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Contribution of non-timber forest products to food security of households bordering the Pô-Nazinga-Sissili ecological complex in Burkina Faso

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Abstract: The current paper analyses the contribution of non-timber forest products (NTFPs) to households' food security bordering the complex Pô-Nazinga-Sissili, a protected area in south Burkina Faso. Using primary data from a sample of 263 randomly selected households, two food security indicators, the Household Dietary Diversity Score and the Household Food Insecurity Access Scale, were calculated. Binary logistic regression and ordered multinomial logistic regression of these respective indicators on the socioeconomic characteristics of households, with a particular focus on economic dependence on NTFPs, have shown that NTFPs are means to improve household food security. It would be more appropriate for NTFPs to be deeply incorporated into public food security policies, especially in rural areas.

Keywords: forest products; non-timber forest products; NTFPs; food security; forest dependence; logit models; Pô-Nazinga-Sissili; PONASI; Burkina Faso.

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1 Introduction

Food insecurity is an economic phenomenon that affects the entire world. Approximately two billion people worldwide, or more than 25% of the world's population, faced moderate to severe food insecurity in 2018 (FAO et al., 2019). Food insecurity affects regions of the world differently. For instance, while only 8% of the population in North America and Europe is affected by food insecurity, more than 52% of the African population suffers from this phenomenon (FAO et al., 2019).

Sub-Saharan Africa is the world region mainly affected by moderate or severe forms of food insecurity, with a prevalence of 57.7% (FAO et al., 2019). Like other populations in this region, many households in Burkina Faso suffer from food insecurity. In 2012, about 19% of these households suffered from this phenomenon, of which 1% was affected by its severe form (World Food Programme, 2014). Almost 20% of Burkinabe households reported running out of food seven days before data collection in the 2014 continuous multisectoral survey (National Institute of Statistics and Demography of Burkina Faso, 2015).

Factors behind food insecurity include climate change (Friel, 2010; Pickson and Boateng, 2022), conflicts (George and Adelaja, 2022; Nnaji et al., 2022), poverty (Mahadevan and Hoang, 2016), and poor agricultural and food policies (Nnaji et al., 2022). Optimal use of forests can solve the food insecurity of rural households by providing wild food, cash income, food diversity and cooking energy and improving the resilience of the ecological and social systems surrounding agriculture (Gitz et al., 2021). These forest goods and services can be classified into three main groups: wood, non-timber forest products (NTFPs) and other environmental resources (Angelsen and Wunder, 2003).

NTFPs are part of the category of supply ecosystem services (Millennium Ecosystem Assessment, 2005). Theoretically, NTFPs affect households' food security by mainly three channels. Firstly, they contribute to households' food security by providing natural food to support the current consumption of these households (Abdulla, 2013; Angelsen and Wunder, 2003). Secondly, NTFPs can serve as safety nets during shocks especially for vulnerable households (Angelsen et al., 2014; Sunderlin et al., 2005). Thirdly, they can also act on food security by providing cash income to households involved in NTFPs' value chain (Abdulla, 2013; Chukwuone and Okeke, 2012). Indeed, cash income from NTFPs can be used to buy other commodities for households' food consumption.

NTFPs contribute to food security for about 20% of the world's population, especially landless women, children, peasants, and other distressed people (FAO, 2018). Indeed, world food from NTFPs was estimated at over 76 million tonnes (FAO, 2014). Between 2017 and 2020, the consumption of NTFPs reduced the proportion of households that suffered from moderate or severe food shortages from 72% to 62% in four regions of Burkina Faso (Tree Aid, 2021). But many empirical studies (Abdulla, 2013; Chukwuone and Okeke, 2012; Ekwugha, 2016; Guerrero et al., 2015; Jimoh and Haruna, 2007; Mipun et al., 2019) on the link between NTFPs and food security explore individually these three channels by which NTFPs can act on households' food security. The current article analyses this link through the channel of direct consumption of NTFPs by calculating two food security indicators [the household dietary diversity score (HDDS) and the household food insecurity access scale (HFIAS)] and through the income channel by examining the role of the economic dependence on NTFPs on food security. This dependence represents the proportion of NTFPs in household income.

While it is true that the contribution of NTFPs to food security at the macroeconomic level is recognised, there appears to be a lack of studies in the microeconomic sense in many NTFP-rich countries such as Burkina Faso which has two major ecological complexes of protected areas. These two complexes are the W-Arly-Pendjiari with 10,795 square kilometres and the Pô-Nazinga-Sissili with 3,792 square kilometres (Bouché et al., 2014; Bathiono, 2009). The contribution of NTFPs to human well-being, such as food security, around these complexes, is unknown due to the lack of national statistics on this issue (MAAHD, 2017). Hence the central question of this research: what is the contribution of NTFPs to the food security of rural households in Burkina Faso? Thus, this research aims to analyse the role of NTFPs in the food security of rural households in Burkina Faso. Considering the above statistics, this article hypothesises that NTFP exploitation improves households' food security in rural Burkina Faso.

The rest of this paper consists of three sections. Section 2 presents a brief literature review on food security and its relationship to NTFPs. The methodology for analysing the contribution of NTFPs to rural household food security is developed in Section 3. The last section presents and discusses the results of the research.

2 Literature review

The current section begins with a discussion of the food security concept's history. The dimensions of that concept and its indicators are presented herein. Finally, a literature review on the relationship between NTFP exploitation and households' food security is given.

2.1 History of the concept of food security

Food security is a concept that has evolved enormously over the years between researchers and development actors. At the dawn of 2000, food security already had more than 200 definitions and 450 indicators (Hoddinott, 1999).

Before the 1970s, the problem in the diet of the world's population was called a 'hunger problem' and was characterised by insufficient food supply compared to the demand (Cafiero et al., 2014). After the World Food Conference organised by the United Nations, following the food and oil crises that shook the world from 1972–1974, food security emerged. At that time, food security was defined as the ability to constantly supply the world with commodities and support growth in food consumption while controlling fluctuations in quantities and prices (Committee on World Food Security, 2012).

In the 1980s, food security analysis focused on people's access to food due to the emergencies of famine and malnutrition observed in developing countries, even in relative to crop abundance at the national level (Sen, 1981). This situation marked the birth of the term household food security and already indicated that the analysis of food insecurity must be done at the household level (Cafiero et al., 2014).

In the 1990s, the World Food Summit, held in Rome in 1996, saw the collapse of the single-minded focus on the adequacy of dietary energy intake to consider economic and nutritional considerations (FAO, 1996). The summit recognised that food security at the individual, family, national, regional, and global levels is achieved when all people constantly have physical and economic access to sufficient, safe, and nutritious food that

enables them to meet their needs and preferences for a healthy and active life (FAO, 1996). This definition was revised in 2001 to consider the social dimension of access to food (FAO, 2002).

Since 2000, the United Nations development agencies' definition of food security has remained stable. Indeed, these organisations define food security as "the situation in which everyone always has material, social and economic access to sufficient, safe, and nutritious food to meet food needs and preferences and can thus lead a healthy and active life" (FAO, 2009). Four dimensions of food security emerged from this definition: availability of food supplies, accessibility of food supplies, stability of food supplies, and use of food.

2.2 Dimensions of food security

One dimension of food security is food *availability*. This dimension refers to the amount of food in a country or region. It can be provided through domestic production, food imports, and food aid (MAAHD, 2017). It, therefore, concerns the physical availability of food.

The *accessibility* of food for a household corresponds to its capacities in terms of production and exchange. This accessibility can be physical or economical. Physical accessibility refers to regular and timely access to food trading places, while affordability relates to household purchasing power (MAAHD, 2017). Poor households may therefore be in a situation of inaccessibility to food because of low incomes or too high prices due to shocks.

The *stability* of food supplies refers to the regularity of food availability in space and time. Several parameters must be considered to ensure this dimension: the stability of domestic production, the adequacy of storage infrastructures and marketing systems, the interannual and intraregional fluctuation of prices, and the cyclical fluctuation of supply and demand on international markets.

The *use* of food products refers to the nutritional aspect of the food that households consume. Thus, food products consumed by households must meet their preferences and individuals' needs for protein-energy elements and micronutrients (World Food Programme, 2014).

2.3 Indicators of food security

In parallel with the evolution of the definition of the concept of food security, several indicators have been designed by researchers and development actors to characterise it (FAO, 1996). These indicators can be divided into groups according to whether they measure food security directly or indirectly. These are the group of indicators based on food consumption adequacy and those that deal with food insecurity as a state capable of being identified and analysed by behavioural experiences and reactions that seemed familiar to most cultures. But Cafiero et al. (2014) estimated that combining indicators from these two groups guarantees better household analysis results.

Among others, indicators based on food consumption adequacy are the prevalence of undernourishment, the food consumption score, and the HDDS. But these indicators, taken individually, do not allow a complete understanding of the food security experienced by households since they have no basis to guarantee the reliability of the

results obtained in practice and to make comparisons between different applications of this method (Cafiero et al., 2014).

The second group of indicators, called 'scale' indicators, are based on the food experiences of households and individuals. They indirectly capture food security by measuring household food consumption behaviours (Ndiaye, 2014). These are mainly the HFIAS promulgated by the Food and Nutrition Technical Assistance (FANTA) Initiative, the Food Insecurity Experience Scale developed by FAO (Cafiero et al., 2014) and the adaptation strategies index (Maxwell and Caldwell, 2008). Also, depending on their fields of application, food security indicators can be classified into two levels: the macro level, which includes the national and regional levels, and the micro level, which unites households.

NTFPs' contribution to household food security analysis occurs at the household level. Thus, the HDDS can be used with other indicators based on household experience, such as the HFIAS, to understand better these households' access to certain food groups (Cafiero et al., 2014). Also, these indicators are relatively simple to calculate and consider several aspects of food security such as food frequency, diversity and eating behaviour. Therefore, the current research uses HDDS and HFIAS to measure rural households' food security.

2.4 NTFPs and food security

NTFPs have a long history in human life (Chukwuone and Okeke, 2012). They contribute to strengthening and diversifying households' food status, mainly rural ones (Angelsen and Wunder, 2003). These products enter the households' nutritional diet through condiments and as supplements to agricultural products (Ekwugha, 2016). Households that collect NTFPs can diversify their diets, not only through the diversity of collected NTFPs but, more importantly, through the fact that the shares sold of these products allow these households to purchase other food groups, such as cereals.

NTFPs act as a food safety net for vulnerable households. They allow households to smoothen their consumption during lean food seasons (Delacote, 2007). They are also a food source for many households during crises such as severe illness or death of their economic pillar (Pouliot and Treue, 2013). NTFPs are rich in nutritional value. They strengthen the nutritional status of individuals, especially for people with low immunity and chronic diseases (Barany et al., 2004). They provide essential micronutrients and vitamins for children's growth in remote or forest-bordering areas (Guerrero et al., 2015). NTFP foods include *Parkia biglobosa* seeds, honey, shea butter, baobab leaves and red kapok flowers.

Empirically, many studies, such as Abegaz (2017), Abubakari and Abubakari (2015), Arora and Nabi (2022), Drammeh et al. (2019), and Ningi et al. (2022) on households' food security determinants in rural areas do not integrate NTFP exploitation as a factor that influences this phenomenon. These studies focused on the socioeconomic determinants of food security, such as the sex and education of the household's head. A few studies, like Abdulla (2013) and Barany et al. (2004) that considered this dimension analysed NTFP's contribution to food security through the total income provided by NTFPs' exploitation. Also, these studies measured households' food security with one indicator. The current article analyses the contribution of NTFP to households' food security through the relative NTFP income, also called economic dependence on NTFP of households. Moreover, households' food security status is not assessed in this paper by

only one indicator but two: the HDDS, which permits assessing the household's food (direct) consumption in a short period, and the HFIAS, which evaluates food insecurity signs experienced by households during a relatively long period.

3 Methodology for analysing the contribution of NTFPs to rural households' food security

Three points constitute the current section. Firstly, it presents the theoretical and empirical models adopted to analyse the contribution of NTFPs to rural households' food security. Secondly, it describes the data collection methodology. Lastly, it underlines the choice and description of variables to analyse the contribution of NTFPs to rural households' food security.

3.1 Theoretical and empirical models for the analysis of food security determinants

The current point presents the theoretical and empirical models used in the current research.

3.1.1 Theoretical model

This article takes the sustainable livelihood approach developed by Chambers and Conway (1992) and Scoones (1998) to analyse the effects of NTFP exploitation on households' food security. Food security for a household implies that it must first have capital that allows it to buy, provide, and consume food. A mathematical formalisation of this relationship is given through equation (1).

$$SA = f(H, F, P, S, N) \tag{1}$$

where SA is a binary variable measuring household food security. H, F, P, S and N represent respectively the household's human capital, financial capital, physical capital, social capital, and the natural capital to which this household has access.

3.1.2 The functional form of the model

In this research, any household is either food secure or food insecure, depending on the value of the food security indicator. Thus, analysing the food security of these households is to analyse the probability of these households being or not food insecure. For this purpose, the food insecurity status of a household is a dichotomous endogenic variable. Logit or probit are indicated for these cases (Greene, 2003). Given the ease with which the logit model can be used to interpret the estimated coefficients (Harari-Kermadec, 2009), it is considered in the rest of the current research.

The logit model has already been widely used in the literature on the analysis of the determinants of household food security (Abegaz, 2017; Abubakari and Abubakari, 2015; Sekhampu, 2013). Two of the variants of this model are used in this research. These are the binary logit model and the ordered multinomial logit model. The binary logit model is used with the HDDS, while the ordered multinomial logit model is used with the household HFIAS score.

For analysis with HDDS, consider Y_i^* a latent variable representing the number of food groups consumed by the household in the last 24 hours. Suppose Y_i^* is explained by the socioeconomic characteristics of the household. Let us designate by Y the binary variable indicating 1 if the household is food insecure and 0 if it is food secure. The relationship between Y_i and Y_i^* is given by equation (2).

$$Y_i = \begin{cases} 1 & if\ Y_i^* \geq 0 \\ 0 & if\ Y_i^* < 0 \end{cases} where\ Y_i^* = X_i\beta + \varepsilon_i \tag{2}$$

With the vector of variables X_i explicating the number of food groups consumed, β the vector of the parameters to be estimated and ε_i the error terms. The probability P_i that this household is food insecure is given by equation (3).

$$\log\left(\frac{P_i}{1-P_i}\right) = X_i\beta + \varepsilon_i \tag{3}$$

This model is estimated by the maximum likelihood method. Following Selvester et al. (2008), the food insecurity status of the household is a binary variable taking the value 1 if HDDS is less than four and the value 0 if HDDS is greater than four. Let's assume *Secure*, this status. Thus, more explicitly:

$$Secure_i = \begin{cases} 1 & if\ HDDS_i < 4 \Rightarrow household\ i\ is\ food\ insecure \\ 0 & if\ HDDS_i \geq 4 \Rightarrow household\ i\ is\ food\ secure \end{cases}$$

Therefore, the empirical equation to be estimated is in the form of equation (4).

$$\begin{aligned} logit(secure_i) = {} & \beta_0 + \beta_1 i.Vil0_i + \beta_2 dep\_PFNL_i + \beta_3 dep\_PFNL2_i \\ & + \beta_4 SexeCM_i + \beta_5 AgeCM_i + \beta_6 StatresidCM_i + \beta_7 EducCM_i \\ & + \beta_8 MemGUFCM_i + \beta_9 ExperPFNLCM_i + \beta_{10} TailleM_i \\ & + \beta_{11} Ratidep_i + \beta_{12} DistAP_i + \beta_{13} Duredeficit_i + \varepsilon_i \end{aligned} \tag{4}$$

where β_j with j = 0, 1, …, 13 the parameters to be estimated and ε_i the error term. The variables *SexeCM*, *AgeCM*, *StatresidCM*, *EducCM*, *MemGUFCM* and *ExperPFNLCM* represent the gender, age, residence status, literacy status, membership of a forest users' group and the number of years of experience of the head of household respectively. The variables *Vil*0, *dep_PFNL*, *dep_PFNL*2, *TailleM* and *Ratidep* represent the village of residence, economic dependence on NTFPs, squared economic dependence on NTFPs, size and demographic dependence ratio of the household respectively. The variable *DistAP* measures the distance between the household's residence and the nearest PA. The variable *Duredeficit* measures the duration of the food deficit experienced by the household in the period September 2019 and October 2020.

The analysis with the HFIAS is like that of the HDDS, with the only difference being that the HFIAS takes four ordered values. Thus, considering a household *i* with a noted HFIAS score, its situation in terms of food insecurity can be expressed as follows:

$$Secure_i = \begin{cases} 1\ if\ HFIAS_i = 0 \Rightarrow the\ household\ is\ food\ secure \\ 2\ if\ 1 \le HFIAS_i \le 9 \Rightarrow the\ household\ is\ low\ food\ insecure \\ 3\ if\ 10 \le HFIAS_i \le 18 \Rightarrow the\ household\ is\ moderately\ food\ insecure \\ 4\ if\ 19 \le HFIAS_i \le 27 = 0 \Rightarrow the\ household\ is\ severely\ food\ insecure \end{cases}$$

In this case, the empirical model to be estimated is in equation (5).

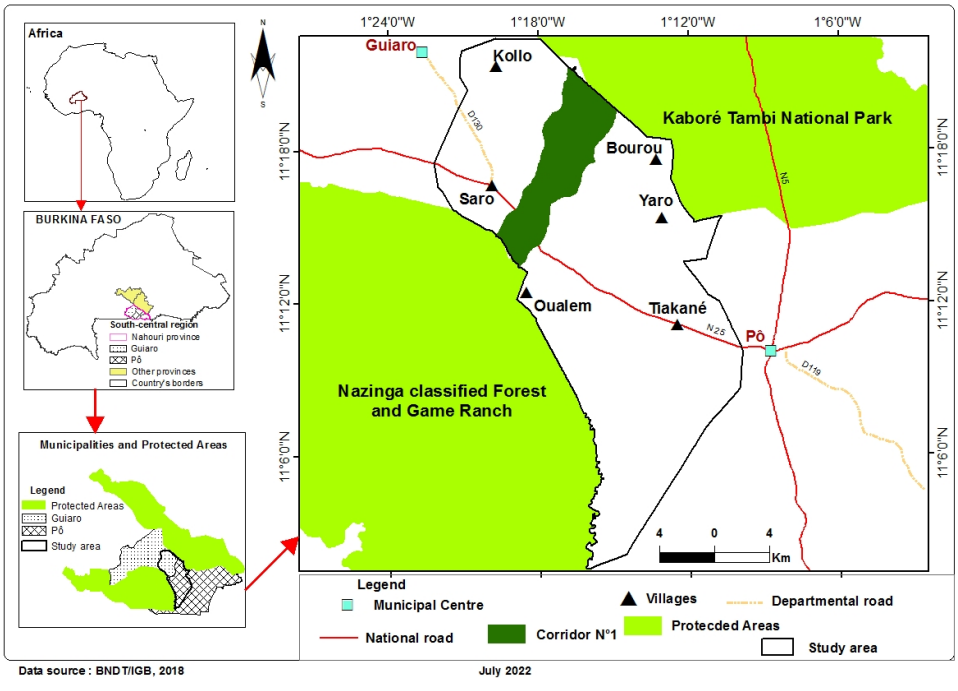
$$\begin{aligned} logit(Secure_i) = & \propto_0 + \propto_1 i.Vil0_i + \propto_2 dep_{PFNL_i} + \propto_3 dep_{PFNL2_i} \\ & + \propto_4 SexeCM_i + \propto_5 AgeCM_i + \propto_6 StatresidCM_i + \propto_7 EducCM_i \\ & + \propto_8 MemGUFCM_i + \propto_9 ExperPFNLCM_i + \propto_{10} TailleM_i \\ & + \propto_{11} Ratidep_i + \propto_{12} DistAP_i + \propto_{13} Duredeficit_i + \mu_i \end{aligned} \quad (5)$$

where α_j with $j = 0, 1, \ldots, 13$ are the parameters to be estimated and μ_i the error term.

3.2 Data collection methodology

This section consists of two subsections. The first section presents the research area, and the second outlines the original data collection.

Figure 1 Presentation of the study area (see online version for colours)



Source: Author's construction

3.2.1 The Pô-Nazinga-Sissili protected area complex

The current research focused on the villages bordering corridor no. 1 of the Pô-Nazinga-Sissili protected area complex (PONASI-PAC) in southern Burkina Faso. Figure 1 shows this study area. PONASI-PAC is located near the border with Ghana, straddling the South Central and Central West regions, with an area of more than 3,792 square kilometres (Bathiono, 2009). It consists of seven PAs: the Kaboré Tambi National Park, the Nazinga Game Ranch (NGR), the Sissili hunting concession, and the village hunting areas of the NGR, the village hunting areas of the Sissili, corridor no. 1 and corridor no. 2.

Corridor no. 1 is an elephant passage corridor linking the Kaboré Tambi National Park and the NGR. It was demarcated in 2006 (Bathiono, 2009). This corridor struggles to find a legal status for its protection despite its ecological and strategic importance. This situation places it at the heart of the PONASI Research and Development Project, which began in 2018 with the main objective of encouraging the achievement of this legal status through scientific research aimed at the conservation of biodiversity and the economic development of local populations. This project is mainly carried out in the villages impacted by the delimitation of corridor no. 1, which are Kollo, Saro, Oualem, Tiakané, Yaro and Bourou.

3.2.2 Data collection

Data used in the current article come from a sample of 263 households constructed using the stratified random sampling technique, with the strata representing the six villages (Bourou, Kollo, Oualem, Saro, Tiakané and Yaro) in the study area. This technique required the constitution of a sampling frame by a census which saw the enumeration of 943 resident households with 6425 persons. With a sampling rate of 27.9%, the study sample is composed as follows: 27 households from Bourou, 44 households from Kollo, 22 households from Oualem, 29 households from Saro, 121 households from Tiakané and 20 from Yaro.

Three data groups were collected over 12 consecutive months, from August 2020 to July 2021: household income, food consumption and food insecurity manifestations, and socioeconomic characteristics of households. Income data were quarterly collected in October 2020, January 2021, April 2021, and July 2021. All sources of income were identified and then grouped into eight classes: income from NTFPs, income from timber forest products, income from agriculture, income from livestock, wage income, non-forest environmental income, cash and non-monetary transfers, and other sources of income. This group is based on the collection methodology of the CIFOR (2007).

Data for households' food security indicators are collected with HDDS and HFIAS questionnaires. The socioeconomic characteristics of households were collected with the HDDS and HFIAS surveys in early October 2020, corresponding to the last days of the lean food season in the study area. To calculate the HDDS, the method of Swindale and Bilinsky (2006) was used. Data for the calculation of the HFIAS were collected by using the method of Coates et al. (2007).

3.3 Choice and description of model variables

This point describes the variables used for the econometric regression.

3.3.1 Dependent variables

The current paper uses two dependent variables: the HDDS and the HFIAS. The HDDS was published in 2006 as an indicator of household access to food as part of the FANTA II project (Swindale and Bilinsky, 2006). FAO uses the HDDS to measure household food access and food diversity (Selvester et al., 2008). Dietary diversity is the number of food groups a household consumes during a given period. The HDDS provides an overview of a household's ability to access food based on information collected about that household within a 24-hour reference period (Kennedy et al., 2011).

For the HDDS calculation, 12 food groups are identified. These are:

1 cereals

2 roots and tubers

3 vegetables

4 fruits

5 meat, poultry, and offal

6 eggs

7 fish and seafood

8 legumes, nuts, and seeds

9 milk and dairy products

10 oils and fats

11 sugars and honey

12 spices, condiments, and beverages (Kennedy et al., 2011).

Each group is assigned a weight of 1 if at least one of its constituent foods is consumed during the 24-hour reference period and 0 otherwise. The HDDS for a given household then varies from 0 to 12, indicating the number of food groups consumed.

Generally, three criteria can be used for classifying households based on their food-secure and non-food-secure HDDS scores (Selvester et al., 2008; Swindale and Bilinsky, 2006). The first criterion is to take as a decision-making threshold the average HDDS of 33% of the most economically wealthy households (Swindale and Bilinsky, 2006). The second criterion is to set the threshold at the level of the average HDDS calculated using 33% of the highest HDDS in the sample (Swindale and Bilinsky, 2006). The latter criterion is possible if the information on the incomes of the individual households in the sample is unavailable. This criterion classifies all households with an HDDS strictly below 4 as food insecure households (Selvester et al., 2008). For simplicity, this research adopts the latter criterion to classify the households in the sample.

The FANTA project developed the HFIAS as a food security indicator between 2001 and 2006. It is a simple tool for measuring food insecurity's 'access' dimension (Gebreyesus et al., 2015). This indicator is based on the idea that food insecurity leads to predictable reactions and responses that can be captured and quantified through a survey and then summarised on a scale (Coates et al., 2007).

The HFIAS score is a discrete variable taking values ranging from 0 to 27. The higher it is, the more severe the food insecurity experienced by the household (Selvester et al., 2008). Classification of household food insecurity determinants is made to facilitate analysis of household groups based on the value of their HFIAS scores. Thus, drawing inspiration from Salarkia et al. (2014) and Selvester et al. (2008), the four groups are:

1 if HFIAS = 0, the corresponding household is food secure

2 if HFIAS is between 1 and 9, the corresponding household is low food insecure

3 if HFIAS is between 10 and 18, the household is moderately food insecure

4 the household is severely food insecure if HFIAS is between 19 and 27.

3.3.2 Explanatory variables

The determinants of food security for a household can be classified into: socio-demographic characteristics and economic characteristics. Selvester et al. (2008) found that the HDDS and HFIAS indicators for measuring food security are strongly related to these two groups. Household's socio-demographic characteristics that may explain its food insecurity include the age of the household head (HH), their level of education, their sex, and the size of their household (Arora and Nabi, 2022; Ningi et al., 2022). The economic characteristics of the household that may explain its food security are the demographic dependency ratio and the total household income (Abegaz, 2017; Asghar and Muhammad, 2013; Sekhampu, 2013).

In rural areas, households engage in several activities, such as crop farming, livestock rearing, or the collection of NTFPs. The older the HH, the more experience he acquires in these activities and the more his household can ensure food security. Thus, the HH's age and household food security are positively linked (Sekhampu, 2013). So, in the current paper, HH's age is expected to affect food insecurity negatively.

The gender of the HH can be a determining factor in household food security. In addition, it is established that the collection of NTFP is generally carried out by women accompanied by their children. This collection provides substantial income to their associated households (Angelsen et al., 2014). Thus, a positive effect of the variable 'female sex' on household food security is expected in the current article. Indeed, Sekhampu (2013) has found a positive effect between the female sex and food security in his work.

Several studies have shown that the HH's level of education positively influences his/her household's food security status (Abdullah et al., 2019; Asghar and Muhammad, 2013; Yabile, 2013). A well-educated HH can better plan the production and consumption decisions of his/her household with the available resources to ensure the household's food security. So, in the current paper, HH's education level is expected to negatively affect household food insecurity.

A large household means more mouths to feed, especially in developing countries. Some researchers like Asghar and Muhammad (2013) and Yabile (2013) found a negative effect of household size on food security. But a large household can mean many workers, which can lead to enough food for household members (Drammeh et al., 2019). Thus, in the current article, the expected effect of household size on food security is ambiguous. Table 1 presents variables used to explain the food situation of

households. Each variable is accompanied by its definition, abbreviation, nature and expected sign of food insecurity.

Table 1 Variables used for food security analysis

Setting the variable	*Abbreviation*	*Nature*	*Expected sign*
The household's dietary diversity score (HDDS): 1 if HDDS is between 0 and 3; 0 if HDDS is between 4 and 12.	Secure	Binary	Dependent variable
The HFIAS: 1 if HFIAS = 0; 2 if HFIAS is between 1 and 9; 3 if HFIAS is between 10 and 18; 4 if HFIAS is between 19 and 27.	Secure	Ordered multinomial	Dependent variable
Age of the HH	AgeCM	Natural number	-
Education of the HH: 1 = literate; 0 = non-educated	EducCM	Dummy	-
Sex of HH: 1 = female; 0 = male	SexCM	Dummy	-
The residence status of the HH: 1 = indigenous; 0 = migrant	StatresidCM	Dummy	+/-
Demographic dependency ratio: ratio of all children (0 to 14 years) and older people (over 65 years) to the total number of persons of working age in the household (15 to 65 years).	Ratiodep	Decimal	+
The household size in adult equivalent	TailleM	Natural number	+/-
Economic dependence on NTFP	Dep_PFNL	%	-
The square of economic dependence on NTFP	Dep_PFNL2	%	+/-
The distance between the household's residence and the nearest protected area	DistAP	Km	+/-
Duration of food deficiency	Duredeficit	Month	+
Bourou	Bourou	Reference	
Kollo	Kollo	Dummy	+/-
Oualem	Oualem	Dummy	+/-
Saro	Saro	Dummy	+/-
Tiakané	Tiakané	Dummy	+/-
Yaro	Yaro	Dummy	+/-

Source: Author from literature review

The household's demographic dependency ratio is given by the inactive persons to the active ones. The inactive are individuals under 15 and those over 65 (Atkinson et al., 1995). The higher this ratio, the higher the food insecurity score since the number of mouths to feed is large. Thus, researchers have found a negative effect between the dependency ratio and household food security (Asghar and Muhammad, 2013). So, the household's demographic dependency ratio is expected to have a positive effect on food insecurity.

The economic dependence of households on NTFP is the variable of interest for this research. It is the percentage contribution of NTFPs to total household income. We

assume that households that earn significant shares of their income from the operation of NTFPs are more likely to be food secure. Indeed, several NTFPs are consumed in the study area as staple foods or condiments that contribute to the calorific needs of individuals. As there is a lack of studies on the link between economic dependence on NTFPs for households and their food security status, we assumed that this dependence positively affects households' food security (or negatively affects food insecurity). To verify the presence of a threshold effect in this relationship, we incorporated the square of the economic dependence on NTFPs.

Belonging to a specific zone can affect food security (Abegaz, 2017). To avoid problems of autocorrelation between the explanatory variables, the village Bourou is retained as a counterfactual. This village was chosen after a random selection. Thus, the effect of belonging to a specific village on food security is given concerning Bourou.

Variables specific to this research were added to the list of explanatory variables. These are the experience in NTFP exploitation of the HH, the distance between the household's residence and the nearest protected area (PA). Like the economic dependence on NTFPs, these three variables have been little studied, to our knowledge, in terms of their relationship to household food security. So, the expected signs of these variables on households' food insecurity are ambiguous.

4 Results and discussion

The current section presents the descriptive statistics of the quantitative variables, it provides statistics on food security indicators based on household characteristics, and it exposes the economic determinants of household food security through two logistical econometric regressions.

4.1 Descriptive statistics

Table 2 summarises the statistics on the quantitative variables used. On average, households in the research area consumed about six food groups in the 24 hours prior to data collection if NTFPs are included in the HDDS estimation process. This average drops to four if NTFPs are excluded. Also, the results of the difference-in-means test showed that the mean of food groups consumed with the inclusion of NTFPs is higher than that obtained by excluding NTFPs. Thus, NTFPs contribute to increasing the number of food groups consumed by households and ensuring food security. But either means shows that households generally have an acceptable dietary diversity score. They, therefore, are food secure according to the criterion of Selvester et al. (2008).

Concerning the occurrence of signs of food insecurity during the four weeks before data collection, an average score of eight is found. This score is less than nine, which targets low food insecurity (Salarkia et al., 2014; Selvester et al., 2008). Households bordering corridor No. 1 of the PONASI-PAC are, on average, in low food insecurity. The median value of the HFIAS also supports this conclusion since 50% of households have an occurrence score less than or equal to 10.

Of the 263 households interviewed in this survey, the average age of HHs is 45. Most HHs are young. For instance, 25% of HHs are under 35, and 50% are under 42. Youths provide a labour force on farms and an asset for labour-intensive NTFP exploitation. In addition, the average economic dependence on NTFP is about 15%. It should be noted

that 25% of households have an economic dependence on NTFPs less than or equal to 8% against a median dependence of 12%.

Table 2 Descriptive statistics

Variable	*First quartile Q1*	*Second quartile Q2*	*Third quartile Q3*	*Average**	*Standard deviation*	*Minimum*	*Maximum*
Food groups consumed in the last 24 hours – with NTFPs	4	6	7	5.76	1.88	2	12
Food groups consumed in the last 24 hours – without NTFPs	3	4	6	4.27	2.03	1	12
Occurrence of signs of food insecurity	4	7	10	7.56	5.09	0	27
Dependence on NTFPs	0.08	0.12	0.19	0.15	0.13	0.03	0.88
Age of HH	35	42	54	44.77	13.9	19	90
Experience of HH in NTFPs collection	0	7	30	14.83	17.39	0	62
Household size	5	6	8	7	3.4	1	21
Distance from residence to the protected area	4	10	14	8.91	5.25	0.5	19
Months in food deficit	0	0	2	0.95	1.63	0	10
Demographic dependency ratio	0.5	1	1.5	1.07	0.75	0	5

Note: *The difference-in-means test showed that the mean HDDS calculated with the inclusion of NTFPs is higher than that obtained with the exclusion of NTFPs.

Source: Author, based on global survey data

Table 2 shows that the HHs has an average experience in collecting NTFP of 15 years, even though 25% of HHs do not practice this activity. The average household size in the research area is seven people, while the average distance between the household residence and the nearest PA is 8.9 km. But 25% of households are within 4 km of the nearest PA. Also, 50% of households claim to have experienced at least one month of food deficit between September 2019 and October 2020. The average household dependency ratio is 1.1.

4.2 Household food security by socioeconomic characteristics

Table 3 summarises the distribution of households about food security indicators and socioeconomic characteristics. The sample includes 10.7% of households headed by women. Concerning the education of HHs, 60.1% are non-educated; while 3.8% have a secondary education. The sample includes 23.2% of migrant households. The Kassena people represent the majority ethnic group with a percentage of 85.2%. Only 7.6% of households' heads are affiliated with a Forest User Group (FUG).

Table 3 Distribution of households by food status and socioeconomic characteristics (in %)

Variables	*Terms*	*HDDS*		*HFIAS*				*Sample size*	*Share in the sample*
		Food security	*Food insecurity*	*Food security*	*Low food insecurity*	*Moderate food insecurity*	*Severe food insecurity*		
Name of the village	Bourou	77.78	22.22	0.00	81.48	18.52	0.00	27	10.27
	Kollo	70.45	29.55	6.82	40.91	40.91	11.36	44	16.73
	Oualem	50.00	50.00	13.64	36.36	36.36	13.64	22	8.37
	Saro	75.86	24.14	10.34	68.97	17.24	3.45	29	11.03
	Tiakané	70.25	29.75	15.70	54.55	28.93	0.83	121	46.01
	Yaro	65.00	35.00	5.00	70.00	20.00	5.00	20	7.60
Gender of HH	Man	69.36	30.64	11.49	57.87	26.38	4.26	235	89.35
	Woman	71.43	28.57	7.14	42.86	46.43	3.57	28	10.65
Education of HH	Non-educated	63.29	36.71	8.23	54.43	32.91	4.43	158	60.08
	Bantaare	75.00	25.00	0.00	37.50	37.50	25.00	8	3.04
	Medersa	100.00	0.00	14.29	71.43	14.29	0.00	7	2.66
	Primary	57.14	42.86	42.86	42.86	14.29	0.00	7	2.66
	Post-primary	82.19	17.81	9.59	63.01	24.66	2.74	73	27.76
	Secondary	60.00	40.00	50.00	50.00	0.00	0.00	10	3.80
Residence status of HH	Migrant	65.57	34.43	6.56	63.93	21.31	8.20	61	23.19
	Indigenous	70.79	29.21	12.38	53.96	30.69	2.97	202	76.81
Ethnicity of HH	*Gourmantche*	50.00	50.00	0.00	0.00	100.00	0.00	2	0.76
	Kassena	69.20	30.80	11.16	55.36	30.36	3.13	224	85.17
	Mosse	65.22	34.78	17.39	56.52	13.04	13.04	23	8.75
	Nakana	33.33	66.67	0.00	33.33	33.33	33.33	3	1.14
	Fulani	100.00	0.00	0.00	90.91	9.09	0.00	11	4.18
Membership in a forest user group	No	68.31	31.69	11.52	57.20	26.75	4.53	243	92.40
	Yes	85.00	15.00	5.00	45.00	50.00	0.00	20	7.60
Total		*69.58*	*30.42*	*11.03*	*56.27*	*28.52*	*4.18*	*263*	*100.00*

Source: Author, based on global survey data

4.2.1 Dietary diversity score and socioeconomic characteristics of households

Considering the HDDS, 69.6% of the 263 households surveyed are food secure (Selvester et al., 2008). The analysis by village shows that apart from Oualem where only 55% of its population is food secure, the other villages have food security rates exceeding 70%. For example, more than half of households in the research area consumed at least four food groups 24 hours before data collection. At this step, the gender of the HH does not appear to influence household food security. Indeed, the percentage of food-secure households for both sexes is about 70%.

The level of education does not appear to have a linear relationship with household food security. Indeed, only 57% of households headed by heads who have reached the post-primary level compared to 63% of households headed by non-educated heads are food secured. Similarly, all households headed by chiefs who attended Koranic School (medersa) are food secured. Direct observation in the field showed that the heads of these households are generally Fulani.

Indigenous households are slightly more food secure (70.8%) than migrant households (65.6%). All Fulani households (100%) included in the sample are food secured against 33% for *Nakana*, 69.2% for *Kassena*, 65.2% for Mosse and 50% for Gourmantche. Social capital seems to positively affect household food security since 85% of households that have joined a FUG are food secure compared to 68% of households that are not affiliated with it.

4.2.2 Food insecurity access scale and socioeconomic characteristics of households

Following the thresholds established by Salarkia et al. (2014) and Selvester et al. (2008), Table 3 shows that only 11% of households are food secure. Also, 56% of households are low food insecure, 28% moderate, and 4% severely food insecure. Low food insecurity appears to affect the village of Bourou, with 81.5% of its households suffering from it. As for moderate food insecurity is more observed in Kollo, with 40% of its households suffering from it. However, the village of Oualem is the first to experience severe food insecurity, with 13.6% of its inhabitants' households suffering from it.

Of the 263 households in the sample, 28 are headed by women, of which only 7% are food secure, 42.3% are low food insecure, and 46.4% are moderately food insecure. In contrast, 11.5% of households headed by men are food secure, and nearly six out of ten male-headed households live in low food insecurity. Households headed by literate leaders are all food insecure according to the HFIAS measure.

Food insecurity measured by HFIAS appears to be related to the residence status of the household. Indeed, only 7% of migrant households are food secure, while 12% of indigenous households are. The *Kassena*, generally indigenous to the area, have a food security rate of 9.5% compared to 4.5% for the Fulani, almost all migrants. But no Fulani household, Gourmantche or Nakana, is in food security according to the HFIAS measure. Apart from the *Gourmantche*, who suffer only from moderate food insecurity, most other ethnic groups suffer from low food insecurity. Also, membership in a FUG does not seem to affect household food security since only 5% of households affiliated with a FUG are food secure.

Table 4 Determinants of food insecurity

Variables	*Household dietary diversity score*			*Household food insecurity access scale*		
	Coefficients	*Standard deviation*	*Odds ratios*	*Coefficients*	*Standard deviation*	*Odds ratios*
Bourou = the reference						
Kollo	0.658	0.646	1.932	1.321**	0.522	3.746
Oualem	1.306*	0.685	3.691	0.714	0.581	2.041
Saro	0.294	0.685	1.342	–0.0781	0.537	0.925
Tiakané	1.651**	0.706	5.214	0.0406	0.552	1.041
Yaro	0.672	0.745	1.958	–0.109	0.596	0.897
Dependence on NTFPs	11.16**	5.647	70,508.90	5.014*	2.831	150.528
Square of dependence on NTFPs	–23.25*	12.13	0.000	–4.690	3.965	0.009
Sex of HH: 1 = Female	0.275	0.559	1.316	0.436	0.450	1.546
Age of HH	–0.00892	0.0124	0.991	–0.00267	0.0106	0.997
Residence status of HH: 1 = Indigenous	–0.0843	0.439	0.919	–0.173	0.369	0.841
Education of the HH: 1 = Literate	–1.014***	0.345	0.363	–0.523*	0.284	0.593
Membership in a forest user group: 1 = Yes	–0.493	0.718	0.611	0.944*	0.495	2.569
HH's experience	–0.0216**	0.0107	0.979	–0.0108	0.00856	0.989
Household size	–0.114**	0.0525	0.892	–0.0109	0.0383	0.989
Demographic dependency ratio	–0.0203	0.215	0.980	–0.194	0.173	0.823
Distance from residence to the protected area	–0.131***	0.0452	0.877	0.00612	0.0360	1.006
Months in food deficit	–0.0543	0.0942	0.947	0.207***	0.0774	1.229
/Threshold 1				–1.959***	0.740	–1.959
/Threshold 2				1.132	0.727	1.132
/Threshold 3				3.801***	0.796	3.801
Constant	0.308	1.002	0.378			
Observations	261			261		
Log-likelihood	–137.4			–256.3		
LR chi2	46.83			39.75		
Prob. > chi2	0.000129			0.00140		
Pseudo R^2	0.146			0.0719		
Degrees of freedom	17			17		

Note: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Source: Author, based on the results of the global survey

4.3 The economic determinants of food (in)security in the vicinity of PONASI-PAC

Table 4 summarises the links between the food security indicators, namely the HDDS and the HFIAS, and the socioeconomic characteristics of households around corridor No. 1 of PONASI-PAC. The probability values (Prob > chi2) for both econometric regressions are less than 0.01. So, both models, taken individually, are globally significant. The estimated coefficients relate to household food insecurity.

Considering HDDS regression, six of the explanatory variables are significant. Indeed, Table 4 shows that the coefficient of economic dependence on NTFPs is statistically non-zero, which means that this variable positively influences the probability of households being food insecure. But this positive influence is valid for a certain threshold since the variable 'square of economic dependence on NTFPs' is also significant with a negative influence on food insecurity. This threshold, obtained by cancelling out the partial derivative of the (probability) function of food insecurity, is equal to 24%. Thus, households that collect more than 24% of their income through NTFP exploitation are more likely to be food secure than households that collect less. This result can be explained by the fact that NTFP exploitation gives much income to households engaged in this activity which permits them to diversify their diet with a high diversity of NTFPs and others bought food.

Household size has a negative coefficient and is statistically non-zero. Thus, an increase in household size leads to a decrease in the probability of that household living in a food insecurity situation. This result contradicts Asghar and Muhammad (2013) and Yabile (2013), for whom food insecurity problems are generally associated with large households. Furthermore, it corroborates the results of Drammeh et al. (2019). One explanation for this result may be that households in the riparian zone of PONASI-PAC have many NTFP collectors. These collected NTFPs contribute to households' direct feeding by forcing the housewife's condiments basket. NTFPs also contribute to the financing of the food budget thanks to the cash income from selling certain NTFPs with high economic value, such as honey, *nere* seeds, and shea nuts. This cash income constitutes about 58% of the total income that NTFPs provide to these households.

The variable 'education of the HH' is significant. Its negative coefficient shows that households with literate heads are less likely to be food insecure than households with non-educated heads. This result corroborates those of other researchers, such as Asghar and Muhammad (2013) and Yabile (2013), who have already found that education is a variable that positively explains the state of household food security. Indeed, a literate HH can help the household cook to diversify their diet. He/she can also lead their household in productive activities, which permits to get much income.

The variable 'HH's experience' in the NTFP collection is significant, with a negative coefficient. It, therefore, harms the likelihood of a household being food insecure. The value of its odd ratio shows that households with experience in collecting NTFPs are less likely to experience food insecurity than others. This result can be explained by the fact that heads of households with extensive expertise in NTFP collection are more likely to encourage their household members to do the same.

The variable 'distance between household residence and the nearest PA' is significant with a negative coefficient. Thus, it harms the likelihood of a household being food insecure. This result is paradoxical since, usually; proximity to PAs allows households to collect more NTFP there, thanks to the high wealth of NTFP PAs. This proximity is also

synonymous with short travel times to reach the PAs. One explanation for this situation is probably linked to movement insecurity in the study area (Ministry of Defence of Burkina Faso, 2019).

Table 4 also shows that compared to Bourou village, residing in Oualem or Tiakané influences the food security status of households. Indeed, these villages stand out in the estimates with positive and statistically non-zero coefficients. Thus, households in these villages are more likely to experience food insecurity than those in Bourou village.

Five variables are significant considering the regression of the HFIAS on the socioeconomic factors of households. Some of the significant variables in the HDDS regression model retain their influence in the HFIAS regression. These are the economic dependence on NTFP and the education of the HH. In addition, the duration of food deficit experienced by the household, the adherence of the HH to a FUG, and the fact that a HH is a resident of Kollo Village compared to Bourou Village have significant effects on food security in the regression of the HFIAS.

The duration of the food deficit carries a positive coefficient in explaining the manifestations of food insecurity captured by the HFIAS. It shows that households with several months of cereal deficit are more likely to be food insecure. Also, compared to the village Bourou, households residing in Kollo are more likely to experience food insecurity as measured by the HFIAS. The odds ratio associated with the 'Kollo' modality of the multinomial variable 'village' equals 3.75. Thus, living in Kollo is four times more likely to experience food insecurity than in Bourou.

The HH's membership in a FUG has a positive and significant relationship with the manifestations of food insecurity in the household. FUGs are spaces for exchange for their members. It also appears from Table 4 that the HH's education is significant in the explanation of the HFIAS scores. Its negative coefficient shows that households with literate HHs are less likely to experience food insecurity than non-educated HHs.

5 Conclusions

This article aims to analyse the effects of NTFP exploitation on the food security of rural households in the villages bordering corridor No. 1 of PONASI-PAC. The data come from a sample of 263 randomly selected households. Two food security indicators at the household level were calculated: the HDDS and the HFIAS. These indicators were regressed on households' characteristics using Logit models. The results showed that including NTFPs in the HDDS calculation significantly increased the number of food groups consumed by households, making them more likely to be more food secure. Results also showed that households that derived almost a quarter of their total income from this activity are more likely to live in food security, as measured by the number of food groups consumed in the last 24 hours. According to this criterion, nearly 70% of households are in a food security position. But, only 11% are food secure according to the HFIAS indicator.

The discrepancy between the values of the two food security indicators can be explained by the reference period for administering the two questionnaires. While the HDDS records the food groups consumed by households 24 hours before data collection, the HFIAS captures experiences of food insecurity and their occurrences over the four weeks preceding the collection. Thus, the results show that households manage to bring

together several food groups over 24 hours but find it challenging to get them together over four consecutive weeks.

Econometric regression by the logit model showed that economic dependence on NTFPs significantly explained the households' food security status. Explanation of food groups consumed by households showed that there is a quadratic relationship between economic dependence on NTFPs and the likelihood of a household experiencing food insecurity. However, a positive linear relationship has been established between this dependence and the number of signs of food insecurity.

The current article indicates that principally, NTFP exploitation, education status of the HH, household size and the location of households nearest protected areas are keys to boosting households' food security in rural Burkina Faso. Some constraints to achieving this food security are specific to the village localisation (next to a protected forest) in some rural areas.

As policy recommendations, it is essential to better integrate NTFPs into countries' food policies. Literacy of HHs would also lead to increased food security for their households. The current article tries to investigate the role of NTFP exploitation in households' food security status by measuring this food security only with two indicators: the HDDS, which measures food diversity and the HFIAS, which specialises in signs of food insecurity. In the future, the nutrition aspect of food security can also be considered to have a whole vision of NTFP's contribution to food security by integrating an appropriate indicator for this purpose.

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