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Access to common resources and food security: Evidence from National Surveys in Nigeria

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Abstract
Common resources (CRs) provide a "hidden harvest" for rural households and can also act as a safety net in the event of poor agricultural output or seasonal food gaps, hence contributing to food security. Yet only limited empirical research has assessed the relationship between CRs and the self-assessed food security conditions recorded among rural households. This exploratory paper draws on recent data from the Nigerian General Household Survey (GHS), a nationally representative sample of households administered in 2012–2013 as part of the World Bank Living Standards Measurement Study — Integrated Surveys on Agriculture (LSMS-ISA). A sustainable livelihood framework was used to contextualise CR access within the broader set of food security drivers. In Nigeria, access to common pasture and water resources is significantly associated with less reporting of food insecurity. In contrast, access to common forest tends to be associated with food insecurity, suggesting that households with access to common forest remain vulnerable (i.e. isolated from services and opportunities) despite having the advantage of the forest as a source of food. Echoing existing literature, the relative importance of these commons decreases when income of households increases. However, there are no clear signs that access to commons acts as a seasonal safety net for households during the lean season. The paper advocates streamlining CR data collection alongside agricultural data for a more integrated food security policy intervention aimed at the most vulnerable.

Keywords Common resources · Wild foods · Food security · Hidden harvest · LSMS-Isa · Nigeria

1 Introduction

Food insecurity remains a reality for 795 million people, despite the fact that the proportion of the global population that is undernourished has fallen from 23% to 13% over the past 25 years (FAO et al. 2015). In sub-Sahara Africa (SSA), the proportion of the population that is undernourished decreased from 33% to 23% over the same period, although the absolute number of undernourished individuals increased by 25%, to 220 million. Moreover, 2 billion individuals worldwide still suffer deficiencies of iron or other micronutrient (vitamins, minerals, etc.), highlighting the importance not only of food quantity but also of quality, and the need for it to be nutritious and healthy (WHO 2012; Kloos and Renaud 2014).

The main direct response to the food and nutrition challenges is that of agriculture and rural development (ARD) support. The focus of intervention is raising productivity of agriculture in SSA, where it is recorded to be lower than in the rest of the world, with particular emphasis on staple crops (Pinstrup-Andersen 2013).

However, food insecurity persists not only because of lack of food or the food production gap, but also because of lack of access and entitlement to food (Sen 1981), conflict, lack of job opportunities, and lack of access to social services or land (FAO et al. 2014; Food Security Information Network 2017). It is also the result of unsustainable natural resource use, on which the rural poor are directly dependent for their livelihood (Cavendish 2000; Kamanga et al. 2009). Sustainably responding to the food and nutrition security challenge therefore entails going beyond improving agriculture performance to considering how to integrate the wider landscape and its wild resources into food security policy.

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Although historically overlooked as the "hidden harvest" by agricultural extension and international aid (Scoones et al. 1992), wild and mainly common resources have been demonstrated to be an important source of income in rural areas (Vedeld et al. 2007; Kabubo-Mariara 2013; Thondhlana and Muchapondwa 2014) and a key asset to the very poor, particularly in SSA (Cavendish 2000; Kamanga et al. 2009). Moreover, agricultural systems displaying a diversity of crop and land uses are more resilient to extreme events, this being an advantage in the context of climate change. Access to forested landscapes and associated wild foods have been identified as a safety net in the event of poor agricultural output or seasonal food gaps (Angelsen and Wunder 2003; Arnold 2008; Cotter and Tirado 2008) (in Sunderland et al. 2013). The safety net function when facing shocks is complex, being dependent on the type of shock, and probably evolving alongside the increased availability of alternatives to households through development (Wunder et al. 2014b).

In the same vein, and although landlessness is not as acute as in other developing regions of the world, fragmentation of private assets makes access to common land vital to many rural households in SSA (Alden Wily 2008).

Forested landscapes, tree cover and tree-based agricultural systems contribute to food security both directly (as agriculture does, through food and fodder) and indirectly through various ecosystem services (Sunderland et al. 2013). Some ecosystems directly benefit agricultural productivity, although evidence is ambiguous in this respect and depends on the woody vegetation/crop combination and context (Bayala et al. 2014; Sinare and Gordon 2015). These sources of food provide dietary diversity and supply key micronutrients, although their contribution to calorie intake is limited (Powell et al. 2015). Although tree cover is not directly linked to tenure or access rights (i.e. land being common or otherwise), it is notable that Ickowitz et al. (2014) identified a significant non-linear positive relationship between tree cover and the vegetable (and fruit) consumption of about 93,000 children in 21 African countries surveyed between 2003 and 2011.[1] Even if wild foods fail to meet the minimum recommended intake of fruit and vegetables, such contributions may be critical when agricultural production falls short of meeting global per capita needs (Siegel et al. 2014 in Rowland et al. 2016). A similar contribution to diets for people close to forests is made by bush meat, which may account for one fifth to three fifths of the national average protein intake, sometimes meeting the minimum intake requirements of the most dependent households (Rowland et al. 2016). Most of the evidence is related to forested landscapes, although non-forested (e.g. pasture) wild or fallow agricultural land has shown similar effects, even in the contexts of defaunation of large game species, as small game species are increasingly managed and hunted in and around agricultural land (Sunderland et al. 2013). This is also the case for wild plants and fruits that grow on cropland (Scoones et al. 1992).

Finally, the support from goods and services provided by forested and non-forested landscapes to agricultural production systems also needs to be acknowledged (Sunderland et al. 2013). The contribution of forested areas and trees to the long-term productivity of agriculture in the face of global changes remains a key area of research, as additional evidence is needed to find "landscapes and land use systems that deliver biodiversity, ecosystem services and productivity functions at the same time" (Sunderland et al. 2013, p4).

The direct livelihood role of common natural resources has benefited from in-depth case studies and subsequent reviews of these, but seldom from large dataset analysis. Exceptions are the Poverty and Environment Network (PEN) dataset of the Center for International Forestry Research (CIFOR) (Wunder et al. 2014a; Rowland et al. 2016) and the USAID standardised Demographic and Health Surveys (Ickowitz et al. 2014; Johnson et al. 2013). The role of the hidden harvest has been demonstrated. However, as lamented by Wunder et al. (2014a), such a role remains mostly absent from population-representative household surveys, limiting our understanding of livelihoods and consequent food and nutrition security policy implications.

The recent drive to improve agricultural statistics, embodied in the World Bank's Living Standards Measurement Study — Integrated Surveys on Agriculture (LSMS-ISA) programme in eight countries in SSA,[2] offers some avenues to explore the resources on which the hidden harvest is based, as it records the existence of and access to common natural resources. One of the most suitable datasets available is that of Nigeria. First, Nigeria is a uniquely diverse and endowed country extending over three different agro-ecological zones (AEZs), from semiarid in the north to humid in the south. It also provides households and agricultural surveys with large samples, which are representatively based on a national census. Finally, the sampling procedure used in these surveys avoids the bias inherent in more specific case studies on wild resources (i.e. PEN-based analyses which focus on communities related to forests; see Wunder et al. (2014b) and Rowland et al. 2016).

Nigeria experienced important, if unequally distributed, GDP growth over the 2003–2013 period, averaging 6.4%

[1] The study was based on USAID standardised Demographic and Health Surveys. It focused on children between the age of 12 and 60 months. Data were gathered at various periods of the year, with this being controlled for in the model. Peak consumption was reached at about 53% of tree cover. The analysis does not provide direct causal relationships, nor does it indicate whether access to food is via forest or agroforestry agriculture, identify the type of trees/forest involved, or account for the effect of forest cover on agricultural output through ecosystem services.

[2] Burkina Faso, Ethiopia, Malawi, Mali, Niger, Nigeria, Tanzania and Uganda. Two of the countries provided information on access to common resources: Malawi and Nigeria.

(McKinsey Global Institute 2014), and, as of the last available estimates, 33% of its population live below an adjusted purchasing power parity poverty line of US$1.4/day (World Bank 2014). It has fared better than its regional neighbours, with a reduction in the proportion of people living below the poverty line[2]. However, the absolute number of people below this poverty line has remained constant, and Nigeria still faces important food security challenges, even more so given that its growth trajectory has weakened and the country is expected to fall into recession (IMF 2016). Nigerians have traditionally exploited wild resources for food (Harris and Mohammed 2003) and other uses (i.e. medicines) (Adebooye and Opabode 2004; Soewu and Ayodele 2009; Soewu and Adekanola 2011). The concerns raised about the sustainability of wild resource use also indicate their importance. Initially such concerns related to fauna (Anadu et al. 1988), but increasingly they relate also to flora (Chukwuone 2009). Furthermore, the conversion of whole ecosystems, such as wetlands, to alternative uses, leading to their loss, points to the level of dependence of populations on such wild resources (Schuyt 2005). As identified in other contexts, it has been documented that wild foods also serve as a safety net by providing "famine foods" (Davies et al. 2012). Certain types of wild food were designated "famine foods" during the great Sahel Drought (1972–1974) in northern Nigeria (Mortimore 1989). Lockett et al. (2000) showed that, among the edible wild plants used by northern herders, those available during the wet season were nutritionally inferior to dry-season plants, which played a more important role in food security. Although not constituting a response to poverty in themselves, such wild resources contribute to resilience, but also depend on the maintenance of and access to their resource base (forests, pastures) and fallow land (Davies et al. 2012).

Accordingly, and with nationwide evidence from Nigeria, this paper explores the following three questions: (i) Is there an association between the recorded food security indicators of households and access to (mostly) locally managed common resources? (ii) Do the most vulnerable households rely more on common resources for their food security than less vulnerable households; and (iii) Does access to wild resource acts as a safety net in general, and specifically during lean seasons?

The approach adopted in this paper provides a broad picture of the connections between given food security indicators and access to (locally) managed common resources, revisiting with a relevant type of data (LSMS-ISA) the existing body of in-depth case studies. Specific limitations to our approach are discussed in the conclusions, particularly in relation to the use of available standard population-representative household surveys.

Ultimately, this paper aims at shedding light on the potential complementarities between conventional intervention in favour of food and nutrition security (i.e. development of agriculture) and other strategies linked to hidden harvest. The association of these can strengthen the achievement of food and nutrition security.

2 Methods

2.1 Data

The data source is the Nigerian General Household Survey (GHS), a survey of a nationally representative sample of households conducted by the Nigerian Bureau of Statistics (NBS 2013) as part of LSMS-ISA. This dataset gathers about 5000 households identified from a larger GHS of 22,000 households. As the survey is representatively based on a national census, its sampling procedure avoids the general bias associated with more specific case studies on wild resources (i.e. PEN-based analyses which focus on communities related to forests, such as those of Wunder et al. (2014b) and Rowland et al. (2016). The sample of households was surveyed in 2012 and 2013. Both post-planting (lean season) and post-harvest data were collected over the period, in two waves.[3] This paper focuses on data from about 3300 households following data preparation and the exclusion of households for which information about access to four common resources, namely pasture, forest, water and arable land, is lacking. Given the centrality of this information, no specific strategy, such as imputation, was deployed to retain more households in the sample. The sample includes both rural (70%) and urban households. To establish a connection between access to common resources (CRs) and food security, a second source was required. This was a community questionnaire, administered in parallel to community leaders to collect information on various socioeconomic indicators of the enumeration areas (EAs, i.e. areas of reference for the national census used as a base for the LSMS-ISA sampling) in which the sample households reside. It is important to highlight that the community questionnaire does not collect information from communities in the sociological sense (NBS 2013). The data cannot be used to represent communities in Nigeria. However, the data collected at the community level represent information that is common to the households selected for inclusion in the selected EAs.

Accordingly, the household data were merged with a selected set of characteristics from the relevant area derived from the community questionnaire. This was based on

[3] The original datasets can be request here: http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:23635560~pagePK:64168445~piPK:64168309~theSitePK:3358997,00.html

information on the existence and status of CRs for water, grazing land, arable land and forest/bush, gathered in surveys of leaders of representative communities from the EAs to which households belonged.

2.2 Empirical model and variables

This exploratory analysis focuses on the drivers expected to provide a given household with food security, or to push it into insecurity. The analysis translates into a sustainable livelihood approach that "comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Chambers and Conway 1991; DFID 2001). A more concrete use of this approach as an aid policy tool was initially fostered through the Sustainable Livelihoods Approach (SLA), supported by the United Kingdom (UK) Department for International Development (DFID) (De Haan 2012; Morse and McNamara 2013). The SLA views livelihoods as systems and focuses on the following four elements: (i) the assets of people; (ii) the strategies developed; (iii) the context of the livelihood; and (iv) specific factors contributing to the vulnerability or resilience of livelihood to shocks (IRP 2010). The approach has been extensively used to analyse poverty in general (De Haan 2012; Morse and McNamara 2013), including household food poverty in Nigeria. Oni and Fashogbon (2013) analysed factors of food insecurity with a sustainable livelihood approach, using 2004 and 2009 data from the Nigerian Living Standard Survey (Oni 2014), which is akin to the LSMS-ISA, and accounting for very broad agro-ecological variation. However, they did not integrate natural assets or contextual variables, such as distance to key markets or services.

The integration of assets offers a suitable framework to analyse the potential contribution to food security made by access to locally managed natural CRs, away from narrower concepts of income and consumption.

To adapt the SLA to food and nutrition security as a subset of livelihood, key characteristics and assets of households and their environment, including geographical proximity to commercial opportunities (i.e. distance to markets), were gathered from the LSMS-ISA database. A multinomial logit (mlogit) analysis was used to examine the effects of the characteristics of households and their environment on the likelihood of reporting food insecurity during the post-planting and post-harvesting seasons, during both seasons, or never, controlling for the clustering of standard errors (i.e. by EA) and related post-estimation commands in Stata 14. The probability of households reporting food insecurity according to the four possibilities can be written as follows:

$$P_i = Prob\left(y = i|X = \frac{\exp(X\beta_i)}{1 + \sum_{k=1}^{m}\exp(X\beta_k)}\right. \quad (1)$$

where $i = 1, \ldots, 4$ represents one of the types of food (in)security situation reported by a household.

$$\sum_1^4 P_i = 1 \quad (2)$$

X is a vector of explanatory variables (i.e. characteristics of households, their assets and environment, and access to CRs), β is a vector of parameters associated with the explanatory variables and k is the baseline (i.e. never reporting food insecurity).

The probability of reporting one type of food insecurity (in either the post-harvest or the post-planting seasons, or in both seasons) is considered in comparison with the probability of reporting the base outcome. This probability can be expressed as:

$$P_i = Prob\left(y = m + 1|X = \frac{1}{1 + \sum_{k=1}^{m}\exp(X\beta_k)}\right. \quad (3)$$

The basic interpretation of the multinomial logit results looks at the variables that influence the probability of reporting food insecurity with reference to never reporting it. To generalise the interpretation of the results, marginal effects of changes in the explanatory variables were estimated using the *margins* command.

The model was first developed by including all potential listed variables of interest from the general framework, as well as references for Nigeria (Oni and Fashogbon 2013; Oni 2014) and the role of wild resources as income source and safety nets (Angelsen et al. 2014; Wunder et al. 2014b). The final model structure was determined through a stepwise process of backward elimination of non-significant ($P > 0.05$) variables and tests on model specification (Bayesian information criterion (BIC) and Akaike information criterion (AIC) fit tests).

The variables used to perform the analysis are presented in detail in section 3.1 Descriptive statistics are discussed below.

Our dependent variables are a selection of indicators of food (in)security.

The food security indicators used here are derived from self-assessment measures of food security (SAFS). This approach is flexible and reduces the cost of information (e.g. implying more recurrent data collection over time). However, critiques highlight the subjective nature of SAFS, and the fact that they are potentially subject to framing effects (Headey and Ecker 2013) and more generally to strategic responses. They show a weak but consistent correlation with alternative indicators (Headey and Ecker 2013). Food security involves not only availability but also access to and utilisation of food within a stable context (Sen 1981; World Food

Summit 1996), and no single indicator can capture its reality and evolution (Pinstrup-Andersen 2009; Leroy et al. 2015). Moreover, various approaches demonstrate the different dimensions of food security (Headey and Ecker 2013; Maxwell et al. 2014; Leroy et al. 2015).

The first indicator selected for this analysis captured whether or not the household was unable to feed itself at some point in the year previous to the survey (i.e. *in the past 12 months, have you been faced with a situation when you did not have enough food to feed the household?*). A second set of indicators collected related to food insecurity events during the 7-day period prior to each survey. We retained two variables of food insecurity: (i) whether or not households reported that they had ever been completely without food (for at least 1 day) and (ii) whether or not members of the household ever had to go to sleep hungry.

Various indicators of food (in)security were collected by the survey and are tested here. In a recent comparative assessment of various indicators in Ethiopia, Maxwell et al. (2014) showed that SAFS were more likely than alternative measures to classify households as food insecure. Moreover, these indicators tend to depict more persistent food insecurity, even when others may hint at a move towards food security. More detailed dietary components of the database were not considered in this exploratory analysis.

Such measures are approximations and prone to measurement errors (i.e. recalling) in the context of household surveys of this type. That said, and accounting for the more general issues with this type of subjective indicator in economic analyses, indicators recording concrete events such as "going to sleep hungry" reduce the associated bias (Headey and Ecker 2013) but limit measurements to a very extreme type of food insecurity, and in this sense are not sufficient. At the study level, the strategy of gathering both post-planting and post-harvest season data partly controls for the bias introduced by the subjective nature of these food and nutrition security indicators.

The independent variables gather characteristics of households and their assets, including user rights (i.e. access to CRs). Being a right, access to CRs is a livelihood asset for a household. Households from different communities are compared, and one characteristic of a given household is that of having or not having that right. As such, access to CRs is a household characteristic. This approach implies that, although we can assess that a household with access to certain CRs (i.e. pasture) is less likely to systematically record food insecurity, we cannot infer that a community as a whole is more food secure, as this should be based on different type of data.

The resources potentially contributing to food security are broadly identified as commonly managed, with rules of access and use independently determined by the community itself (to be distinguished from a national park or other resource managed by the state at national or regional level). These include forest land, pasture land, arable land and water resources. At this stage it is important to highlight that, although distinctions are drawn between these base resources, wild foods and services span a continuum (Wiersum 2004; Cronkleton et al. 2013) from forest and pasture to fallow land and active cropland. Another concrete sign of such continuity is the transplantation by farmers of wild species from their field boundaries to their own land (Harris and Mohammed 2003). Access to common arable land is of limited value as an explanatory variable given that most arable land under cultivation is under common rights anyway. Arable land is allocated to only a few landowners (3.2% of the sample), reducing the discriminatory value of this variable and suggesting that it has limited explanatory potential.

Data on CRs indicate whether or not communities have access to and locally manage a given CR within the EA. It is important to highlight that merging the existing datasets results in inefficiencies. A perfect match is not possible given the required preservation of household confidentiality. Households cannot be specifically located except within a radius of 0–5 km (for 1% of the population this range can reach 10 km). As structures of local management are not limited to a single village and can be under the jurisdiction of several villages under a council of elders, as described by Osemeobo (1991), the match is assumed to be consistent with an analysis of this type.

Access to some or all of these resources by households is expected to reduce the likelihood of reporting food insecurity, as all potentially contribute to the agricultural harvest (land, water and pasture) but also to the "hidden harvest" (pasture, forest, water and fallow land). That said, the literature shows that such a relationship is not linear, and depends on household characteristics and context, as well as on the nature of contingencies and shocks (Cavendish 2000; Angelsen et al. 2014; Wunder et al. 2014b).

Variation in the characteristics of households is controlled for by including variables for age, gender and education level of the head of the household, as well as their size (i.e. total number of individuals in the household, whether adults, children or the elderly) and dependents ratio. Regarding gender, environmental resources are expected to be more important for women in general, and in particular for female-headed households, which tend to be marginalised in terms of agricultural land tenure but also with respect to off-farm opportunities (Pouliot and Treue 2013). Reviews of the gendered extraction of forest products point to a dominance of women's involvement, particularly in the case of flora in Africa (Sunderland et al. 2014). However, this is not always the case (Pouliot and Treue 2013).

Household total income is captured through the proxy of aggregate consumption, assuming that not much is left for savings. Dummy variables indicating whether or not the household head is primarily involved in agriculture, and whether or not the head is also active in an off-farm activity, were tested. The relation between agriculture as a primary activity *per se* and food security is ambiguous, but involvement in secondary off-farm activities is expected to be positively associated with food security. For reference, the household food expenditure ratio is reported, including both purchased food and the value equivalent of self-consumption. Higher income (i.e. consumption) is associated with a reduced likelihood of food insecurity, as it is linked to lower food expenditure ratios.

The household property variable captures whether or not a household owns its dwelling and whether or not it owns part or all of its farming plots. Independently of tenure, the variable farm size per capita (the total area of all recorded farm plots divided by the number of individuals in the household) is used to integrate the basic endowment of the household, accounting for its size. More liquid assets are embodied by livestock and smaller animals. Better endowed households are expected to be less vulnerable to food insecurity. Liquid assets are expected to be used to smooth consumption when needed.

Various (negative) shocks to households were recorded during the interviews, ranging from loss of the main income earner (death, change in the composition of the household) to events with implications for whole communities. Such occurrences are likely to negatively influence food security. To capture the effect of such shocks and their interaction with access to CRs, they were divided into idiosyncratic shocks (affecting individual households or a small proportion of households only, such as labour supply) and covariate shocks (potentially affecting all households, such as drought, input and output price fluctuations, etc.). The expected direction of these relationships follows that of Wunder et al. (2014b), who, in their comprehensive review, found that alternative strategies were more important than increasing environmental harvesting. The same review reported that only 10% of households used wild resources as their main shock response, with most of those resources harvested from the forest. In addition, environmental harvesting is expected to increase more significantly when covariate shocks occur, as such harvesting requires additional labour, seldom available to single households faced with idiosyncratic shocks. In turn, households have a wider range of options for dealing with idiosyncratic shocks (e.g. seeking outside help) than they do when faced with covariate shocks. Responses to shocks vary, with increased environmental extraction tending to be favoured by asset-poor households, while extraction of more valuable resources may be limited to better-off members of the community because it requires access to capital (Wunder et al. 2014b). The related concept of gap-filling resource extraction on a seasonal basis is not well supported by the evidence gathered by Wunder et al. (2014b), who found that income from extraction from the wild is positively related to crop and general income. Although Angelsen et al. (2014) clearly show that wild products are a key addition to income, the seasonal safety net role is less clear and should probably be seen as an option of last resort (Wunder et al. 2014b).

Market access is captured by proxy as distance to the nearest market in kilometres, with the expectation that the closer the market, the less likely a household is to face food insecurity. However, this is a limited way of conceptualising market access, and the various ways of translating it into a measurable variable have shown empirical ambiguity of the effects on welfare (Chamberlin and Jayne 2013). The limitation of a single variable for market access is linked to the fact that access is defined not only by distance but also by its variation through time (e.g. seasonality), infrastructural and non-infrastructural components of access, impact of new information and communication technologies (i.e. mobile phones), liberalisation of trade, and characteristics of marketing chains (Chamberlin and Jayne 2013). To explore some of these effects, interaction variables with the agro-ecological zones (distance to market X AEZ dummy variable) were also introduced to identify regionally differentiated effects of distance to market on food insecurity.

Access to credit, both formal and informal, is accounted for. However, it is difficult to distinguish households that choose not to use credit from those that wish to do so but are unable. A third credit-related variable is also used, capturing rejections of credit request, which should prove a better indicator. Governmental social aid is also included, and is expected to reduce the likelihood of insecurity. However, its targeting could prove ambiguous as it is supposed to be directed at the most vulnerable.

Basic environmental indicators were needed to control for the level of abundance of given resources. Precipitation and temperature indicators as well as other more comprehensive indicators were available, such as AEZ classes and key GLOBCOVER landscapes (Arino et al. 2012). For simplicity, dummy variables identifying households living in the semiarid (Sahelian) and subhumid zonea of Nigeria were used, derived from the available AEZ classification.

3 Results

3.1 Descriptive statistics

The proportion of households that experienced difficulties in feeding themselves, based on their recall of the last 7 days or the last 12 months, was 11.5% and 33.5%, respectively. As expected, households are more likely to run into difficulties during the post-planting season (identified as the “lean” period) than after harvest. However, about 40% of the food-insecure sample remained in difficulties even during the post-harvest period (Table 1).

Table 1 Descriptive statistics of food insecurity indicators (dependent variables), according to season

	Household without food, last 12 months		Household empty of food, last 7 days		Household members went to sleep hungry	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
"Never" food insecure (in both waves of the survey)	2195	66.47	2925	88.58	2971	89.98
Post-harvest only	235	7.12	92	2.79	81	2.45
Post-planting only	418	12.66	148	4.48	152	4.6
"Always" food insecure (in both waves of the survey)	454	13.75	137	4.15	98	2.97

NBS (2013) Merged datasets from Households and Community questionnaires (both seasons, 2012 2013). General Household Survey-Panel (GHS-Panel) conducted in 2012/13 by the Nigeria National Bureau of Statistics (NBS) in collaboration with the World Bank Living Standard Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA)

Access to common resources is widespread, yet the majority of households are recorded as having no such access. The available data suggest that 40% of households surveyed have access to one or more common resources under local management, of which one third have access to only one type of resource. However, fewer than 10% have access to all four types of resources (pasture, forest, water and land) as commons (Table 2).

Household composition varies: the average size is 5.9 individuals. Some 84% of households have a male head, and the average age of household heads is 52-years. The average education level of household heads is close to 6 years, but only 20% completed primary education, and 46% dropped out before completion.

Annual household expenditure per capita (as a proxy of income per capita) ranges from NGN7,150 to NGN4,639,410 (EUR32 to EUR 211,109),[4] with an average of NGN112,156 (approximately EUR515) and standard deviation of NGN98,762. In turn, the average food expenditure ratio, that is the proportion of income spent on food, reached 73.8%. This confirms the validity of using total consumption as a proxy for income in this context. The majority (55.5%) of household heads had agriculture as their main activity, and about 20% had a complementary off-farm job.

Although most of the households own their dwelling, they are rarely land owners. In the countryside, a household holds (at least with user rights, as private arable land property is the exception rather than the norm) 0.7 ha on average, which equates to 0.13 ha of available land per capita.

The survey registered a series of shocks affecting households. Idiosyncratic shocks affected 30% and 20% were affected by covariate shocks, along with the rest of their communities.

Formal access to credit is granted to only 5% of the sample. In contrast, access to informal services reaches at least 10% among the heads of households surveyed. However, 13% of the individuals reported being refused credit when requested. Governmental social aid directly reaches only 2.8% of the surveyed heads of households.

The households surveyed live an average of 66.45 km from a market centre and the most common climate zone is a warm subhumid zone akin to the Guinean savannah (55% of households), followed by warm semiarid or Sahelian savannah (30% of households). Most of the remaining households are located in the southern and more humid part of the country, comprising savannah and humid forest (Table 3).

The distribution of households indicates that about 50% of households live in landscapes dominated by agricultural areas (Categories 1–3) (Arino et al. 2012). The remainder live in areas that are dominated by other types of landscape, including grasslands and forests, which do not preclude agriculture or livestock, but are not dominated by them (details are available in Table 6 in the appendix).

3.2 Estimations and interpretation

3.2.1 Livelihood model: Interpretation

The inclusive approach, which tests a number of potential drivers of food insecurity in order to contextualise the potential contribution of access to common resources, has a downside. Several variables used include missing values, so that the total number of households analysed is reduced from 3302 to 3203 (Table 4) for the final analysis. Marginal effects were estimated on the 3203 sample size. Following estimation with all variables, fit tests (BIC and AIC) were performed to identify more parsimonious specifications (models with all variables are available in Table 8 in the appendix). The final models are presented in Table 4. With multinomial logit specification, coefficients need to be interpreted relative to a base outcome. Here, the base outcome is "never reporting food insecurity". Therefore, a significant coefficient with a negative sign indicates that such a variable reduces the likelihood of reporting "unable to feed household" in a given season (in either the post-

[4] Exchange rate: NGN1 = EUR0.00455 (31 December 2013).

Table 2 Estimated access to common resources of households

Resource	Code: forest, land, pasture, water	Freq.	Percent	Cum.
No commons	0 0 0 0	1957	59.27	59.27
Water only	0 0 0 1	123	3.73	62.99
Pasture only	0 0 1 0	29	0.88	63.87
Pasture and water	0 0 1 1	37	1.12	64.99
Land only	0 1 0 0	272	8.24	73.23
Land and water	0 1 0 1	45	1.36	74.59
Land and pasture	0 1 1 0	56	1.7	76.29
Land, pasture and water	0 1 1 1	20	0.61	76.89
Forest only	1 0 0 0	39	1.18	78.07
Forest and water	1 0 0 1	116	3.51	81.59
Forest and pasture	1 0 1 0	20	0.61	82.19
Forest and land	1 1 0 0	109	3.3	85.49
Forest, Land and water	1 1 0 1	89	2.7	88.19
Forest, Land and pasture	1 1 1 0	112	3.39	91.58
All resources	1 1 1 1	278	8.42	100
	Total	3302	100	

NBS (2013) Merged datasets from Households and Community questionnaires (EA level) and Households from each EA (both seasons, 2012–2013). NBS (2014) Merged datasets from Households and Community questionnaires (both seasons, 2012 2013). General Household Survey-Panel (GHS-Panel) conducted in 2012/13 by the Nigeria National Bureau of Statistics (NBS) in collaboration with the World Bank Living Standard Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA)

planting or the post-harvest seasons, or in both seasons) relative to never doing so (e.g. total expenditure).

3.2.2 Model results: Common resources

Having access to common resources is significantly related to the selected food security indicators, particularly when these are systematically reported during both seasons. Households' likelihood of reporting food insecurity is reduced, and this is significant for access to both pasture and water CRs. At the same time, being associated with access to common forests exacerbates the likelihood of reporting food insecurity throughout all seasons.

Access rights to pasture land significantly reduce the likelihood of reporting events of extreme (all season) food insecurity, compared with not reporting any event. The effect captured by the model increases as food security reporting goes from only one season to all seasons with respect to never reporting, pointing to the importance of access to common pasture for the more vulnerable. The marginal effects of access to pasture are more important to the poorest households (Table 5). For example, the probability of reporting food insecurity in both seasons (7-day recall) is reduced by 5.8% if there is access to pasture for the poorest, decreasing to 3.14% at average income and 1.73% for the wealthiest. Access to pasture is also significant in reducing the probabilities of households reporting food insecurity during one or the other season (7-day recall). A first connection between access to pasture land and food security is that of sustaining livestock, known for its storage value properties. The model, however, controls for the value of animals owned by households, as these could be sold to smooth consumption (significant in reducing the likelihood of households having to record food consumption adaptation). However, the direct food security value of pasture land could also lie elsewhere, as a key contributor to the "hidden harvest". Average non-forest environmental income reaches only 5% in the PEN world review (Angelsen et al. 2014), but this non-forest source is considered to be critical (Cavendish 2000) and tends to have a substantial subsistence focus, more closely related to questions of food security than total income. Moreover, non-forest sources as a proportion of all income can reach 30–35%, as demonstrated for Ghana and Burkina Faso in rural West Africa (Pouliot and Treue 2013). Many "famine foods" (Davies et al. 2012; Mortimore 1989) are found in pasture and on the edges of farms.

Table 3 Definition and summary statistics of independent variables

Variable	Obs.	Mean	Std.Dev.	Min.	Max.	Exp. Sign
Common resources access**						
Arable land	3302	0.297093	0.457047	0	1	−/+
Pasture	3302	0.167171	0.373185	0	1	–
Forest	3302	0.231072	0.421582	0	1	–
Water	3302	0.214416	0.410478	0	1	–
Household characteristics						
Age of head of household	3302	52.32314	15.20983	18	110	+
Education level of head of household (simplified to higher level of qualification)	3206	5.951341	5.447363	0	15***	–
Gender of head of household (male = 1)	3302	0.840703	0.366009	0	1	–
Size of household	3302	5.958207	3.181676	1	31	−/+
Dependents ratio	3302	0.561612	0.255193	0	1	+
Income and consumption levels						
Total expenditure of household (Nairas)	3302	538,714	417,035.1	14,300.39	6,247,191	–
Total expenditure of household per capita (Nairas)	3302	112,156.4	98,762.36	7150.196	2,082,397	–
Food expenditure ratio (%)	3302	0.742809	0.134444	0.075283	0.974411	+
Agriculture is the man activity of head	2922	0.556126	0.496925	0	1	−/+
Besides agriculture, the head has an off-farm job	2941	0.201632	0.401287	0	1	–
Endowment of households						
Partial of total ownership of arable land	3302	0.033919	0.181048	0	1	–
Ownership of dwelling	3299	0.721734	0.448213	0	1	–
Total farm size of households (m^2)	3302	5399.448	11,685.26	0	238,258.6	–
Total farm size of rural households/capita (m^2)	3302	1003.683	2413.954	0	39,880.7	–
Total estimate value of livestock and small animals (Nairas)	3302	136.8941	577.9342	0	10,067	–
Shocks						
Covariate shocks	3302	0.192005	0.393937	0	1	+
Idiosyncratic shocks	3303	1.306481	1.461102	1	2	+
Markets and social aid access						
Distance to nearest market (km)	3302	66.47156	42.50824	0.28	195.34	−/+
Distance to nearest market (km^2)	3302	6224.872	6692.568	0.0784	38,157.71	−/+
Access to formal credit	3207	0.044278	0.205745	0	1	–
Access to informal credit	3207	0.107265	0.309499	0	1	−/+
Credit request was rejected	3207	0.125974	0.331872	0	1	+
Beneficiary of government social subsidy	3302	0.02877	0.167186	0	1	−/+
Environmental context****						
Sahelian households	3302	0.299515	0.458115	0	1	−/+

*Data for each season data (lean and post-harvest) is presented in Appendices

**combinations of access to resources are presented in Table 2

***simplified to 15 years or more

****Agro-ecological zones and characteristic landscapes summary statistics are provided for reference in Appendices

NBS (2013) Household surveys, (both seasons, 2012–2013). NBS (2014) Merged datasets from Households and Community questionnaires (both seasons, 2012 2013). General Household Survey-Panel (GHS-Panel) conducted in 2012/13 by the Nigeria National Bureau of Statistics (NBS) in collaboration with the World Bank Living Standard Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA)

Finally, the existing continuity between various resource bases, from forest to pasture and agricultural land, is expected to be at play in this case (Wiersum 2004; Cronkleton et al. 2013).

Access to commonly managed water resources emerges as a positive asset regarding food security. Although the pathway of the connection is not direct, it most probably operates through agriculture, but not

Table 4 Estimates of the multinomial logit models, food security related indicators recorded during both waves at household level (HH)

	12 months previous to survey			7 days previous to survey					
	Unable to feed household			Faced with no food at home			Gone to sleep hungry		
Variable	Post-harvest	Lean	All seasons	Post-harvest	Lean	All seasons	Post-harvest	Lean	All seasons
Water	−0.336	0.0813	−0.950***	−0.304	−0.207	−2.286***	−0.114	−0.18	−2.061***
	(−1.36)	−0.45	(−3.46)	(−0.65)	(−0.49)	(−4.23)	(−0.19)	(−0.43)	(−4.22)
Pasture	−0.579*	−0.436	−0.824**	−1.571**	−0.957*	−1.958**	−0.803	−0.932	−2.873**
	(−2.14)	(−1.58)	(−2.93)	(−3.11)	(−2.38)	(−2.98)	(−1.52)	(−1.83)	(−2.79)
Forest	0.567*	−0.121	0.821**	1.116*	0.562	2.345***	0.63	0.39	2.068***
	−2.5	(−0.55)	−3.12	−2.33	−1.3	−5.96	−0.97	−0.89	−6.07
Age of head of household	−0.000602	−0.00852*	0.00989*	0.00992	0.00263	0.00611	0.0114	−0.00106	0.00814
	(−0.10)	(−2.00)	−2.05	−1.29	−0.36	−0.83	−1.15	(−0.15)	−0.96
Education level of head of household	−0.0203	0.000471	−0.0216	−0.01	−0.00106	−0.047	0.0369	−0.0096	−0.0329
	(−1.05)	−0.04	(−1.49)	(−0.39)	(−0.05)	(−1.57)	−1.28	(−0.46)	(−0.94)
Gender of head of HH household	−0.151	−0.478**	−0.29	−0.0211	−0.575**	−0.252	−0.246	−0.284	−0.00738
	(−0.62)	(−2.85)	(−1.77)	(−0.06)	(−2.75)	(−0.97)	(−0.65)	(−1.11)	(−0.03)
Size of household	0.120**	0.0990**	0.0665	0.0229	0.0233	−0.0177	0.218**	−0.0268 0.0133	
	−2.73	−2.67	−1.75	−0.3	−0.34	(−0.23)	−3	(−0.37)	−0.19
Dependents ratio	0.445	0.187	−0.44	−0.855	−0.034	−0.21	0.264	−0.48	−1.098
	−0.91	−0.48	(−1.37)	(−1.39)	(−0.07)	(−0.35)	−0.39	(−0.85)	(−1.82)
Dependents ratio (x) Size of household	−0.123	−0.113	0.0389	0.115	−0.0555	0.0394	−0.308*	0.119	0.0378
	(−1.49)	(−1.50)	−0.57	−0.83	(−0.52)	−0.25	(−2.05)	−0.96	−0.25
Total expenditure of household (1)	−0.000825	−0.000402**	−0.00121***	−0.00209***	−0.000489	−0.00197**	−0.00209***	−0.00108**	−0.00281***
	(−1.92)	(−2.61)	(−3.59)	(−3.85)	(−1.15)	(−3.13)	(−3.43)	(−2.60)	(−3.97)
Ownership of dwelling	−0.369*	−0.147	−0.564***	−0.656*	0.0502	−1.071***	−0.735**	0.152	−1.238***
	(−2.10)	(−1.00)	(−3.43)	(−2.55)	−0.24	(−4.09)	(−2.73)	−0.71	(−4.00)
Value of livestock and small animals (1)	−0.000277	−0.000316	−0.0000823	−0.00246	−0.000489	−0.00502	(.)	(.)	(.)
	(−1.18)	(−1.81)	(−0.35)	(−1.66)	(−0.67)	(−1.88)	(.)	(.)	(.)
Distance to (nearest) market (km)	−0.0129*	0.0117	−0.00668	−0.0171	0.0074	−0.00827	−0.0105	0.00563	−0.00139
	(−1.97)	−1.84	(−1.32)	(−1.71)	−1.39	(−1.01)	(−0.98)	−1.14	(−0.22)
Distance to market (x) semiarid AEZ	0.0203**	−0.0109	0.0139*	0.00963	−0.0207*	−0.000598	0.000565	−0.0180*	0.0643***
	−2.73	(−1.56)	−2.02	−0.72	(−2.50)	(−0.03)	−0.04	(−2.49)	−4.52
Distance market (x) subhumid AEZ	0.00683	−0.0210**	−0.00763	0.00768	−0.0133*	−0.0168	−0.00446	−0.0159*	−0.0226**
	−0.98	(−3.08)	(−1.31)	−0.74	(−2.14)	(−1.66)	(−0.38)	(−2.57)	(−2.68)
Semiarid AEZ	−1.541**	0.446	−1.574**	−1.673*	−0.00822	−1.768	−0.732	−0.607	−10.09***
	(−3.23)	−0.97	(−2.94)	(−2.10)	(−0.01)	(−1.02)	(−0.89)	(−1.23)	(−5.24)
Subhumid AEZ	−0.0409	1.163**	1.350***	−0.397	0.461	1.491*	0.248	0.335	1.586**
	(−0.10)	−2.67	−3.39	(−0.64)	−0.98	−2.17	−0.34	−0.76	−2.8
Idiosyncratic shocks	0.129	0.248	0.889***	0.622**	0.162	0.767***	0.595*	0.185	0.861***

Table 4 (continued)

Variable	12 months previous to survey			7 days previous to survey					
	Unable to feed household			Faced with no food at home			Gone to sleep hungry		
	Post-harvest	Lean	All seasons	Post-harvest	Lean	All seasons	Post-harvest	Lean	All seasons
	−0.72	−1.94	−7.59	−2.59	−0.84	−4.14	−2.18	−0.92	−3.89
Covariate shocks	0.922***	−0.0446	0.813***	−0.208	0.0852	0.702*	0.272	−0.111	0.311
	−4.26	(−0.27)	−5.01	(−0.52)	−0.34	−2.17	−0.81	(−0.39)	−0.87
Constant	−1.380*	−1.327*	−1.432**	−1.503	−2.330***	−1.549	−2.886***	−1.677**	−1.812*
	(−2.50)	(−2.43)	(−3.00)	(−1.87)	(−3.61)	(−1.95)	(−3.51)	(−2.76)	(−2.31)
Number of observations			3203			3203			3203
Wald Chi-Square	(57)		409.03	(57)		439.66	(54)		597.4
Log Pseudolikelihood			−2909.7986			−1251.251			−1152.9137
Pseudo R-Square			0.0839			0.1736			0.1581

(1) (NGN/1000 = EUR 5) equivalent value

(2) z statistics in parentheses

(3)Level of significance are indicated with* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

exclusively so, as wetlands can provide many goods and services (see, for example, the section about Nigerian wetlands in Schuyt 2005). At the margins, access to water is also more important for low-income households in reducing the probability of facing food insecurity (Table 5).

Conversely, access to forests increases the likelihood of reporting the most critical cases of food insecurity (both 12-month and 7-day recall). Marginal effects also suggest that this trend is exacerbated as household income decreases (Table 5). Such results do not contradict the literature and do not prevent extraction from the forest of valuable resources, even making an important contribution to total income (with an average of 22% in the PEN sample in Angelsen et al. 2014). However, a plausible hypothesis is that households associated with this asset and access to common forest could be still more vulnerable without access to common forest. The relationship which emerges from the analysis of other cases is that households closer to this type of asset are worse off than others because they may have lower access to social services and infrastructure in general (Wunder et al. 2014a). Another dimension is that the types of food resource extracted from forest tend not to be associated with staple foods, with the exception of some roots, limiting their impact from a caloric intake point of view (Rowland et al. 2016). However, other studies have shown that households with access to forest as a CR may be better off than other households sharing similar characteristics of isolation, but without access to forest as a CR (Clements et al. 2014), highlighting the need for further investigation of this dimension. At the margin (Table 5), the effect of living in areas with access to forest is exacerbated by low incomes. The probability of always reporting not having food at home increases from 6.79% at the 90th percentile to 16.07% at the 10th percentile of total income. Reporting food insecurity during the lean season only is not affected by having access to common forests, pointing to a weak seasonal effect.

Access to common arable land is explored only at initial stages (Table 8 in the appendix), as it is non-significant and not included in the final model.

The degree to which households' reporting of food security is sensitive to their access to commons is most acute when reporting in both seasons. This result is similar to what Wunder et al. (2014b) found for forests when looking at their potential gap-filling function, suggesting that wild resources are more likely to be an option of last resort than a mechanism used regularly to deal with seasonal fluctuation. In an independent survey of coping mechanisms and food insecurity in south-west Nigeria, Akerele et al. (2013) did not record wild resource harvesting to be among the most common household choices.

Table 5 Difference at the margins: Percent change in the probability of reporting the given food insecurity indicator (12 months recall, 7 days recall) against variation in total expenditure and the occurrence of shocks, in a given season

			10% percentile of tot. Exp.	Mean tot. Exp.	90% percentile of tot. Exp.	Idiosyncratic shocks	Covariate shocks	Gender (if female head)
Unable to feed household (12 months)	Lean season only	Pasture	−2.48	−2.96	−3.14	−2.57	−1.85	−3.53
		Forest	−4.03	−3.25	−2.64	−3.94	−3.33	−4.43
		Water	3.53	2.63	2.02	3.49	2.97	3.63
	In both seasons	Pasture**	−8.09	−6.01	−4.45	−8.51	−8.17	−6.55
		Forest**	11.08	8.80	6.86	11.66	10.65	9.68
		Water***	−10.79	−7.79	−5.66	−11.21	−10.84	−8.80
Faced with no food at home (7 days)	Lean season only	Pasture*	−2.83	−2.79	−2.51	−2.79	−2.76	−4.04
		Forest	0.54	1.32	1.64	0.86	0.84	1.70
		Water	−0.15	−0.44	−0.53	−0.26	−0.22	−0.56
	In both seasons	Pasture***	−5.86	−3.14	−1.73	−4.74	−5.24	−3.79
		Forest***	16.07	10.82	6.79	13.98	15.05	12.04
		Water***	−7.66	−4.14	−2.31	−6.23	−6.74	−5.01

Level of significance are indicated with * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$"

3.2.3 Model results: Contextual factors

We expected that food insecurity would be reported more frequently by households whose heads were older and had lower levels of education. However, ageing was found to be significant in increasing the likelihood and frequency of reporting food insecurity only for the 12-month recall indicator. When contextualising food security indicators to gender, female-headed households are more likely to report frequent food insecurity than those with male heads. Marginal effects indicate that access to pasture land reduces the probability that female-headed households will report food insecurity (7-day recall), both during the lean season only and always, by 4.04% (for comparison, access to pasture land reduces the probability of food insecurity among the poorest 10% of households by 3.83%). This points to a limited safety net effect for female-headed households, in addition to a more structural effect.

Larger households (in terms of number of individuals) tend to report more food insecurity, but this effect is systematically significant only for the 12-month recall indicator. The effect of the ratio of dependants within each household was also tested but was not found to be significant. The same can be said of the interaction variable linking size and dependency ratio of households, but for one, significant, counterintuitive finding during the post-harvest period. Controlling for income is expected to be a defining factor in reducing the effect of these household characteristics.

Total household expenditure (as a proxy of total income), as expected, is a significant variable in reducing the likelihood of frequently (i.e. in both seasons) reporting food insecurity compared with never doing so. At the margins (Table 5), as income decreases, the influence of access to CRs also increases. Poorer households are less likely to report systematic food insecurity if they have access to common pasture and water. Wealthier households are marginally influenced by these variables.

When looking at the conventional household assets assessed, ownership of arable land and the area of arable land per capita were not found to be significant in the models. This is line with evidence that land size per se is not necessarily correlated with a likelihood of being poor, as highlighted for Nigeria (2010/2011 season) by Oseni et al. (2014). There are two main reasons that could explain this. One is that farm size is not necessarily associated with wealth, as most land is allocated through family or community. The second is linked to differences in land productivity, for example between extensive farming systems and intensive ones. However, owning a home is associated with a lower likelihood of frequently reporting food insecurity events. Finally, the value of all livestock significantly reduces the likelihood of frequently reporting "no food at home". Some elements of the expected consumption-smoothing role of this asset do indeed help but selling livestock does not seem to be triggered by seasonal variation, as the likelihood of food insecurity during specific seasons is not significantly reduced by the value of all livestock.

Idiosyncratic shocks make food insecurity reporting significantly more likely during both seasons. However, they do not significantly increase the likelihood of reporting food insecurity during the lean season only. Covariate shocks are significant only when households report food insecurity based on 12-month recall. Marginal effects estimates indicate that access to common resources does not significantly change when there is shock, suggesting a limited use of this asset as a response mechanism to shocks.

"Distance to market" as a proxy for market access is neither significantly nor coherently related to self-reporting of food insecurity in this Nigerian sample when controlling for regional effects (with the exception of the 12-month recall indicator in the post-harvest season). In this specific case, the exception indicates that as distance increases between households and market, the probability of food insecurity decreases. This echoes the fact that distance to market is not significantly associated to gross crop income either, but for a minority of farms in Nigeria, also with the expected sign (Scandizzo and Savastano 2017). Moreover, urban and closer to market populations seem to be more at risk from food insecurity, as suggested by the variable capturing whether the household is classified as urban or rural. However, and this is an important caveat, interpreting these results is complicated by the fact that urban-rural classification in Nigeria is outdated, as many areas classified as rural could be now considered as urban (World Bank 2014). When controlling for regional specificities, simplified here by three AEZs (semiarid, subhumid and humid, following a north-south divide), being distant from a market has a more negative impact on food security for a household located in the humid zone than for a household in the subhumid zone. In contrast, there is no clear effect when comparing impact of distance from market for the semiarid zone (where there are significant results with contradictory signs).

Despite having lower average income, households located in the semiarid (Sahelian, i.e. northern) region are significantly less likely than others to face food insecurity situations, corroborating existing analysis of the whole LSMS-ISA sample for Nigeria (NBS 2014). A possible explanation is related to the average value of livestock and farm animals in this region, which is higher than that of households located in other AEZs, although this effect was only weakly captured by the models.

4 Conclusions and discussion

To the best of our knowledge, the influence of access to commons on livelihoods — and by extension on food security — has generally been approached through cases studies using a limited number of households, with rare exceptions such as the cross-continental reviews by Wunder et al. (2014b) and Angelsen et al. (2014). However, census-based surveys do not routinely include information on CRs. Such resources, and in particular forest and non-forest (fallow and arable land, pasture, etc.) resources, make important contributions to rural and peri-urban income and livelihoods. This inquiry on Nigeria focused on arable land, pasture, forest and water under common management. Accounting for but bypassing the question of environmental income by identifying the possible direct connections with food security indicators, the paper explored the following questions: (i) Is there is a connection between the recorded food security indicators of households and access to locally managed CRs in Nigeria? (ii) Is access to common resources relatively more important for the food security of the most vulnerable households? and (iii) Does access to wild resources acts as a safety net in general, and during lean seasons in particular?

The answer to the first question is positive, but not for all resources. Access to pasture reduced the likelihood of reporting events of extreme food insecurity, and even, to a limited extent, reduced the likelihood of reporting food insecurity during one of the seasons. Access to commonly managed water sources is also positively linked with food security. This confirms the importance of non-forest resources in West Africa (Pouliot and Treue 2013). However, access to common arable land is non-significant and is not associated with a consistent change in either direction. It is possible that, given that common arable land in rural Nigeria is ubiquitous, the variable "access to common arable land" does not allow for discriminating between households, as it does not include elements about quality or quantity.

Access to forest is more closely related to food insecurity. However, the fact that access to forest is associated with food-insecure events does not mean that forest is an unimportant supplier of food for households, but rather that it assumes more importance for households in a more vulnerable situation. Furthermore, access to forest is known to improve the diversity of the diet, albeit such a diet is deficient in starchy foods.

With regard to the second question, total income (using as a proxy total expenditure) and dwelling ownership were identified as the significant livelihood variables influencing whether or not a given household reported food insecurity. The value of livestock captures some positive effect but is rarely significant.

The probable greater reliance on access to CRs among more vulnerable households was also confirmed by looking at sensitivity when income rises. The marginal effects of access to these commons lowers the probability of facing food insecurity, particularly for the most critical cases, and is more important for households with lower incomes (Table 5). In the same vein, part of the evidence also points to the fact that female-headed households can benefit more positively from access to pasture lands.

Finally, and relating to the third question, access to pasture acts as a safety net by reducing the probability of reporting food insecurity in both seasons, with similar effects regarding water and associated wetlands. However, an apparently greater sensitivity to access to commons during the lean season could not be confirmed with the data available under this format for Nigeria. There is a safety net effect but a seasonal effect is only weakly captured by the data. This is in line with Wunder et al. (2014b), who argue that this safety net function is probably evolving alongside the widening of alternatives to households through development, and depends on the magnitude of the shock.

Although CRs as a whole are significantly related to food security indicators, various data limitations apply. To its credit, the sample is not biased towards more environmentally dependent households or towards households particularly close to the resources analysed, but benefits from the sampling procedure of the LSMS. However, the nature of the data regarding access to resources is limited because environmental resources are not systematically integrated in its protocol. Also, and given the confidentiality constraints of the survey, a partial mismatch between the data from the enumeration area and a given household has potentially misclassified access to resources for some of the households. As developed in the analysis of results, access to common land as a contributor to food security is ambiguous given some definition problems, which limit its study.

The other issue with the data, which needs to be accounted for, is that they are based on recall over 12 months or 7 days and self-assessment of food security variables, and thus of limited value in reflecting the actual food security of a given household. However, the analysis addressed this problem by controlling for the various waves of surveys on food security challenges. In addition, as discussed by Headey and Ecker (2013), not all indicators are the same, with some being more reliable and more consistent than others. In our case, the time of recall of the indicators creates a continuum of reliability, from lower reliability of the 12-month recall to higher reliability of the 7-day recall.

Using a sustainable livelihood approach to contextualise the potential represented by commons could be adequately performed despite the constraints of the existing database. Initial responses to this weakness of the LSMS-ISA are currently being explored, such as the extension of the LSMS-ISA with forest modules (Bong et al. 2016). Their integration is required to capture with more confidence and precision the influence of the "hidden harvest" on the dimension of quality and quantity of household food security. Independently of these developments, further analysis of the relationship between access to CRs and nutrition security could be undertaken with the data available, calculating a composite score based on dietary diversity, food frequency and the relative nutritional importance of different food groups, such as a food consumption score card (WFP 2008).

This brief analysis has two direct implications. The first is that food security intervention can be enhanced by integrating the question of access to CRs, alongside more conventional agricultural yield-enhancing approaches, when targeting the most vulnerable (i.e. those who tend to always report food insecurity events). This is especially the case for the most vulnerable who cannot successfully mobilise agricultural support because of their limited resources, and could be described as "subsistence farmers without profit potential" (Fan et al. 2013). A relevant framework in this direction is that of "integrated landscape" approaches, which encompass multiple goals (e.g. improved agricultural productivity, climate change resilience, improved CR management) at various scales (farm, community and landscape) (Gray et al. 2016). Although more advanced in other developing regions, such approaches are considered an emerging trend in SSA in a recent review by Milder et al. (2014).

Secondly, this exploratory paper highlights the limitations of current standard population representative household surveys with regard to the role played by the hidden harvest (i.e. environmental income and source of subsistence for food security). If food security is to be addressed in a more effective way, the addition of complementary questionnaire modules to existing agriculture surveys is warranted. A more detailed record of access to the hidden harvest, aligned with both farm and non-farm activities, allows for a more coherent grasp of population needs, and particularly those of the more vulnerable.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Disclaimer The views expressed are purely those of the authors and may not in any circumstances be regarded as stating an official position of the European Commission.

Appendix

Table 6 Distribution of households by landscape category (GLOBCOVER (Arino et al. 2012))

N.	Majority landcover class	Freq.	Percent	Cum.
1	Rainfed Croplands	300	9.09	9.09
2	Mosaic cropland (50–70%)/vegetation (grassland/shrubland/forest) (20–50%)	622	18.84	27.92
3	Mosaic vegetation (grassland/shrubland/forest) (50–70%)/cropland (20–50%)	710	21.5	49.42
4	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5 m)	291	8.81	58.24
5	Open (15–40%) broadleaved deciduous forest/woodland (>5 m)	73	2.21	60.45
6	Mosaic forest or shrubland (50–70%)/grassland (20–50%)	227	6.87	67.32
7	Mosaic grassland (50–70%)/forest or shrubland (20–50%)	91	2.76	70.08
8	Closed to open (>15%) (broadleaved or needleleaved, evergreen or deciduous) shrubland (<5 m)	554	16.78	86.86
9	Closed to open (>15%) herbaceous vegetation (grassland, savannas or lichens/mosses)	75	2.27	89.13
10	Sparse (<15%) vegetation	28	0.85	89.98
11	Closed to open (>15%) grassland or woody vegetation on regularly flooded orwaterlogged soil – fresh, brackish or saline water	10	0.3	90.28
12	Closed (>40%) broadleaved forest or shrubland permanently flooded - Saline or brackish water	28	0.85	91.13
13	Artificial surfaces and associated area	264	8	99.12
14	Bare areas	29	0.88	100
	Total	3302	100	

NBS (2014) Household survey, post-harvest wave data 2012–2013. NBS (2014) Merged datasets from Households and Community questionnaires (both seasons, 2012 2013). General Household Survey-Panel (GHS-Panel) conducted in 2012/13 by the Nigeria National Bureau of Statistics (NBS) in collaboration with the World Bank Living Standard Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA)

Table 7 Distribution of households by agro-ecological zones

Agro-ecological Zones	Freq.	Percent	Cum.
Tropic-warm/semiarid	989	29.95	29.95
Tropic-warm/subhumid	1846	55.91	85.86
Tropic-warm/humid	458	13.87	99.73
Tropic-cool/subhumid	9	0.27	100.00
Total	3302	100.00	

NBS (2014) Household survey, post-harvest wave data 2012–2013. NBS (2014) Merged datasets from Households and Community questionnaires (both seasons, 2012 2013). General Household Survey-Panel (GHS-Panel) conducted in 2012/13 by the Nigeria National Bureau of Statistics (NBS) in collaboration with the World Bank Living Standard Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA)

Table 8 Estimates for the multinomial logit models with all variables, for both seasons and recall times (12 m. and 7 d.)

	12 months previous to survey			7 days previous to survey					
	Unable to feed household			Faced with no food at home			Gone to sleep hungry		
Variable	Post-harvest	Lean	All seasons	Post-harvest	Lean	All seasons	Post-harvest	Lean	All seasons
Arable land	−0.397	0.0945	0.188	0.670*	−0.104	0.0774	0.666*	0.239	0.117
	(−1.51)	−0.49	−0.87	−2.02	(−0.36)	−0.24	−1.98	−0.78	−0.35
Water	−0.376	0.0213	−0.967***	−0.24	−0.186	−2.303***	−0.0641	−0.127	−2.095***
	(−1.55)	−0.12	(−3.83)	(−0.58)	(−0.44)	(−3.96)	(−0.12)	(−0.31)	(−3.89)
Pasture	−0.407	−0.427	−0.868**	−1.825***	−0.923*	−2.190**	−1.118	−1.133	−3.116**
	(−1.37)	(−1.53)	(−3.07)	(−3.63)	(−2.03)	(−3.21)	(−1.94)	(−1.87)	(−3.02)
Forest	0.772**	−0.0883	0.764**	0.895*	0.6	2.426***	0.333	0.327	2.233***
	−2.93	(−0.39)	−3	−1.97	−1.41	−6	−0.58	−0.78	−6.18
Age of head of household	−0.000819	−0.00767	0.0110*	0.00746	0.00252	0.00777	0.0118	−0.000712	0.0106
	(−0.14)	(−1.82)	−2.23	−0.93	−0.35	−1.03	−1.19	(−0.10)	−1.29
Education level of head of household	−0.0166	−0.000971	−0.0191	−0.0122	−0.00439	−0.0555	0.0387	−0.014	−0.0382
	(−0.87)	(−0.07)	(−1.30)	(−0.47)	(−0.19)	(−1.85)	−1.3	(−0.63)	(−1.11)
Gender of head of HH household	−0.173	−0.451**	−0.241	−0.0498	−0.522*	−0.153	−0.207	−0.203	0.0435
	(−0.70)	(−2.66)	(−1.45)	(−0.15)	(−2.45)	(−0.58)	(−0.55)	(−0.79)	−0.15
Size of household	0.115*	0.104**	0.055	0.0375	0.0122	−0.0262	0.215**	−0.0331	0.0255
	−2.56	−2.81	−1.42	−0.46	−0.18	(−0.33)	−2.82	(−0.45)	−0.36
Dependents ratio	0.401	0.243	−0.452	−0.802	−0.08	−0.243	0.238	−0.56	−1.11
	−0.8	−0.62	(−1.35)	(−1.33)	(−0.16)	(−0.40)	−0.34	(−0.99)	(−1.87)
Dependents ratio (x) Size of household	−0.128	−0.125	0.0312	0.0982	−0.0466	0.0608	−0.320*	0.135	0.0517
	(−1.51)	(−1.68)	−0.44	−0.69	(−0.43)	−0.39	(−2.05)	−1.08	−0.35
Total expenditure of household (1)	−0.000874	−0.000483**	−0.00132***	−0.00209***	−0.000555	−0.00224***	−0.00206**	−0.00125**	−0.00316***
	(−1.88)	(−2.94)	(−3.66)	(−3.67)	(−1.31)	(−3.30)	(−3.27)	(−2.93)	(−4.22)
Partial / total ownership of arable land	−0.328	0.248	0.224	1.132*	−0.648	0.0224	−0.498	−0.691	−0.0819
	(−0.61)	−0.84	−0.62	−2.06	(−0.87)	−0.02	(−0.49)	(−1.01)	(−0.07)
Ownership of dwelling	−0.276	−0.086	−0.470**	−0.584*	0.132	−0.949***	−0.629*	0.281	−1.100***
	(−1.51)	(−0.57)	(−2.77)	(−2.21)	−0.61	(−3.46)	(−2.27)	−1.34	(−3.41)
Total farm size of households (1000 m^2)	0.00463	0.0115	−0.133	0.0343	−0.097	−0.221	−0.145	−0.0968	0.0374
	−0.15	−0.61	(−1.92)	−0.73	(−0.93)	(−0.84)	(−1.78)	(−0.88)	−0.8
Value of livestock and small animals (1)	−0.000259	−0.000295	−0.0000544	−0.00256	−0.000386	−0.00388	(.)	(.)	(.)
	(−1.15)	(−1.78)	(−0.28)	(−1.74)	(−0.62)	(−1.79)			
Distance to nearest market (km)	−0.0145*	0.0118	−0.0085	−0.0199	0.00755	−0.00746	−0.0126	0.0064	0.000489
	(−2.00)	−1.91	(−1.52)	(−1.74)	−1.47	(−0.90)	(−0.97)	−1.32	−0.07

Table 8 (continued)

	12 months previous to survey			7 days previous to survey					
	Unable to feed household			Faced with no food at home			Gone to sleep hungry		
Variable	Post-harvest	Lean	All seasons	Post-harvest	Lean	All seasons	Post-harvest	Lean	All seasons
Distance to market (x) semiarid AEZ	0.0219**	−0.0113	0.0157*	0.0124	−0.0208**	−0.000352	0.003	−0.0187**	0.0635***
	−2.71	(−1.65)	−2.19	−0.85	(−2.68)	(−0.02)	−0.19	(−2.72)	−4.31
Distance market (x) subhumid AEZ	0.00846	−0.0214**	−0.00522	0.0102	−0.0123*	−0.0146	−0.000986	−0.0147*	−0.0226**
	−1.11	(−3.22)	(−0.83)	−0.86	(−1.99)	(−1.43)	(−0.07)	(−2.42)	(−2.75)
Access to formal credit	−0.0997	0.431	−0.399	0.248	0.181	0.641	0.384	−0.185	0.506
	(−0.25)	−1.65	(−1.18)	−0.4	−0.42	−1.33	−0.73	(−0.38)	−0.98
Access to informal credit	−0.104	0.156	0.223	−1.758*	−0.137	0.00984	−0.0416	0.335	0.0324
	(−0.42)	−0.8	−1.15	(−2.38)	(−0.39)	−0.03	(−0.10)	−1.1	−0.09
Credit request was rejected	0.832***	0.833***	1.365***	0.421	0.206	0.351	0.618	0.0914	0.453
	−3.58	−4.59	−7.17	−1.31	−0.78	−1.3	−1.86	−0.33	−1.64
Beneficiary of government social subsidy	0.515	0.029	0.21	0.383	0.0674	0.33	0.515	0.301	0.443
	−0.8	−0.07	−0.62	−0.34	−0.09	−0.6	−0.62	−0.47	−0.83
Idiosyncratic shocks	0.135	0.229	0.858***	0.575*	0.169	0.771***	0.538	0.191	0.834***
	−0.8	−1.73	−7.18	−2.34	−0.87	−4.22	−1.94	−0.95	−3.6
Covariate shocks	0.882***	−0.0897	0.774***	−0.3	0.107	0.794*	0.217	−0.124	0.323
	−4.5	(−0.51)	−4.67	(−0.74)	−0.41	−2.47	−0.6	(−0.42)	−0.96
Rural household	0.0596	−0.116	0.0579	−0.112	−0.105	−0.446	0.0641	−0.427	−0.676*
	−0.26	(−0.67)	−0.27	(−0.34)	(−0.39)	(−1.20)	−0.19	(−1.48)	(−1.97)
Located under the semiarid AEZ	−1.686***	0.427	−1.544**	−1.821*	0.0607	−1.715	−0.594	−0.443	−10.23***
	(−3.45)	−0.93	(−2.92)	(−2.29)	−0.11	(−1.02)	(−0.69)	(−0.94)	(−5.29)
Located under the subhumid AEZ	−0.0203	1.145**	1.305***	−0.503	0.431	1.379*	0.139	0.246	1.487**
	(−0.05)	−2.66	−3.32	(−0.77)	−0.91	−1.99	−0.17	−0.57	−2.58
Constant	−1.426*	−1.467**	−1.645***	−1.418	−2.218**	−1.449	−3.130***	−1.513*	−1.782*
	(−2.49)	(−2.72)	(−3.42)	(−1.59)	(−3.29)	(−1.79)	(−3.37)	(−2.42)	(−2.13)
Number of observations			3193			3193			3193
Wald Chi-Square	(81)		578.3	(81)		626.05	(78)		844.42
Log Pseudolikelihood			−2836.4971			−1230.995			−1134.5778
Pseudo R-Square			0.103			0.1863			0.1687

1) (NGN/1000 = EUR 5) equivalent value

(2) z statistics in parentheses

(3)Level of significance are indicated with = "* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

References

Adebooye, O., & Opabode, J. (2004). Status of conservation of the indigenous leaf vegetables and fruits of Africa. *African Journal of Biotechnology, 3*(12), 700–705.

Akerele, D., Momoh, S., Aromolaran, A. B., Oguntona, C. R. B., & Shittu, A. M. (2013). Food insecurity and coping strategies in south-West Nigeria. *Food Security, 5*(3), 407–414. https://doi.org/10.1007/s12571-013-0264-x.

Alden Wily, L. (2008). Custom and commonage in Africa rethinking the orthodoxies. *Land Use Policy, 25*(1), 43–52. https://doi.org/10.1016/j.landusepol.2007.02.002.

Anadu, P. A., Elamah, P. O., & Oates, J. F. (1988). The bushmeat trade in southwestern Nigeria: A case study. [journal article]. *Human Ecology, 16*(2), 199–208. https://doi.org/10.1007/bf00888092.

Angelsen, A., & Wunder, S. (2003). *Exploring the forest–poverty link: Key concepts, issues and research implications*. Bogor: CIFOR.

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N. J., Bauch, S., et al. (2014). Environmental income and rural livelihoods: A global-comparative analysis. *World Development, 64*(Supplement 1), S12–S28. https://doi.org/10.1016/j.worlddev.2014.03.006.

Arino, O., Ramos Perez, J. J., Kalogirou, V., Bontemps, S., Defourny, P., & Van Bogaert, E. (2012). Global land cover map for 2009 (GlobCover 2009). *European Space Agency (ESA) & Université catholique de Louvain (UCL)*.

Arnold, J. M. (2008). *Managing ecosystems to enhance the food security of the rural poor*. Gland: IUCN.

Bayala, J., Sanou, J., Teklehaimanot, Z., Kalinganire, A., & Ouédraogo, S. J. (2014). Parklands for buffering climate risk and sustaining agricultural production in the Sahel of West Africa. *Current Opinion in Environmental Sustainability, 6*(0), 28–34. https://doi.org/10.1016/j.cosust.2013.10.004.

Bong, I. W., Hogarth, N., & Wunder, S. (2016). Pilot-testing the up-scaled forestry module and sourcebook for the LSMS-ISA Indonesia. CIFOR http://www1.cifor.org/fileadmin/subsites/PEN/IndopilottestforestrymoduleCIFOR.pdf.

Cavendish, W. (2000). Empirical regularities in the poverty-environment relationship of rural households: Evidence from Zimbabwe. *World Development, 28*(11), 1979–2003. https://doi.org/10.1016/S0305-750X(00)00066-8.

Chamberlin, J., & Jayne, T. S. (2013). Unpacking the meaning of 'market access': Evidence from rural Kenya. *World Development, 41*, 245–264. https://doi.org/10.1016/j.worlddev.2012.06.004.

Chambers, R., & Conway, G. (1991). Sustainable rural livelihoods: Practical concepts for the 21st century. *Institute of Development Studies Discussion Paper, 296*, 1–29. Brighton: Institute of Development Studies. http://opendocs.ids.ac.uk/opendocs/handle/123456789/775

Chukwuone, N. A. (2009). Socioeconomic determinants of cultivation of non-wood forest products in southern Nigeria. *Biodiversity and Conservation, 18*(2), 339–353. https://doi.org/10.1007/s10531-008-9489-y.

Clements, T., Suon, S., Wilkie, D. S., & Milner-Gulland, E. J. (2014). Impacts of protected areas on local livelihoods in Cambodia. *World Development, 64*(*Supplement 1*), S125–S134. https://doi.org/10.1016/j.worlddev.2014.03.008.

Cotter, J., & Tirado, R. (2008). Food security and climate change: The answer is biodiversity. In *A review of scientific publications on climate change adaptation in agriculture*. Exeter: Greenpeace.

Cronkleton, P., Larson, A. M., Feintrenie, L., Garcia, C., & Levang, P. (2013). Reframing community forestry to manage the Forest–farm Interface. *Small-scale Forestry, 12*(1), 5–13. https://doi.org/10.1007/s11842-012-9229-8.

Davies, J., Poulsen, L., & Schulte-Herbrüggen, B. (2012). Conserving dryland biodiversity. United Nations convention to combat desertification.

De Haan, L. J. (2012). The livelihood approach: A critical exploration. *Erdkunde, 66*(4), 345–357.

DFID. (2001). *Sustainable livelihoods guidance sheets*. London: UK Department for International Development.

Fan, S., Brzeska, J., Keyzer, M., & Halsema, A. (2013). *From subsistence to profit: Transforming smallholder farms* (Vol. 26, food policy report). Wasinghton: International Food Policy Research Institute.

FAO, IFAD, & WFP (2014). The State of Food Insecurity in the World 2014. Strengthening the enabling environment for food security and nutrition. Rome: FAO.

FAO, IFAD, & WFP (2015). The State of Food Insecurity in the World 2015. Meeting the 2015 international hunger targets: Taking stock of uneven progress. Rome: FAO.

Food Security Information Network. (2017). *Global report on Food Crises*, 2017. Rome: FSIN, EU, FAO, WFP. http://www.wfp.org/content/global-report-food-crisis-2017

Gray, E., Henninger, N., Reij, C., Winterbottom, R., & Agostini, P. (2016). *Integrated landscape approaches for Africa's drylands*. Washington DC: World Bank Publications.

Harris, F. M., & Mohammed, S. (2003). Relying on nature: Wild foods in northern Nigeria. *Ambio: A Journal of the Human Environment, 32*(1), 24–29.

Headey, D., & Ecker, O. (2013). Rethinking the measurement of food security: From first principles to best practice. *Food Security, 5*(3), 327–343. https://doi.org/10.1007/s12571-013-0253-0.

Ickowitz, A., Powell, B., Salim, M. A., & Sunderland, T. C. H. (2014). Dietary quality and tree cover in Africa. *Global Environmental Change, 24*(0), 287–294. https://doi.org/10.1016/j.gloenvcha.2013.12.001.

IMF (2016). World economic outlook. International Monetary Find. http://www.imf.org/external/pubs/ft/weo/2016/02/index.htm

IRP. (2010). *Guidance note on recovery: Livelihoods*. Genève: IRP, UNISDR, UNDP.

Johnson, K. B., Jacob, A., & Brown, M. E. (2013). Forest cover associated with improved child health and nutrition: Evidence from the Malawi demographic and health survey and satellite data. *Global Health: Science and Practice, 1*(2), 237–248.

Kabubo-Mariara, J. (2013). Forest-poverty nexus: Exploring the contribution of forests to rural livelihoods in Kenya. Natural Resources Forum*,* 37(3), 177–188, doi:https://doi.org/10.1111/1477-8947.12003.

Kamanga, P., Vedeld, P., & Sjaastad, E. (2009). Forest incomes and rural livelihoods in Chiradzulu District, Malawi. *Ecological Economics, 68*(3), 613–624.

Kloos, J., & Renaud, F. G. (2014). Organic cotton production as an adaptation option in north-west Benin. *Outlook on Agriculture, 43*(2), 91–100. https://doi.org/10.5367/oa.2014.0166.

Leroy, J. L., Ruel, M., Frongillo, E. A., Harris, J., & Ballard, T. J. (2015). Measuring the food access dimension of food security: A critical review and mapping of indicators. *Food and Nutrition Bulletin, 36*(2), 167–195. https://doi.org/10.1177/0379572115587274.

Lockett, T., Christopher, C., Calvert, L. E., & Grivetti, C. (2000). Energy and micronutrient composition of dietary and medicinal wild plants consumed during drought. Study of rural Fulani, Northeastern Nigeria. *International Journal of food sciences and nutrition, 51*(3), 195–208.

Maxwell, D., Vaitla, B., & Coates, J. (2014). How do indicators of household food insecurity measure up? An empirical comparison from Ethiopia. *Food Policy, 47*, 107–116. https://doi.org/10.1016/j.foodpol.2014.04.003.

McKinsey Global Institute (2014). Nigeria's renewal: Delivering inclusive growth in Africa's largest economy. http://www.mckinsey.com/global-themes/middle-east-and-africa/nigerias-renewal-delivering-inclusive-growth.

Milder, J. C., Hart, A. K., Dobie, P., Minai, J., & Zaleski, C. (2014). Integrated landscape initiatives for African agriculture, development, and conservation: A region-wide assessment. World Development*,* 54(0), 68–80, doi:https://doi.org/10.1016/j.worlddev.2013.07.006.

Morse, S., & McNamara, N. (2013). The theory behind the sustainable livelihood approach. In *Sustainable livelihood approach: A critique of theory and practice* (pp. 15–60). Dordrecht: Springer. https://doi.org/10.1007/978-94-007-6268-8_2

Mortimore, M. (1989). *Adapting to drought: Farmers, famines and desertification in West Africa*: Cambridge University press.

NBS. (2013). *Basic information document. Nigeria general household survey–panel 2012/13*. Abuja: National Bureau of Statistics.

NBS (2014). LSMS-integrated surveys on agriculture general household survey panel. Abuja: A Report by the Nigerian National Bureau of Statistics in Collaboration with the Federal Ministry of Agriculture and Rural Development and the World Bank.

Oni, O. A. (2014). Livelihood, agro ecological zones and poverty in rural Nigeria. *Journal of Agricultural Science, 6*(2), 103-113, https://doi.org/10.5539/jas.v6n2p103.

Oni, O. A., & Fashogbon, A. E. (2013). Food poverty and livelihoods issues in rural Nigeria. *African Journal of Agricultural and Resource Economics, 8*(2), 108–135.

Osemeobo, G. J. (1991). Effects of common property resource utilization on wildlife conservation in Nigeria. *GeoJournal, 23*(3), 241–248.

Oseni, G., McGee, K., & Dabalen, A. (2014). Can agricultural households farm their way out of poverty? *World Bank Policy Research Working Paper*(7093).

Pinstrup-Andersen, P. (2009). Food security: Definition and measurement. *Food Security, 1*(1), 5–7.

Pinstrup-Andersen, P. (2013). Can agriculture meet future nutrition challenges? *The European Journal of Development Research, 25*(1), 5–12. https://doi.org/10.1057/ejdr.2012.44.

Pouliot, M., & Treue, T. (2013). Rural People's reliance on forests and the non-Forest environment in West Africa: Evidence from Ghana and Burkina Faso. *World Development, 43*, 180–193. https://doi.org/10.1016/j.worlddev.2012.09.010.

Powell, B., Thilsted, S. H., Ickowitz, A., Termote, C., Sunderland, T., & Herforth, A. (2015). Improving diets with wild and cultivated biodiversity from across the landscape. *Food Security, 7*(3), 535–554.

Rowland, D., Ickowitz, A., Powell, B., Nasi, R., & Sunderland, T. (2016). Forest foods and healthy diets: Quantifying the contributions. *Environmental Conservation, 44*(22), 102–114. https://doi.org/10.1017/S0376892916000151

Scandizzo, P. L., & Savastano, S. (2017). Revisiting the farm size-productivity relationship: New evidence from sub-Saharan countries. In P. Pingali & G. Feder (Eds.), *Agriculture and rural development in a globalizing world: Challenges and opportunities* (pp. 26–55). Abingdon: Routledge.

Schuyt, K. D. (2005). Economic consequences of wetland degradation for local populations in Africa. *Ecological Economics, 53*(2), 177–190. https://doi.org/10.1016/j.ecolecon.2004.08.003.

Scoones, I., Melnyk, M., & Pretty, J. N. (1992). *The hidden harvest: Wild foods and agricultural systems. A literature review and annotated bibliography*. London: CAB & IIED.

Sen, A. (1981). *Poverty and famines: An essay on entitlement and deprivation*. Oxford: Clarendon Press.

Sinare, H., & Gordon, L. J. (2015). Ecosystem services from woody vegetation on agricultural lands in Sudano-Sahelian West Africa. *Agriculture, Ecosystems & Environment, 200*(0), 186–199. https://doi.org/10.1016/j.agee.2014.11.009.

Soewu, D. A., & Adekanola, T. A. (2011). Traditional-medical knowledge and perception of pangolins (Manis sps) among the Awori people, southwestern Nigeria. *Journal of Ethnobiology and Ethnomedicine, 7*(1), 25. https://doi.org/10.1186/1746-4269-7-25.

Soewu, D. A., & Ayodele, I. A. (2009). Utilisation of pangolin (Manis sps) in traditional Yorubic medicine in Ijebu province, Ogun state, Nigeria. *Journal of Ethnobiology and Ethnomedicine, 5*(1), 39. https://doi.org/10.1186/1746-4269-5-39.

Sunderland, T. C. H., Powell, B., Ickowitz, A., Foli, S., Pinedo-Vasquez, M., Nasi, R., et al. (2013). *Food security and nutrition: The role of forests.* Bogor: Center for International Forestry Research (CIFOR).

Sunderland, T. C. H., Achdiawan, R., Angelsen, A., Babigumira, R., Ickowitz, A., Paumgarten, F., et al. (2014). Challenging perceptions about men, women, and forest product use: A global comparative study. *World Development, 64*(S1), S56–S66.

Thondhlana, G., & Muchapondwa, E. (2014). Dependence on environmental resources and implications for household welfare: Evidence from the Kalahari drylands, South Africa. Ecological Economics*,* 108(0), 59–67, doi:https://doi.org/10.1016/j.ecolecon.2014.10.003.

Vedeld, P., Angelsen, A., Bojö, J., Sjaastad, E., & Berg, G. K. (2007). Forest environmental incomes and the rural poor. *Forest Policy and Economics, 9*(7), 869–879.

WFP. (2008). *Food consumption analysis. Calculation and use of the food consumption score in food security analysis*. World Food Programme, Vulnerability Analysis and Mapping Branch (ODAV): Rome.

WHO (2012). Micronutrient deficiencies. http://www.who.int/nutrition/topics/ida/en/.

Wiersum, K. F. (2004). Forest gardens as an 'intermediate' land-use system in the nature–culture continuum: Characteristics and future potential. *Agroforestry Systems, 61*(1), 123–134. https://doi.org/10.1023/b:agfo.0000028994.54710.44.

World Bank. (2014). *Nigeria Economic Report*. Washington DC: The World Bank http://documents.worldbank.org/curated/en/2014/07/19883231/nigeria-economic-report-no-2.

World Food Summit. (1996). *Rome declaration on world food security and world food summit plan of action*. Rome: FAO.

Wunder, S., Angelsen, A., & Belcher, B. (2014a). Forests, livelihoods, and conservation: Broadening the Empirical Base. *World Development, 64(Supplement 1),* S1-S11, doi:https://doi.org/10.1016/j.worlddev.2014.03.007.

Wunder, S., Börner, J., Shively, G., & Wyman, M. (2014). Safety nets, gap filling and forests: A global-comparative perspective. *World Development, 64*(*Supplement 1*), S29–S42. https://doi.org/10.1016/j.worlddev.2014.03.005.

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