practices if forest resources become scarce (Gilmour, 1990). Indigenous practices may occur not only based on common property regime, for example, community forestry but also in private forestry where there are private user rights over the forest resources (Fortmann and Nihra, 1992).

The difference between common property and private forest management regimes may not be apparent due to local arrangements for the use of resources (Wiersum, 1997Wiersum, 1997). However, evidence shows that the more people are closely connected to the benefits from resources, for example, in a private property, the less pervasive the attitude of free-riding (Ostrom and Hess, 2008). Furthermore, gender and age were significantly associated with traditional knowledge regarding the use of palm in regions in northwestern South America, with men having more knowledge than men while knowledge increased with age (Paniagua-Zambrana et al., 2014). Although the finding shows that indigenous knowledge increases with age, there is no explicit agreement regarding the influence of age on the practice of harvesting of forest products. While Mamo et al. (2007) and Coulibaly-Lingani et al. (2009) found that young people collect forest products more than older people, Hong and Saizen (2019) found that older people collect more forest products than younger people.

Regarding participation in forest management, Oli and Treue (2015) found that gender and household size significantly influenced participation with male-headed households participating more than female-headed households while large households participated more. Das (2000) found out that conservation activities in common property resources are weak in a labor-constrained setting. Invariably, households with large size in which labor is available and not constrained will be involved in labor demanding practices, such as selective weeding. Generally, participation in forest management activities depends largely on the socioeconomic attributes of the people in forest communities, physical and environmental factors (Ranjit, 2016). Overall, forest conditions and the size of landholding positively and significantly influenced participation in forest management and protection. In contrast, gross income from community forestry and distance between residence and community forestry negatively and significantly influenced participation in forest management and protection (Ranjit, 2016).

3. Methodology

3.1. Study area

The study was carried out in Enugu State of Nigeria. The State was selected purposively because of some reasons. Firstly, the State is the derived savanna ecosystem where the original forest cover is now degraded and needs to be managed sustainably. Secondly, Enugu State was among the states that "introduced forest management committees involving the indigenous communities in the management of forest reserves" (Chukwuone, 2009), although this was not sustained. Currently, the State is facilitating community-based forest management to support the indigenous community in managing their forest resources to facilitate poverty reduction and sustainable development and to get involved in the Reducing Emissions Deforestation and Degradation (REDD+) activities in Nigeria. In this regard, the State Forestry Commission selected 20 communities with forest resources, on a pilot scheme, after consultation with the communities. Besides, NWFPs are traded widely in the State so that even hawkers trade them along major roads, an indication of the role of NWFPs in livelihoods sustenance in the area (Chukwuone and Okeke, 2012).

Enugu State is situated between Latitudes 5° 55′N and 7° 06′N and Longitudes 6° 54′E and 7° 52′E (Figure 1). Its mean daily temperature lies between 27 °C and 28 °C. The rainy season (April–October) and dry season (November–March) are the two main climatic seasons in the State. Agricultural activities especially crop farming, is practiced predominantly in the State. Some of the crops grown in the State, not in order of importance, are cassava, yam, taro, grain legumes, maize, vegetables, sweet potatoes, oil palm, pawpaw, banana, and plantain (The Editors of Encyclopedia Britannica, 1998). Income from the sale of forest products and indigenous economic tree crops, such as breadfruit (*ukwa* in the Igbo language), oil beans, kola nut, oil palm, cashew, coconut, and mangoes, among others, serve as a source of supplement to farm income.

3.2. Sampling procedure and sample size

A multistage random sampling procedure was applied in the selection of respondents. Firstly, 10 communities were randomly selected from among the list of communities with forest resources. The list was compiled with the help of Enugu State Forestry Commission. In the second stage, households were randomly selected from the list obtained from the forest communities with the help of community leaders and staff of Enugu State Forestry Commission. The total number of households in the communities with forest resources varied from 150 to 250 households. To have a manageable and representative sample, 20 households were randomly selected from the list of households in each of the communities. Thus, a sample size of 200 households was used for the study.

3.3. Data collection

The survey method of data collection was applied using a semi-structured interview questionnaire. Trained field officers of the Enugu State forestry commission served as enumerators during data collection. The interview questionnaire was subjected to a pilot test before the actual data collection. The pilot test was carried out in two communities from among the 20 forest communities noted earlier. A total of 40 households, 20 from each of the two communities, were sampled and interviewed during the pilot test. These two communities are not part of the 10 communities used for the main study. The pilot test aimed to ensure that ambiguous questions were corrected and that the enumerators became familiar with the questions and how to elicit information from the respondents. An open-ended question was also included in the questionnaire used for the pilot test to find out the different indigenous plant NWFP management practices used by the households. Based on this and information from key informants, a list was provided in the actual survey questionnaire for the respondents to indicate the ones they practiced and the regularity of practice. The key indigenous practices performed by the

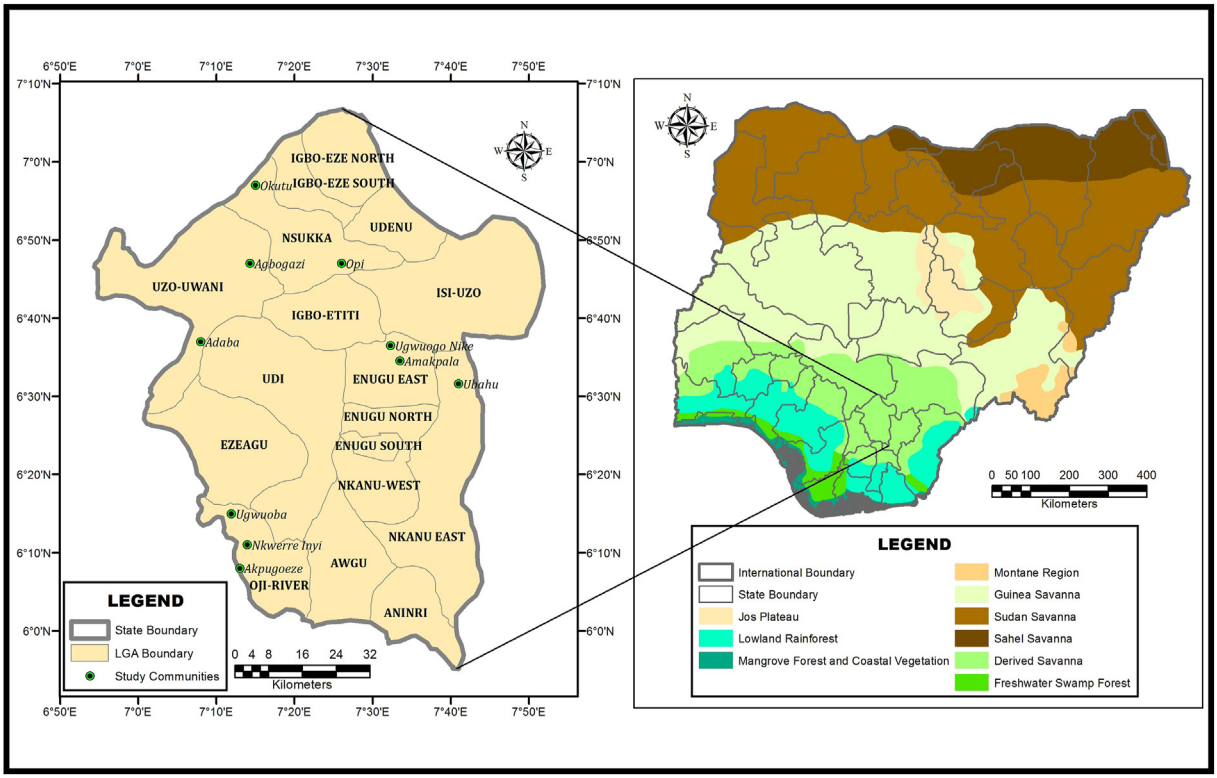

Figure 1. Map of Nigeria showing the ecological zones, Enugu State in the derivedsavannah zone, and the study communities in the State. Source: produced by the authors.

households for management of plant NWFP which we identified in the pilot test are as follows: weeding around valued species, enrichment planting/cultivation, controlled harvesting, use of indigenous protective mechanisms (placing objects ascribed to deities for protection), and fire break. In the actual survey, we interviewed the household head or his/her representative. Also, the respondents were provided a list of non-wood forest products found in the State to indicate the major ones that they focus on when using the different indigenous practices. Data for the study (Chukwuone, 2018) was fully collected from 188 households, and these were used for the data analysis.

3.4. Econometric approach and model specification

The study applied a multivariate probit model (Cappellari and Jenkins, 2003) to estimate the factors that influence the simultaneous adoption of indigenous forest management practices included in the questionnaire. We applied this model because our data shows that households in forest communities adopted and applied multiple indigenous practices simultaneously in the management and conservation of NWFP, implying that the decision is a multivariate one. Thus, estimating and independent model will lead to loss of information regarding interrelations and simultaneous adoption decisions of the households (Dorfman, 1996), while the estimates will be biased and inconsistent (Greene, 2008). In the multivariate probit model, the correlation coefficient between two indigenous practices may be positive, suggesting that the two approaches complement each other, or it may be negative, indicating that they are substitutes. The general form of the multivariate probit model is given as follows:

$$Y_{ij} = X_{ij}^{'}\beta_j + \varepsilon_{ij} \quad (1)$$

where Y_{ij} $(j = 1 - - -n)$ is the indigenous forest management practices for NWFP management and conservation, n representing the number of indigenous forest management practices; $X_{ij}^{'}$ represents the vector of observed explanatory variables; β_j represents the vector of unknown parameters, which will be estimated; while ε_{ij} represents the unobserved error term. The assumption is that the error term across the indigenous forest management practices $(j = 1 - - -n)$ is multivariate normally distributed with mean vector equal to zero. We estimated the unknown parameters in Eq. (1) using simulated maximum likelihood (SML). We evaluated the multivariate normal distribution functions using Geweke–Hajivassiliou–Keane (GHK) smooth recursive conditioning simulator (Cappellari and Jenkins, 2003). Five indigenous forest management practices indicated by the households as strategies used in the management and conservation of NWFP were considered. The practices are controlled harvesting, enrichment planting, selective weeding, fire breaks, and use of indigenous protective mechanisms. Thus, Y is equal to 1 if a household applies any of the indigenous forest management practices, 0 otherwise.

The empirical model for estimating the determinants of indigenous forest management practices is specified as follows:

Table 1. Definition, means, standard deviation and percentages of variables applied in the analysis.

Explanatory Variables	Definition and Means of Measurement	Mean	Standard Deviation	Percentage (%)
Household/Individual Characteristics				
Total number of years spent in school	Number of years	6.84	4.45	
Gender male (female otherwise)	Dummy variable- takes the value of 1 if male; 0 if female	0.76	0.43	75.53
Household size	Measured in number of persons	5.80	2.99	
Occupation farming	Dummy variable- takes the value of 1 if farming; 0 if non-farming	0.76	0.43	75.53
Age of household head	Age measured in years	51.55	15.55	
Credit access	Dummy variable- 1 if respondent has credit access; 0 if not	0.33	0.47	32.98
Forestry Based explanatory Variables				
Distance to Forest (km)	Measured in kilometers	4.92	4.68	
Change and increasing	Dummy variable – takes the value of 1 if respondents indicates increasing change in availability of NWFP; 0 if not	0.29	0.46	29.26
Change and decreasing	Dummy variable – takes the value of 1 if respondents indicate decreasing change in availability of NWFP; 0 if not	0.45	0.50	44.68
Existence of rules and regulations for forest use	Dummy variable-takes the value of 1 if rules and regulation exist for forest use in the community; 0 if not	0.36	0.48	35.64
Experienced Conflict	Dummy variable- takes the value of 1 if household experienced conflict in forest use; 0 if not	0.31	0.47	31.38
Main source of NWFP- community forests	Dummy variable- takes the value of 1 if community forest is the source of NWFP; 0 if the government-owned forest	0.38	0.49	37.77
Main source of NWFP – individual/family-owned forest	Dummy variable- takes the value of 1 if individual/family-owned forest is the source of NWFP; 0 if the government-owned forest	0.36	0.48	36.17
Access to forests	Dummy variable-takes the value of 1 if the respondent has access to forest; 0 if not	0.86	0.35	86.17

Source: Computed from field survey data.

$$LFMP_{ij} = \beta_1 + \beta_2 total\_number\_years\_school_i + \beta_3 farming\_occupation_i + \beta_4 credit\_access_i + \beta_5 age_i + \beta_6 gender_i + \beta_7 distance\_forest_i + \beta_8 change\_increasing_i + \beta_9 change\_decreasing_i + \beta_{10} rules\_regulation_i + \beta_{11} bush\_fire\_complete_i + \beta_{12} bush\_fire\_partial_i + \beta_{13} experienced\_conflict_i + \beta_{14} source\_nwfp\_commu\_forest_i + \beta_{15} source\_nwfp\_indiv\_family\_forest_i + \beta_{16} access\_forest_i \quad (2)$$

3.5. Variables used in the model

The definition and description of the variables we used in the analysis are presented in Table 1.

We tested for multi-collinearity of the independent variables by checking the variance inflation factor (VIF), which showed the non-existence of multi-collinearity as the VIF of each of the variables was less than ten (10). Greene (2008) noted that a variable is taken as being collinear if VIF exceeds 10. To capture the determinants of use of indigenous forest management practices for the management of plant NWFP, we categorized the variables used into household/individual characteristics and forestry indicator variables. The household/individual characteristics variables are the age of the household head measured in years, the total number of years spent in school by the household head, gender, and number of males in the household. Gender was captured with a dummy variable which takes the value of one (1) if male and zero (0) if female. The average number of years spent in school by the respondents was seven years, while the average number of household members was six (6). The majority (75.53%) of the respondents are males, while 75.53% of them are farmers.

Also, we included access to credit variable in the model. We expect that households that have access to credit are less likely to use indigenous forest management practices in managing NWFP. We captured access to forests and NTFP using the distance to forests, which were measured in kilometers (km). We expect a negative relationship between distance and use of a given number of indigenous forest management practices. Households would likely manage resources near, which they are sure of using, more than those far away. We included the existence of rules and regulations for forest use in a community as a dummy variable (1 if rules exist and zero otherwise) to capture the effect of indigenous institutions on the extent to which households use indigenous/indigenous management practices for the management of plant species of NWFP. Indigenous institutions and rules play much role in forest and natural resource management; in fact, Ite (2003) argues that indigenous institutions and indigenous/indigenous practices complement each other. We expect that the variable would have a positive effect on the use of indigenous management practices for NWFP management.

We equally included a variable to capture environmental change, in this case, change in the availability of plant NWFP resources. The respondents were asked to indicate if the resources were increasing or decreasing in availability based on their experience. This variable was considered a proxy of environmental resource scarcity or abundance. Thus, two dummy variables, increasing change and decreasing change, were included in the model. We expect that the households to use indigenous practices when they perceive that NWFP is scarce or when there is a decrease in the availability of plant NWFP resources. For example, Cooke (2000) finds that collection time by households increases as environmental resource scarcity measures increase. The highest proportion (44.68%) of the respondents indicated that there was a change in the availability of NWFP, and it was decreasing.

Also, we included a variable to capture conflict over NWFP resources within the communities and its effect on indigenous management practices. This is because of the increasing number of conflicts within communities everywhere over resource use (Sunderland and Ndoye, 2017). This variable was included as a dummy, which takes the value of one (1) if the household indicated that it experienced conflict, zero (0) otherwise. We expect the variable to have a positive effect on the use of indigenous practices as those who have experienced conflict would want to protect what they have. We also included the primary source of NWFP, whether community forest or individually/family-owned forest, as a variable. Respondents were asked to indicate the main source of NWFP, whether community, individual/family, or government-owned forests. We expect that those whom their main source of NWFP is community forest will use the practice because of community regulation while we expect those that their main source is individual/family-owned forests to use the practices because it is more of a private property.

3. Results

3.1. Plant species of non-wood forest products (NWFP) managed by households

From the list provided, the respondents were asked to indicate the major plant species of NWFPs that they focus on when using the different forest management practices. The result is presented in Table 2.

The findings reveal that the respondents apply their indigenous forest management practices in managing different varieties of NWFP. The majority (71.28%) of the respondents said they managed bush mango (*Irvingia gabonensis* and *wombulu*), while the lowest proportion (21.28%) managed bush buck (*Gongronema latifolium)*.

3.2. Use of different indigenous forest management practices for NWFP management and conservation and the regularity of use

The results regarding the use of different indigenous forest management practices for the management and conservation of NWFP and the regularity of use is presented in Table 3.

Table 2. Plant species of NWFP managed by households.

S/No	Common name	Indigenous Name*	Botanical Name	Frequency**	Percentage of respondents
1	Bitter Kola	Akuilu	*Garcina kola*	62	32.98
2	Oil palm	Nkwu	*Eleis guinensis*	84	44.68
3	Bread fruit	Ukwa	*Treculia africana*	130	69.15
4	Kola nut	Oji	*Cola nitida*	95	50.53
5	Bush mango	Ogbono/Ugiri	*Irvingia gabonensis* and *wombulu*	134	71.28
6	Wild spinach	Okazi	*Gnetum africanum*	127	67.55
7	Bush buck	Utazi	*Gongronema latifolium*	40	21.28
8	False cubeb leaves	Uziza	*Piper guineense*	50	26.60
9	Oil bean	Ukpaka/Ugba	*Pentaclatra macrophyla*	87	46.28
10	African mesquite	Okpei/okpeye	*Prosopis Africana*	56	29.79

Source: Computed from field survey data.
*The indigenous names are in the Igbo language; **Multiple responses were observed.

Table 3. Distribution of the respondents based on a percentage of those using different indigenous management and conservation practices and regularity of use.

S/No	Indigenous Forest Management Practices for NTFP	Percentage of Respondents Using it*	Regularity of Practice		
			Often	Occasionally	Rarely
1	Controlled harvesting	82.45	27.30	60.70	12.00
2	Enrichment Planting	75.53	28.40	62.30	9.30
3	Selective weeding	82.98	34.00	60.10	5.90
4	Fire Breaks	76.06	28.20	45.40	26.40
5	Indigenous Protection	45.74	28.30	44.80	26.90

Source: Computed from field survey data; * Multiple responses observed.

Table 4. Covariance of the error term and likelihood ratio test.

Correlation pair	Coefficient	Standard error
Selective weeding and controlled harvesting	0.761***	0.157
Enrichment planting and controlled harvesting	0.705***	0.119
Local protective mechanism and controlled harvesting	0.011	0.177
Fire break and controlled harvesting	0.679***	0.167
Enrichment planting and selective weeding	0.839***	0.079
Local protective mechanism and selective weeding	0.087	0.142
Fire break and selective weeding	0.517***	0.135
Local protective mechanism and enrichment planting	0.077	0.129
Fire break and enrichment planting	0.583***	0.115
Fire break and local protective mechanism	0.570***	0.107

Note: ** and *** indicates significance at $p < 0.05$ and $p < 0.01$, respectively.

Table 5. Parameter estimates of the multivariate probit model of determinants of use of indigenous and forest management practices in NWFP management.

Explanatory Variable	Controlled Harvesting Coefficients	Selective Weeding	Enrichment planting	Indigenous protective mechanism	Fire Break
Household/Individual Characteristics					
Total number of years spent in school	0.018 (0.035)	0.007 (0.032)	-0.002 (0.029)	-0.083*** (0.278)	0.008 (0.029)
Household Size	0.017 (0.049)	0.083** (0.041)	-0.003 (0.041)	0.030 (0.035)	-0.028 (0.036)
Farming occupation	1.293*** (0.376)	0.481 (0.301)	0.529** (0.262)	0.016 (0.249)	0.522** (0.259)
Credit access	0.384 (0.313)	0.380 (0.288)	0.481* (0.259)	-0.073 (0.241)	-0.408* (0.227)
Age of household head	-0.038*** (0.011)	-0.022*** (0.009)	-0.008 (0.008)	0.010 (0.008)	0.011 (0.008)
Gender	-0.273 (0.391)	-0.127 (0.311)	0.225 (0.280)	0.218 (0.258)	0.169 (0.275)
Forestry based explanatory variables					
Distance to Forest (km)	0.009 (0.032)	-0.002 (0.028)	0.024 (0.027)	-0.007 (0.024)	-0.031 (0.023)
Change and increasing	-1.023*** (0.366)	-0.333 (0.324)	-0.046 (0.290)	0.128 (0.287)	0.157 (0.293)
Change and decreasing	0.523 (0.377)	0.083 (0.330)	0.362 (0.289)	0.508* (0.268)	0.954*** (0.280)
Existence of rules and regulations for forest use	-0.302 (0.311)	0.002 (0.277)	-0.336 (0.241)	0.163 (0.231)	0.302 (0.251)
Experienced Conflict	-0.263 (0.342)	-0.015 (0.283)	0.203 (0.265)	0.276 (0.245)	0.184 (0.247)
Main source of NWFP- community forests	-0.586* (0.345)	-0.195 (0.306)	-0.464 (0.288)	0.441 (0.281)	0.304 (0.260)
Main source of NWFP – individual/family owned forest	0.903** (0.431)	0.389 (0.331)	0.264 (0.310)	1.105*** (0.287)	0.146 (0.276)
Access to forest	-0.251 (0.392)	-0.276 (0.353)	-0.687** (0.345)	-0.128 (0.310)	0.125 (0.306)
Constant	2.684*** (0.927)	1.485* (0.790)	0.966 (0.771)	-1.245* (0.692)	-1.327* (0.785)
Number of observations	186				
Wald chi2 (70)	137.94				
Prob > chi2	0.000				
Log-likelihood	-374–098				

Source: Computations from 2016 field survey data.
Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0.
chi2(10) = 113. 613 Prob > chi2 = 0.0000; ***, **, and * indicate variables that are significant at 1%, 5% and 10% levels of probability. Values in parenthesis are standard errors.

The result shows that the proportion of respondents using different indigenous forest management practices varied from the lowest (45.74%) for those who practiced indigenous protection to highest (82.98%) for selective weeding. Selective weeding could be an essential practice for managing leafy NWFP like *Gnetum africanum*.

Our findings on the regularity of use of the indigenous forest management practices revealed that the respondents occasionally use the practices. For example, the majority (62.30%, 60.70%, and 60.10%) respectively used enrichment planting/cultivation, controlled harvesting, and selective weeding occasionally.

3.3. Determinants of use of indigenous forest management practices in NWFP management and conservation

We first present the correlation coefficients of pair-wise correlation across the residuals of the multivariate probit model of the five-selection equations in Table 4. The result shows that there is a significant association between the residuals of the indigenous forest management practices in NWFP management and conservation. This finding indicates that the error terms of the selection decision equations are correlated; thus, justifying the use of multivariate probit instead of the univariate probit model. The result shows explicitly that the indigenous forest management practices, namely, selective weeding and controlled harvesting, are positively and significantly associated. This finding suggests that the indigenous forest management practices complement each other. Thus, as the households in forest communities use selective weeding, they also apply controlled harvesting in NWFP management and conservation. The findings show that all the other indigenous forest management practices are positively and significantly associated except local protective mechanism and controlled harvesting, local protective mechanism and selective weeding, and local protective mechanism and enrichment planting that are not associated. This finding suggests that indigenous/local protective mechanism is not significantly associated with controlled harvesting, selective weeding, and enrichment planting.

We then present the result of the multivariate probit analysis in Table 5. The result shows that the multivariate probit model was useful in explaining the effect of the independent variables on the decision of the household in forest communities to use the indigenous forest management practices in NWFP management as the Wald chi2 is significant at 1% level ($p < 0.01$). Also, the loglikelihood ratio test was significant at 1% level ($p < 0.01$). This finding suggests that the equations in the model are not independent and that the estimated coefficients are responsible for unobserved correlation among the indigenous forest management practices. The result equally shows that keeping all other things constant, the households are more likely to use controlled harvesting and selective weeding but are less likely to use indigenous protective mechanism and fire breaks in NWFP management.

As regards the influence of the explanatory variables on the use of the indigenous forest management practices, the result shows that some variables significantly influenced the likelihood of simultaneous use or adoption of the indigenous forest management practices. From Table 5, the result shows that farming occupation significantly increases the likelihood of use of controlled harvesting, enrichment planting, and use of fire breaks as indigenous forest management practices in the management and conservation of NWFP. Also, individually owned forest as the main source of NWFP significantly increases the likelihood of simultaneous use of controlled harvesting and indigenous protective mechanisms in the management and conservation of NWFP. Likewise, a decrease in the availability of NWFP significantly increases the likelihood of simultaneous use of indigenous protective mechanism and fire breaks in the management and conservation of NWFP. On the other hand, age significantly reduces the likelihood of simultaneous use of controlled harvesting and selective weeding as indigenous forest management practices in the management and conservation of NWFP. The result also shows that household size is positively and significantly associated with the use of selective weeding while the number of years spent in school is negatively and significantly associated with the use of indigenous protective mechanisms. Moreover, we find that credit access influences the likelihood of simultaneous adoption or use of indigenous forest management practices. While it significantly increases the use of enrichment planting, access to credit reduces the use of fire breaks.

4. Discussion

The finding that bush mango and wild spinach, are the main target of the respondents when applying the indigenous practices, is not surprising as Osemeobor and Ujor (1999) found that the products are among the most important NWFP species in Nigeria. For example, Chukwuone and Okeke (2012) equally found that wild spinach (*Gnetum africanum*), and bush mango (*Irvingia gabonensis* and *wombulu*) appeared mostly (26.4% and 22.8% times respectively) in meals of households in a 7- day period in the savannah and rain forest regions of Nigeria thus, reflecting the importance of these products to livelihood sustenance in the region. Bread fruit is a major delicacy in most ceremonies in communities in the derived savannah region. Also, *Prosopis Africana* fruit is a popular seasoning product used by the people. The product which is currently being processed and packaged is now very popular as a food seasoning commodity. Kola nut is also popularly used in "Igbo" language-speaking areas of the derived savannah ecology in traditional ceremonies and for welcoming guests to a household (Obineche, 2017).

In addition, controlled harvesting, enrichment planting, selective weeding, and the use of fire breaks are among the indigenous forest management practices used by the respondents in forest management for NWFPs. These practices have been used by indigenous people in some developing countries in the management of forests. Reis (1995) indicated that selective weeding and enrichment plating are among the indigenous essential silvicultural components of the Ilha das Oncas, State of Pará, Brazil, for the management of forests for NWFPs. Fire breaks are also used as part of community-based fire management (CBFiM). CBFiM has been recommended as a sustainable and adaptive mechanism for fire management especially for prevention and is an emerging practice in Africa and Southeast Asia (FAO, 2007). Fire breaks are also an indigenous practice used in fire pre-suppression in Ghana (Kosoe et al., 2015). Although these practices are among the indigenous forest management practices used by the respondents in the management of forest for NWFPs, their occasional use suggests that these practices are waning. This supports the argument by Parotta et al. (2016) that fewer households are involved in traditional forest management practices, and that plant species of NWFPs may not be effectively managed, resulting in loss of the species. It equally corroborates the observed decrease in the availability of the resources, as indicated by most of the respondents. Thus, it stresses the need to find out factors that could support the use of these practices by households in forest communities.

Furthermore, the fact that farming occupation positively and significantly influences the likelihood of simultaneous use of controlled harvesting, enrichment planting, and use of fire breaks in the management and conservation of NWFP is not surprising as farming is inextricably linked to forestry activity. Farmers often engage in these practices in their farms and will practice them in managing forests for NWFPs, especially if they harvest the products. Chukwuone (2009) found that farming occupation was a significant determinant of cultivation of NWFP, while Nguyen et al. (2020) found that forestry production experience was a significant factor in the planting of NWFP. Our finding suggests the need to support farmers and increase efforts to prevent bush/forest fires in order to ensure NWFP management.

An interesting finding is the fact that individual owned forests being the main source of NWFP increases the likelihood of simultaneous use of controlled harvesting and the use of indigenous protective mechanisms as indigenous forest management practices of NWFP. This finding shows that people will better control the harvest and protect forests resources in a privately or individually-owned forest than that of community forest, which is a common property. This follows Ostrom and Hess (2008)

opinion that free-riding will be less pervasive in the management of private property than a common property. This suggests that strengthening the ownership rights in forestry, even in a common property regime, will support controlled harvesting and protection of NTFP and other forest resources, thus guaranteeing sustainable management and conservation. The importance of secure property right in indigenous forest management is corroborated by our result, which equally shows that community-owned forest being the major source of NWFP significantly decreases the likelihood of use of controlled harvesting.

Our study also shows that a decrease in NWFP availability significantly increases the likelihood of simultaneous use of indigenous protective mechanism and fire breaks in the management and conservation of NWFP. This finding is in line with the observation of Wiersum (1997) that local people would be less interested in forest protection if forest resources are in abundance but will be more interested in protection as resources become scarce. Also, previous evidence shows that the concern about forest degradation and loss affects the attitude of stakeholders regarding forest management (Ansong and Røskaft, 2011). We also found that an increase in the availability of NWFP significantly decreases the likelihood of controlled harvesting. This finding supports the observation of Gilmour (1990) that indigenous forest management practices for NWFP would less likely be focused on biologically-oriented practices, for example, controlled harvesting when resources are in abundance.

Furthermore, our finding shows that age significantly reduces the likelihood of simultaneous use of controlled harvesting and selective weeding as indigenous forest management practices in NWFP management and conservation, suggesting that elderly people are less likely to use controlled harvesting and selective weeding simultaneously. This finding is not in line with the fact that indigenous knowledge increases with age (Paniagua-Zambrana et al., 2014) and that indigenous management practices are a reflection of indigenous knowledge. However, although older people are the repository of indigenous knowledge, our findings suggest that older people, who are no longer in their active working age, may not have the strength and energy to practice controlled harvesting and selective weeding simultaneously. This assertion is supported by Mamo et al. (2007) and Coulibaly-Lingani et al. (2009), finding that young people collect forest products more than older people.

In addition, our study shows that household size is positively and significantly associated with selective weeding. The positive and significant effect could be that large households, given unconstrained labor, have more labor to carry out selective weeding, which could be labor demanding. Das (2000) observed that conservation activities in common property resource is weak in labor constrained setting. The finding also suggests that large households, as indicated by Hong and Saizen (2019), are involved in indigenous forest management practices for NTFP management and conservation because of their need for forest products to ensure their livelihoods. Also, the finding that the number of years spent in school is negatively and significantly associated with the use of indigenous protective mechanisms suggests that educated people who are pragmatic in their thinking will not rely on the efficacy of indigenous protective mechanisms for forest protection.

Moreover, the fact that credit access increases the use of enrichment planting but reduces the use of fire breaks simultaneously is interesting. The finding suggests that those with access to credit will instead invest in enrichment planting, which will lead to the accumulation of forest resources, especially NWFP, rather than use their credit in practicing fire breaks, although an activity that will help in forest protection.

5. Conclusions

Given the enormous loss of plant NWFPs, especially in developing countries, and coupled with the erosion of indigenous forest management practices that can be used to manage them sustainably, there is a need to find ways to stimulate, preserve, or improve indigenous management practices. This study, therefore, estimated the determinants of use of indigenous forest management practices by households in the management of NWFPs in forests in the derived savannah ecology of Nigeria. We focused on NWFP management in ecosystems dominated by trees, farm bushes, and trees on farms. Data collected from 200 randomly selected households in ten randomly selected forest communities in Nigeria derived savannah was used for the study.

The result shows that some indigenous practices (controlled harvesting, selective weeding, enrichment planting, use of indigenous protective mechanisms, and fire breaks) are applied in the management of some NWFPs. The proportion of respondents using different indigenous forest management practices for management of NWFPs varied from the lowest (45.74%) for those who practiced indigenous protection to highest (82.98%) for selective weeding. However, we found out that the practices are carried out occasionally. The majority (71.28%) of the respondents said they managed bush mango (*Irvingia gabonensis* and *wombulu*) using the practices, while the lowest proportion (21.28%) managed bush buck (*Gongronema latifolium*). .

The result further shows that the indigenous forest management practices, such as selective weeding and controlled harvesting, are positively and significantly associated, thus suggesting that the indigenous forest management practices complement each other. However, indigenous/local protective mechanism is not significantly associated with controlled harvesting, selective weeding, and enrichment planting. The result equally shows that some variables significantly influenced the likelihood of simultaneous use or adoption of some indigenous forest management practices in the management and conservation of NWFP. The result shows explicitly that farming occupation significantly increases the likelihood of use of controlled harvesting, enrichment planting, and use of fire breaks as indigenous forest management practices in the management and conservation of NWFP. Also, individually owned forest as the main source of NWFP significantly increases the likelihood of using controlled harvesting and indigenous protective mechanisms in the management and conservation of NWFP. Likewise, a decrease in the availability of NWFP significantly increases the likelihood of simultaneous use of indigenous protective mechanism and fire breaks as indigenous forest management practices in the management and conservation of NWFP. Based on the findings, the study recommends the provision of support to young people who are more likely to be involved in the indigenous forest management practices and support to farmers who simultaneously use the practices, for example, through the provision of credit facilities. Also, a proper definition of user rights in community forests, for example, a well-defined common property resource management with some characteristics of private property, could facilitate the use of indigenous forest management practices. Interventions to stimulate, preserve, or improve indigenous management practices by the government should consider individually owned forests or community forests with depleted resources. They should also consider large households with younger heads of households who are likely to be more involved in indigenous forest management practices for the management and conservation of NWFP.

Declarations

Author contribution statement

Nnaemeka Andegbe Chukwuone: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Kehinde Paul Adeosun: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Chiamaka Adaobi Chukwuone: Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

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