

Analysis of the effects of non-timber forest products on food consumption expenditure by agricultural households in Burkina Faso: Empirical evidence of an endogenous switching model

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Abstract

The objective of this research was to assess the effects of non-timber forest products (NTFPs) on food consumption expenditure by agricultural households in the southwestern region of Burkina Faso. The empirical analysis is based on secondary data collected from 2 381 households during the 2018/2019 agricultural season. This research makes a major contribution to the economic literature by separately analysing the individual direct effects of NTFP exploitation and sales on household food consumption expenditure. Empirically, this research focuses on impact assessment using an endogenous switching model, estimated by the full information maximum likelihood method. The main results indicate, on the one hand, that the exploitation of NTFPs has a negative effect on household food consumption expenditure and, on the other hand, that the sale of NTFPs has a positive effect on household food consumption expenditure. Furthermore, the results highlight that the main determinants of the decision to exploit NTFPs differ from those of selling NTFPs. These results call into question the need to promote the sustainable management of agroforestry products and the development of marketing chains associated with NTFPs.

Key words: Burkina Faso, endogenous switching model, food consumption expenditure, maximum likelihood method with complete information (MVIC), non-timber forest products (NTFPs)

1. Introduction

The prevalence of food insecurity in Burkina Faso has exhibited a concerning escalation, increasing from 38.9% of the population being affected between 2018 and 2019 to 40.7% during the period between 2021 and 2022 (INSD 2024). The persistent deterioration of the situation can be attributed to two interconnected factors: low agricultural production (M'Kiabi *et al.* 2015) and household poverty, which limit the financial capacity of households to access food (Somé & Jones 2018). Food insecurity is defined as the lack of constant and universal access to adequate food for a healthy and active life (FAO 1996). Consequently, diversifying food and income sources is predicted to enhance household food security. In the context of Burkina Faso, some households use non-timber forest products (NTFPs) as a strategy to diversify their sources of monetary income and food (Leßmeister *et al.* 2016; Sawadogo 2023). Non-timber forest products (NTFPs) have an influence on food consumption expenditure, a direct reflection of economic access to food (World Bank Center for Development Data [C4D2] 2020). These products refer to any good of biological origin, other than wood and wildlife, derived from forests and trees outside forests, consisting of spontaneous, domesticated plants and those intended for reforestation (Ministère de l'environnement et du développement durable [MEDD] 2012).

A number of theories have been advanced to establish an explicit link between NTFPs and food security. First, Walrasian general equilibrium theory (Walras 1874) posits that markets are interconnected through price-induced adjustments in supply and demand. According to this theory, NTFPs traded in the market are considered goods or services that have a price. The income derived from this sale is the primary factor influencing food consumption expenditure. Secondly, the agricultural household theory, developed by Singh *et al.* (1986), establishes an explicit link between NTFPs and food consumption expenditure. This theory posits that households are to be regarded as integrated units of production and consumption, with decisions being made based on socio-economic characteristics. According to these theories, NTFPs impact food security by serving as a direct source of food supply for households and as a source of income, both of which, in turn, influence household food consumption expenditure.

In line with these theories, several studies have examined the effects of NTFPs on certain development indicators (Abdulla 2013; Suleiman *et al.* 2017; Widianingsih *et al.* 2019; Sawadogo 2023; Sawadogo *et al.* 2025; Thiombiano 2025). For example, Abdulla (2013) showed that NTFP exploitation improved income and food security in Ethiopia. Similar findings on food security are reported by Sawadogo (2023) in the case of Burkina Faso. Suleiman *et al.* (2017) also show that NTFP exploitation improved agricultural income in Nigeria. Other studies show that NTFP exploitation reduces poverty levels among rural households (Sawadogo *et al.* 2025). Furthermore, looking at the effects of NTFP sales, Widianingsih *et al.* (2019) show that NTFP sales contribute to household income in Indonesia. Thiombiano (2025) finds that short and medium marketing channels significantly improve household food security compared to long channels.

A thorough analysis of these studies shows that they examine the link between NTFPs and certain development indicators other than household food consumption expenditure. Examining NTFPs in relation to food consumption expenditure provides a complementary perspective on households' ability to have physical and economic access to food. The main empirical gap also lies in estimating the distinct causal effects of exploitation and sales of NTFP on food consumption expenditure in accordance with agricultural household theory. Empirically, taking both effects into account makes it possible to determine whether households substitute self-consumed food for market expenditure, or whether they use NTFP income to increase their food budget. This approach avoids confusion bias

when correlated, but independent factors influence both household food expenditure and the understanding of the magnitude of each mechanism.

The southwestern region of Burkina Faso provides an important setting for investigating the effects of NTFP exploitation and sales on household food consumption expenditure. NTFPs play a crucial role in the subsistence strategies of rural households, often acting as a food safety net and source of income in this region. Indeed, this region is among the most affected by poverty (INSD 2021). More than a third (38.9%) of its population lives below the poverty line (INSD 2023). According to the INSD (2023), the incidence of poverty is significantly higher (41.4%) in rural areas, where the main activity is agriculture. Faced with low agricultural yields caused by climatic hazards, NTFPs are emerging as a vital alternative source of income and subsistence, offering crucial diversification of livelihoods for households in this region. The study of this phenomenon is all the more relevant, given that 79.21% of households exploit NTFPs and 54.80% sell them, demonstrating their central role in the economic resilience and food security of the region.

To this end, the present research aims to answer the following research question: What are the effects of NTFPs on the food consumption expenditure of agricultural households in Burkina Faso? The objective of this research was to analyse, on the one hand, the effects of NTFP exploitation on the food consumption expenditure of agricultural households and, on the other hand, the effects of NTFP sales on the food consumption expenditure of agricultural households in Burkina Faso.

Empirically, this research favours the use of the endogenous switching model to address the direct individual effects of NTFP exploitation and sales on food consumption expenditure in Burkina Faso. This impact assessment model offers decisive advantages by explicitly addressing selection bias and endogeneity in household decisions. This research focuses on selection bias related to observable and unobservable factors that affect both the decision to exploit NTFPs and food consumption expenditure on the one hand, and the decision to sell NTFPs and household food consumption expenditure on the other. These unobservable household factors lead to a situation of endogeneity. The ESR model, which is an improvement on Heckman's (1979) two-step method, resolves the problems of endogeneity, selection bias and heterogeneity, while estimating several equations – the first being a selection equation and the second a result equation.

The rest of this article is organised as follows: The second section outlines the research methodology, while the third presents and discusses the econometric results. The final section draws conclusions and offers economic policy implications.

2. Research methodology

This section details the empirical model, as well as the sources and method of data collection.

2.1 Empirical model

This research used the endogenous switching model (ESR) to test the individual effects of NTFP exploitation and sales on household food consumption expenditure. This model is based on the analysis of two distinct groups: households that choose to participate in a given activity (the 'selected' group) and households that do not participate (the 'non-selected' group). To estimate this impact correctly, the ESR generally follows a three-step procedure, as described by Zereyesus *et al.* (2017). The first step is to estimate a selection equation using a probit model. This equation determines the factors that influence the probability of a household 'selecting' itself into one or the other group. Based on the results of this probit equation, the inverse Mill's ratio (IMR) values were calculated.

These IMRs are crucial because they capture potential selection bias. The second step involved estimating the outcome equations for each of the two groups (participants and non-participants). These equations explain the variable. The IMRs calculated in step 1 were included as additional regressors in each outcome equation. Including the IMR corrects for selection bias, ensuring that the estimated effects on the variable of interest are causal and not due to unobserved differences between groups. The third step was to use these estimates to calculate the specific treatment effects.

The estimation of the endogenous switching regression (ESR) model is crucial for analysing the impact of a treatment by correcting for selection bias. Rather than using two-stage least squares, we favoured the maximum likelihood method with full information (MVIC), as it allows for the simultaneous estimation of selection and outcome equations, ensuring robust standard deviations (Lokshin & Sajaia 2004). This approach, based on the normality of the error terms, assesses the effects of the treatment on the treated and untreated populations. For identification, an instrumental variable is required; in our study, this is the number of agroforestry trees per family farm.

In this research, we estimated an ESR model of the effects of NTFP exploitation on household food consumption expenditure and an ESR model of the effects of NTFP sales on the same expenditure. Equations (1), (2) and (3) present the selection and outcome model of the effects of NTFP exploitation, and equations (4), (5) and (6) present the effects of NTFP sales. The variables used across the different models are as follows: the dependent variable is food consumption expenditure (Food Cons); the primary treatment variables are decision to exploit NTFPs (Expl.PFNL) and decision to sell NTFPs (Sale.PFNL); the instrumental variable is number of agroforestry trees (Trees); and a set of control variables includes household wealth (Wealth), the ratio of inactive to active members (Inactive/Active), the area of the cultivated plot (Plot), the sex of the household head (Sex), the age of the household head (Age), plot location (Plot_loc), access to agricultural credit (Credit), use of mechanised ploughing (Ploughing), and use of paid labour (Labour).

For model identification, the variable ‘Trees’ is used as an exclusion restriction. It is included in the selection equation under the assumption that it directly influences the decision to participate in NTFP activities, but only indirectly affects food consumption expenditure through this participation decision.

- The selection model of the effects of NTFP exploitation is presented by Equation (1), with equations (2) and (3) being the respective outcome equations for households that exploit NTFPs and households that do not.

$$\text{Expl. PFNL} = \beta_0 + \beta_1 \text{Labor} + \beta_2 \text{Wealth} + \beta_3 \frac{\text{Inactive}}{\text{Active}} + \beta_4 \text{Plot} + \beta_5 \text{Sex} + \beta_6 \text{Age} + \beta_7 \text{Plot_loc} + \beta_8 \text{credit} + \beta_9 \text{Ploughing} + \beta_{10} \text{Trees} + v \quad (1)$$

$$\ln \text{Food Cons1} = \alpha_0 + \alpha_1 \text{Labor} + \alpha_2 \text{Wealth} + \alpha_3 \frac{\text{Inactive}}{\text{Active}} + \alpha_4 \text{Plot} + \alpha_5 \text{Sex} + \alpha_6 \text{Age} + \alpha_7 \text{Plot_loc} + \alpha_8 \text{credit} + \alpha_9 \text{Ploughing} + \varepsilon_1, \text{ if Expl. PFNL} = 1 \quad (2)$$

$$\ln \text{Food Cons0} = \alpha_0 + \alpha_1 \text{Labor} + \alpha_2 \text{Wealth} + \alpha_3 \frac{\text{Inactive}}{\text{Active}} + \alpha_4 \text{Plot} + \alpha_5 \text{Sex} + \alpha_6 \text{Age} + \alpha_7 \text{Plot_loc} + \alpha_8 \text{crédit} + \alpha_9 \text{Ploughing} + \varepsilon_0, \text{ if Expl. PFNL} = 0 \quad (3)$$

- The selection model of the effects of NTFP sales is presented by Equation (4), while equations (5) and (6) are the equations for the results of households that sell NTFPs and those that do not, respectively.

$$\text{Sale PFNL} = \gamma_0 + \gamma_1 \text{Labor} + \gamma_2 \text{Wealth} + \gamma_3 \frac{\text{Inactive}}{\text{Active}} + \gamma_4 \text{Plot} + \gamma_5 \text{Sex} + \gamma_6 \text{Age} + \gamma_7 \text{Plot_loc} + \gamma_8 \text{credit} + \gamma_9 \text{Ploughing} + \gamma_{10} \text{Expl. PFNL} + \gamma_{11} \text{Trees} + u \quad (4)$$

$$\ln \text{Food Cons1} = \theta_0 + \theta_1 \text{Labor} + \theta_2 \text{Wealth} + \theta_3 \frac{\text{Inactive}}{\text{Active}} + \theta_4 \text{Plot} + \theta_5 \text{Sex} + \theta_6 \text{Age} + \theta_7 \text{Plot_loc} + \theta_8 \text{credit} + \theta_9 \text{Ploughing} + \theta_{10} \text{Expl. PFNL} + \mu_1, \text{ if Sale PFNL} = 1 \quad (5)$$

$$\ln \text{Food Cons0} = \theta_0 + \theta_1 \text{Labor} + \theta_2 \text{Wealth} + \theta_3 \frac{\text{Inactive}}{\text{Active}} + \theta_4 \text{Plot} + \theta_5 \text{Sex} + \theta_6 \text{Age} + \theta_7 \text{Plot_loc} + \theta_8 \text{credit} + \theta_9 \text{Ploughing} + \mu_0, \text{ if Sale PFNL} = 0 \quad (6)$$

After estimating the selection equations and outcome equations, the treatment effects (T) in each case were obtained using the following equations:

- Average treatment effect on the treated (ATT): this measures the average effect of the treatment on individuals who actually received it.

$$ATT = E(Y0 - Y1|T = 1), \text{ with } Y0 = \ln \text{ Food Cons, if } T = 0 \text{ and } Y1 = \ln \text{ Food Cons, if } T = 1$$

- Average treatment effect on the untreated: This estimates the average effect that the treatment would have had on individuals who did not receive it.

$$ATU = E(Y1 - Y0|T = 0)$$

- Average treatment effect: The ATE measures the average effect of the treatment on the entire population (treated and untreated).

$$ATE = E(Y1 - Y0)$$

Table 1 summarises the variables used in the different models.

Table 1: Summary of variables used

Variables	Measurements
Food consumption expenditure (Food Cons)	Amount of money in CFA francs
Decision to exploit NTFPs (Expl.PFNL)	1 if the household exploits NTFPs, 0 otherwise
Decision to sell NTFPs (Sale PFNL)	1 if the household sells NTFPs, 0 otherwise
Trees	Number of agroforestry trees
Wealth	1 if the household sleeps in a concrete block house, and 0 if not.
Inactive/Active	Number of inactive people out of the total number of active people
Area of the cultivated plot (plot)	Hectare (ha)
Sex	1 if the head of household is female, 0 otherwise
Age	In years
Plot_loc	1 if plot location = bush or camp, 0 otherwise
Agricultural credit (credit)	1 if the household received agricultural credit, 0 otherwise
Mechanised ploughing (Ploughing)	1 if mechanised ploughing, 0 otherwise
Paid labour (Labour)	1 if the household employed labour, 0 otherwise

Source: Authors

2.2 Data source and collection method

This study is based on data from the Permanent Agricultural Survey (EPA) for the 2018/2019 agricultural season in Burkina Faso, conducted by the General Directorate of Sector Studies and

Statistics (DGESS). The survey used a two-stage stratified random sampling design. In the first stage, all administrative villages were grouped into four strata based on farm size and village agricultural potential. A total of 887 villages were selected from these strata using probability proportional to size (PPS) sampling. In the second stage, which followed the stratification defined in the first stage, farm households in each selected village were selected using simple random sampling. This process produced a sample of 5 322 farm households for the southwestern region. Data collection was conducted from June 2018 to December 2019 (INSD 2019).

The initial sample for the southwestern region comprised 5 322 households. The final analytical sample of 2 381 households was obtained after the following steps: (1) merging relevant data files (household, plot and NTFP modules) that have different sample sizes, the smallest of which was 3 100 observations; (2) limiting the sample to households that provided complete information on all variables essential to our model (food expenditure, NTFP exploitation/sale, land area, demographic composition, etc.); and (3) identifying and removing extreme outliers in continuous variables (e.g., the top and bottom 1% of the food expenditure and land area distributions) to reduce the influence of implausible values on the estimates.

3. Presentation and discussion of econometric results

A descriptive analysis is presented in this section, and the results of the econometric estimates are discussed.

3.1 Descriptive analysis

Table 2 presents descriptive statistics for the qualitative variables, revealing several characteristics of the households. A large majority (79.21%) of households exploited non-timber forest products (NTFPs), while 20.79% did not. With regard to commercialisation, 54.81% of households sold NTFPs compared to 45.19% that did not. Furthermore, the data indicate a predominance of male heads of household (93.78%) and a low percentage (15.25%) of households with a high level of wealth. Most households (80.79%) did not employ paid labour, and 39.40% had farms located far from their place of residence. Finally, access to credit was limited, with only 22.22% of households having access to it, and 43.18% practised mechanised farming.

Table 2: Descriptive statistics for qualitative variables

Variable	Description	Frequency (%)
Sale PFNL	Yes = 1	54.81
	No = 0	45.19
Expl. PFNL	Yes = 1	79.21
	No = 0	20.79
Sex	Female = 1	6.22
	Male = 0	93.78
Plot_loc	Remote farm = 1	39.40
	Not distant = 0	60.60
Labour	Yes = 1	19.21
	No = 0	80.79
Wealth	High level = 1	15.25
	Low level = 0	84.75
Ploughing	Mechanised ploughing = 1	43.181
	Manual labour = 0	56.82
Credit	Yes	22.22
	No	77.78

Source: Authors

Table 3 compares the descriptive statistics of the quantitative variables between households that exploited NTFPs and households that did not exploit NTFPs. The average age of the household heads was 50 years, with a significant difference (51 for households that exploited NTFPs versus 48 for households that did not exploit NTFPs). The average dependency ratio (inactive/active) was 2, with no significant difference between the groups. The average farm size was 6.116 hectares, with a significant difference in favour of households that exploited NTFPs (6.480 ha versus 5.796 ha). Farmers' farms also had more agroforestry trees (68 versus 52). Regarding food consumption expenditure, the average was 1 088 CFA francs, but curiously, non-farmers spent more (1 104 CFA francs) than farmers (1 025.59 CFA francs).

Table 3: Test for comparing the means of quantitative variables between groups relating to the exploitation of NTFPs

Variables	Total observations (2 381)			Households that exploited NTFPs (1 886)	Households that did not exploit NTFPs (495)	Difference in means
	Average	Min	Max	Average	Average	
Inactive/active	1.838	0	28	1.935	1.991	0.651
Plot	6.116	0.098	24.61	6.480	5.796	-0.684***
Age	49.453	21	88	51.123	47.979	-3.144***
Food Cons	1 087.73	0	10 954	1 025.59	1 104.039	78.44881
Trees	59.468	0	358	67.698	52.207	-15.491***

Source: Authors

Table 4 compares the descriptive statistics of the quantitative variables between households that sold NTFPs and those that did not. Heads of households that sold NTFPs were significantly older (51.42 years old compared to 47 years) and owned larger farms (6.63 ha compared to 5.55 ha), with significant differences at 1%. The number of agroforestry trees was similar (around 60 trees in both groups), and the average dependency ratio was 2, with no significant difference. Notably, food consumption expenditure (Food Cons) was much higher among NTFP sellers (2 014 297 FCFA) than among non-sellers (746 292 FCFA).

Table 4: Comparison test of the means of quantitative variables between groups relating to the sale of NTFPs

Variables	Total observations (2 381)			Sellers (1 305)	Non-sellers (1 076)	Difference in means
	Average	Min	Max	Average	Average	
Inactive/active	1.838	0	28	1.963	1.967	0.004***
Plot	6.116	0.098	0.490	6.63	5.55	-1.079***
Age	49.453	21	88	51.42	47	-4.066 ***
Food Cons	1 087.73	0	10 954	2014.29	746.292	-1268 ***
Trees	59.468	0	358	60	59	-1***

Source: Authors

3.2 Presentation of econometric results

This section, which is divided into two parts, details the results of this research. The first part analyses the effects of NTFP exploitation on household food consumption expenditure, while the second focuses on the effects of NTFP sales on this same expenditure.

3.2.1 Results of the effects of NTFP exploitation on household food consumption expenditure

In this section we focus on analysing the results equations concerning food consumption expenditure and the associated treatment effects. Table 5 presents the results of the effects of NTFP exploitation

on household food consumption expenditure. Columns 1, 2 and 3 present the results of the households' decision to exploit NTFPs, the consumption expenditure for households that did not exploit NTFPs and for those that exploited NTFPs, respectively.

An analysis of Table 5 shows that the model fits well, as evidenced by the Wald test (60.36***), which rejects the null hypothesis of zero coefficients. The independence tests confirm a significant dependence between the outcome and selection equations, with an LR test (1 279***) rejecting the hypothesis of independence. The significance of the covariance terms (ρ_0 and ρ_1) validates the presence of selection bias, justifying the use of an endogenous switching model. The results in column 1 reveal that the number of agroforestry trees, the demographic dependency ratio (inactive to active population), the gender of the household head, access to credit, the area of the cultivated plot, the type of plot location and mechanised ploughing are the factors that significantly influence households' decisions to exploit NTFPs.

Table 5 reveals an interesting contrast regarding the influence of household wealth on food consumption expenditure, depending on whether households exploited NTFPs or not. For households that did not exploit NTFPs, a high level of wealth is associated with higher food consumption expenditure and is not significant for those that exploited. This contrasting effect of wealth highlights a fundamental difference in how resources are allocated. For households not exploiting NTFPs, higher wealth translates directly into greater food consumption expenditure, as their financial resources are likely used to purchase more or higher quality food from the market. In contrast, for households that do exploit NTFPs, their wealth level showed no significant link to food spending. This suggests that these households may use their additional resources not to increase market-based food consumption, but to invest in other priorities such as education, health care or productive assets for their farm or NTFP activities. Otherwise it could be that they simply are more reliant on self-consumption from their diversified resources, making their food consumption less dependent on monetary wealth and market purchases.

The results also indicate that an increase in the demographic dependency ratio (more inactive people per active person) leads to an increase in food expenditure for households that exploited NTFPs and for those who did not exploit NTFPs. The consistent positive and significant effect of the dependency ratio (Inactive/Active) on food expenditure for both groups underscores a fundamental demographic pressure that transcends livelihood strategies. A higher ratio, indicating more dependants per working-age member, universally increases the household's caloric and nutritional requirements. This demographic reality forces all households, regardless of their engagement in NTFP exploitation, to allocate a greater share of their resources to meeting basic food needs, thereby directly driving up their food consumption expenditure. This result highlights that the sheer number of mouths to feed is a primary and inescapable determinant of a household's food budget.

Mechanised ploughing had a divergent effect on household food consumption expenditure. The divergent impact of mechanised ploughing on food expenditure underscores the distinct livelihood strategies between households. For those not exploiting NTFPs, mechanised ploughing likely enhanced agricultural productivity and marketable surplus, generating income that is directly channelled into increased food purchases. In contrast, for households that exploit NTFPs, mechanised ploughing is associated with a significant decrease in food expenditure. This suggests that, for these households, the capital invested in ploughing is part of a broader investment strategy focused on enhancing productive capacity (either in agriculture or NTFP activities), rather than on immediate consumption. This reallocation of resources towards production investments reduces their reliance on the market for food, likely due to a greater emphasis on self-consumption from their diversified livelihood sources.

The divergent impact of remote plot location (Plot_loc) reveals a critical difference in how households manage distance and resources. For households that did not exploit NTFPs, a distant plot significantly increased food expenditure. This is likely due to the higher transaction costs associated with remoteness, such as increased transportation expenses for getting produce to market or for traveling to purchase food, which inflates the overall cost of securing nourishment. In contrast, for households that exploited NTFPs, a remote plot location was associated with lower food spending. This suggests that these households are strategically leveraging their location; the remote areas, often closer to forests, provide better access to NTFPs, which are then used for direct consumption. This self-provisioning acts as a buffer, reducing their need to purchase food and effectively offsetting the additional costs and inconveniences of their remote location.

Table 5: Effects of NTFP exploitation on household food consumption expenditure

	1	2	3
Variables	Expl. NTFP	Ln Food Cons0	Ln Food Cons1
Trees	0.001*** (0.001)		
Ploughing	-0.086*** (0.0)	0.276*** (0.1)	-0.399*** (0.1)
Labour	0.256 (0.014)	0.158 (0.02)	-0.256 (0.145)
Wealth	-0.021 (0.058)	0.168** (0.109)	0.083 (0.268)
Inactive/Active	0.021*** (0.007)	0.027* (0.016)	0.107*** (0.031)
Plot	-0.086 (0.035)	0.276 (0.088)	-0.399 (0.154)
Sex	0.662*** (0.036)	-1.425 (0.05)	1.180 (0.02)
Age	-0.0001 (0.002)	-0.002 (0.004)	0.011 (0.008)
Plot_loc	-0.096** (0.056)	0.279*** (0.115)	-0.417** (0.245)
Credit	-0.129** (0.049)	0.382 (0.128)	-0.334 (0.229)
Constant	-0.522*** (0.092)	2.134*** (0.206)	-1.071** (0.452)
lns0		0.943*** (0.038)	
lns1		1.495*** (0.057)	
rho0		-3.796*** (0.669)	
rho1		3.745*** (0.173)	
Observations		2 381	
LR test Chi ²		1 279***	
Wald test Chi ²		74.10***	

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

Table 6 presents the results on the treatment effects with regard to the exploitation of NTFPs and food consumption expenditure of agricultural households in the southwestern region of Burkina Faso.

The results indicate that the average treatment effect on the treated (ATT) is significant and amounts to -0.519. The ATT represents the average difference between the food consumption expenditure observed among households exploiting NTFPs and what they would have spent if they had not chosen this activity. A value of -0.519 means that, by exploiting NTFPs, these households reduce their food consumption expenditure by an average of 51.9%, compared to a scenario in which they would not have exploited these products. More specifically, their participation in NTFP exploitation led to an average decrease of 51.9% in their food consumption expenditure compared to what it would have been if they had not exploited NTFPs. Such a result in this region of Burkina Faso could be explained by the fact that NTFP exploitation allows for greater self-consumption of foodstuffs, reducing the need for food purchases. In this sense, NTFPs could serve as direct food substitutes, thereby reducing expenditure on the purchase of certain food products. Studies such as those by Mukul *et al.* (2016), Partakson and Tomba (2017) and Talukdar *et al.* (2021) support this interpretation by showing that rural populations depend mainly on NTFPs for their direct subsistence, rather than for commercial gains. This conclusion corroborates the work of Suleiman *et al.* (2017), who observed in Nigeria that NTFPs are mainly used for subsistence, rather than as a major source of income. In such a context, households may consume NTFPs directly, or exchange them for other food items, thereby reducing their need for monetary purchases.

The results also indicate that the average treatment effect on the untreated (ATU) is statistically significant at -0.227. This means that, if non-exploiting households began exploiting NTFPs, they would reduce their food consumption expenditure by 22.7%. This result highlights the current dependence of non-exploitation on food purchases at the market. By integrating NTFP exploitation into their subsistence strategy, these households could ease their budgets by reducing their need for cash to purchase food, thanks to the self-consumption of NTFP products. Indeed, access to NTFPs would enable them to compensate for existing food deficits without increasing their monetary expenditure, in particular by providing direct nutritional supplements. This finding is highlighted by the work of Sawadogo (2023). The latter author notes that, by including NTFPs in the calculation of the food diversity score, the number of food groups consumed increases significantly. This confirms that NTFPs are actively consumed by households, which can consequently lead to a reduction in their food consumption expenditure by substituting purchased products with collected products.

The results also show that the average treatment effect (ATE) is statistically significant at -0.256. It estimates the average impact of non-timber forest product (NTFP) exploitation on food consumption expenditure for the entire population studied, i.e., considering both households that currently exploit NTFPs and those that do not. The result indicates that NTFP exploitation would lead to a reduction of -0.256 units in food consumption expenditure for a randomly selected household in the population. In the southwestern region, where approximately -0.256% of households exploit NTFPs, this phenomenon supports the idea of prioritising self-consumption and direct subsistence. Indeed, direct consumption of these products significantly reduces the need for market purchases, thereby freeing up monetary resources that would otherwise be allocated to food expenditure.

Table 6: Results of the effects of NTFP exploitation treatments

Variables	Coefficients (%)	P-values
ATT	-51.9	0.0000
ATU	-22.7	0.0000
ATE	-25.6	0.0000

Source: Authors

3.2.2 Results of the effects of NTFP sales on household food consumption expenditure

This section presents the results of the effects of NTFP sales on household food consumption expenditure. The analysis in Table 7 shows that the model fits well, as evidenced by the Wald test (86.77), which rejects the null hypothesis of zero coefficients. Independence tests confirm a significant dependence between the outcome and selection equations, with an LR test (880.22) rejecting the hypothesis of independence. The significance of the covariance terms (ρ_0 and ρ_1) validates the presence of selection bias, justifying the use of an endogenous switching model.

The results in column 1 reveal that the number of agroforestry trees, paid labour, the area of the cultivated, plot location, the demographic dependency ratio (inactive/active), access to credit and the exploitation of NTFPs are the variables that significantly influence the sale of NTFPs.

With regard to the results equations (Table 7), the results indicate that, for households that sell and those do not sell NTFPs, paid labour has a positive and statistically significant effect on their food consumption expenditure. The consistent positive influence of employing paid labour on food expenditure for both sellers and non-sellers of NTFPs underscores its role as a universal catalyst for enhancing household productivity. For households not selling NTFPs, hiring labour likely boosts agricultural output on their farms. This leads to a larger harvest, which translates into both greater food for self-consumption and a higher marketable surplus, the income from which is channelled into purchasing additional food. For households that sell NTFPs, investing in paid labour likely increases the efficiency and scale of their harvesting or processing activities. The resulting increase in income from the sale of these products is then allocated primarily to the household's food budget. In both cases, the decision to hire labour represents a strategic investment that ultimately enhances the household's capacity to generate resources for food consumption.

The analysis in Table 7 also reveals that access to agricultural credit influences food expenditure consumption negatively for households that do not sell NTFPs, and that it has a positive impact for those who sell. The diverging impacts of agricultural credit reveals a fundamental strategic difference in how households allocate borrowed capital. For households that do not sell NTFPs, access to credit provides crucial liquidity that is directed toward immediate consumption needs, resulting in a significant increase in food expenditure. This suggests that credit acts primarily as a tool for consumption smoothing, enabling these households to better meet their dietary requirements. In stark contrast, for households that sell NTFPs, access to credit is associated with a decrease in food spending. This indicates a more investment-oriented strategy; rather than being spent on immediate consumption, the borrowed capital is likely invested in productive assets or in activities that enhance their NTFP enterprises (e.g., better equipment, transportation or processing tools). This investment aims to boost future income and long-term resilience, temporarily reducing the funds available for current food purchases in favour of greater productive capacity.

The different impacts of remote plot location underscore the critical role of NTFP sales in mitigating the economic burdens of geography. For households that do not sell NTFPs, a distant plot exerts a significant negative influence on food consumption expenditure. The remoteness likely imposes high transaction costs, such as increased transportation expenses for taking goods to market and for travelling to purchase food, which effectively reduces the household's disposable income available for food purchases. In contrast, for households that engage in the sale of NTFPs, the location of their plot shows no significant effect on food spending. This suggests that the income generated from selling forest products provides a vital financial buffer, effectively offsetting the additional costs and logistical challenges associated with their remote location. The revenue from NTFP sales allows these

households to maintain their level of food expenditure, despite the potential economic disadvantages of their geographical position.

Another finding in Table 7 indicates that the exploitation of NTFPs has a negative effect on the food consumption expenditure of households that sell NTFPs. In fact, households that exploit and sell NTFPs are often also consumers of these products. They may increase their own consumption of NTFPs (fruits, leaves, game, etc.) during periods of abundance, thereby reducing their need to purchase other food items on the market. NTFPs then serve as direct substitutes for or supplements to purchased foods. In addition, the income derived from the sale of NTFPs by these households can be reinvested strategically. Rather than spending it on more food consumption, it can be allocated to improving NTFP exploitation (tools, processing techniques), investing in other income-generating activities, or non-food expenditures deemed to be priorities.

Table 7: Effects of the sale of NTFPs on household food consumption expenditure

Variables	1 Sale PFNL	2 ln Food Cons0	3 ln Food Cons1
Trees	0.003*** (0.001)		
Labor	-0.159*** (0.069)	0.481*** (0.167)	0.518*** (0.225)
Inactive/Active	0.017** (0.008)	0.032 (0.019)	-0.036 (0.024)
Wealth	-0.150 (0.257)	-0.314** (0.125)	0.254* (0.24)
Sex	0.155 (0.14)	-0.132 (0.014)	0.24 (0.033)
Plot	-0.103** (0.042)	0.159 (0.099)	0.116 (0.156)
Age	-0.00005 (0.002)	0.00001 (0.005)	0.0003 (0.007)
Plot_loc	0.090** (0.056)	-0.203** (0.133)	0.469 (0.179)
Credit	0.255*** (0.069)	-0.401*** (0.176)	1.106*** (0.147)
Expl. PFNL	0.249* (0.118)	0.001 (0.11)	-0.225* (0.130)
Ploughing	0.066** (0.0)	-0.109 (0.062)	-0.076 (0.176)
Constant	-0.372***	1.616	0.920***
lns0	1.0*** (0.057)		
lns1	0.8*** (0.037)		
Rho1	3.249** (0.169)		
Rho1	-0.409*** (0.102)		
Observations	2 381		
LR test Chi ²	880.22***		
Wald test Chi ²	86.77***		

*** = $p < 0.01$; ** = $p < 0.05$; * = $p < 0.1$

Table 8 presents the treatment effects with regard to the effects of NTFP sales on household food consumption expenditure. The results indicate that the average treatment effect on the treated (ATT) is significant and amounts to 0.492. This means that households that derive income from the sale of

NTFPs spend, on average, 49.2% more on food than they would have spent if they had not sold these products. Indeed, the sale of NTFPs generates increased income and purchasing power for these households, a dynamic that is particularly relevant in the southwestern region of Burkina Faso, where 54.81% of the population sells these products. The income generated by the sale of NTFPs is used to diversify food consumption, enabling the purchase of larger quantities of higher quality and more nutritious products, as well as more regular meals. In the face of food security concerns, this increase in income is logically directed primarily towards meeting basic food needs. This result is corroborated by the work of Melaku *et al.* (2014), who estimated that the main NTFPs in the Bonga forest area contributed 47% of household monetary income, thus highlighting the importance of these products as a source of cash.

The results in Table 8 also reveal an average treatment effect on the untreated (ATU) of 0.154, and this result is statistically significant. This means that, for households that do not currently sell non-timber forest products (NTFPs), their food consumption expenditure would increase if they began selling NTFPs by 15.4% on average compared to their actual food consumption expenditure. This result is particularly important because it sheds light on the potential impact of NTFP commercialisation on a population that is not yet engaged in it. For households that do not currently sell NTFPs, starting this activity would open up a new source of monetary income. This additional income would logically be allocated as a priority to meeting basic needs, particularly the purchase of food, which would enable them to improve the quantity, quality or diversity of their diet. This result corroborates the observations of Somé *et al.* (2024), conducted in the Bontioli wildlife reserves in southwestern Burkina Faso, which showed that households devote a significant portion of their NTFP income to food purchases. This is all the more relevant given that households that do not sell NTFPs are likely to face food shortages that they must compensate for by purchasing food on the market.

Another result from the table indicates that the average treatment effect (ATE) is positive and significant. This means that, on average, the sale of NTFPs would lead to a 18.7% increase in food consumption expenditure for a randomly selected household in the southwestern region of Burkina Faso. The result suggests that the sale of NTFPs acts primarily as a driver of improved food consumption for the overall population. Furthermore, this increase in spending could be explained by the fact that income from the sale of NTFPs facilitates households' access to a wider range of food products available on the market. This allows them to purchase foods that they cannot produce or collect themselves, thereby contributing to a diversification of their diet. This is particularly crucial in developing countries such as Burkina Faso, where access to markets, agricultural inputs and modern techniques are often limited for smallholders (Balana & Oyeyemi 2022). This finding is reinforced by the work of Thiombiano (2025), who demonstrated that short and medium marketing channels significantly improve household food security. He explains this phenomenon by the fact that reducing intermediaries in the sale of NTFPs allows households to maximise their monetary income, leading them to increase their food consumption expenditure.

Table 8: Results on the effects of treatments for the sale of NTFPs

Variables	Coefficient (%)	P-value
ATT	49.2	0.000
ATU	15.4	0.0000
ATE	18.7	0.0000

Source: Authors

4. Conclusion and economic policy implications

The objective of this research was to assess the effects of non-timber forest products (NTFPs) on food consumption expenditure in agricultural households in the southwestern region of Burkina Faso. The empirical analysis was based on secondary data collected by the DGESS through a survey of the 2018/2019 agricultural season. This research makes a major contribution to the economic literature by separately analysing the individual direct effects of NTFP exploitation and sales on household food consumption expenditure, a link that has not been explored in previous studies. Empirically, this research favours an impact assessment method using the endogenous switching model. The maximum likelihood method with complete information (MVIC) was used as the estimation method.

The results reveal that households' decisions to exploit NTFPs are significantly influenced by the number of agroforestry trees, the demographic dependency ratio (inactive to active), the gender of the household head, the level of wealth and access to credit. As for the sale of NTFPs, it is determined significantly by the number of agroforestry trees, the wealth level of the head of household, the area of cultivated land, the demographic dependency ratio, the age of the household head, access to credit and the exploitation of NTFPs themselves.

An analysis of the effects of treatment on food consumption expenditure reveals distinct effects depending on households' involvement in NTFP activities. On the one hand, NTFP exploitation has a significant negative effect on food consumption expenditure, both for current harvesters and potential non-harvesters, suggesting that exploitation contributes to a decrease in household food consumption expenditure through self-consumption and reduced monetary purchasing needs. On the other hand, the sale of NTFPs shows a positive and significant effect on food expenditure, both for households that already engage in it and for those that could engage in it, indicating that the commercialisation of NTFPs increases the overall food purchasing power of households. The average treatment effect confirms these overall trends for the population.

These results suggest differentiated economic policies. With regard to the effects of NTFP exploitation, the results suggest implementing sustainable management policies for agroforestry trees and collection areas. This includes raising awareness of good exploiting practices to avoid overexploitation, promoting natural regeneration, and establishing protection zones through community participation. In addition, it would be beneficial to promote and encourage the integration of NTFPs into the daily diet through awareness campaigns on their nutritional value. With regard to the effects of NTFP sales, the results suggest facilitating and professionalising the marketing chain for these products. This could include improving access to local and regional markets, building rural roads and reducing barriers to trade. In addition, in order to boost income from sales, it is essential to support households in NTFP processing and valorisation activities.

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