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

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Abstract

The objective of this research is to assess the effects of Non-Timber Forest Products (NTFPs) on food consumption expenditure in agricultural households in the South-West 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 analyzing 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 impact on household food consumption expenditure and, on the other hand, that the sale of NTFPs has a positive impact 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 agro-forestry products and the development of marketing chains associated with NTFPs.

Keywords: Non-Timber Forest Products (NTFPs); Food consumption expenditure; Endogenous switching model; Maximum likelihood method with complete information (MVIC); Burkina Faso.

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1- Introduction

The prevalence of food insecurity in Burkina Faso has exhibited a concerning escalation, increasing from 38.9% of the population affected between 2018 and 2019 to 40.7% during the period 2021-2022 (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 limits their financial capacity 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 (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 (MEDD, 2012).
A number of theories have been advanced to establish an explicit link between non-timber forest products (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 on 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 and 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 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) shows that NTFP exploitation improves 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 improves agricultural income in Nigeria. Other studies show that NTFP

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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 NTFP exploiting and sales 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 understanding the magnitude of each mechanism.

The southwestern region of Burkina Faso provides an important setting for investigating the effects of NTFP exploiting 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 for 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 same source, 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 this 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 is to analyze, 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.

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Empirically, this research favors the use of the endogenous switching model to address the direct individual effects of NTFP exploiting 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 organized into four parts. The first presents the economic literature on the effects of non-timber forest products on food consumption expenditure. The second outlines research methodology. The third presents and discusses the econometric results. Finally, the fourth part draws conclusions and economic policy implications.

2- Economic literature on the effects of non-timber forest products on food consumption expenditure.

2.1- Review of theorical literature

Non-timber forest products (NTFPs) play a complex role in food security, interpreted differently according to economic theories. Walrasian general equilibrium theory (Walras, 1874) posits that markets are interconnected through price-induced adjustments in supply and demand. In line with this theory, NTFPs are considered economic goods integrated into the market and operated by a price mechanism: income from the sale of NTFPs eases household budget constraints, allowing them to purchase more food. This theory is market-based and only considers consumers with purchasing power (Padilla, 1992). According to this theory, NTFPs influence food consumption expenditure only through market dynamics.

The agricultural household theory developed by Singh et al. (1986) also establishes an explicit link between NTFPs and food consumption expenditure. This theory integrates producer theory and consumer theory by considering households as integrated units of production and consumption that make decisions based on socio-economic characteristics. In line with producer theory, households engaged in activities such as NTFPs function as producers who use a set of inputs to produce several

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different types of products or services. The income generated from the sale of NTFPs directly improves household food security by giving them the means to purchase food on the market and reducing their budgetary pressures. This income is also important because it finances the inputs needed to transform collected NTFPs into food for consumption. As a consumption unit, a significant portion of NTFPs is also consumed directly by the household itself, entering into its utility function as a source of nutrition. Thus, NTFPs supplement self-consumed diets and generate monetary income when sold, smoothing food expenditures and recursively stabilizing consumption in the face of agricultural shocks (Chayanov, 1925; Nakajima, 1969). According to these theories, NTFPs affect food security as a direct source of food supply for households and a source of income, both of which influence household food consumption expenditure.

2.2- Review of empirical literature

Several studies have examined the effects of NTFPs on certain development indicators, particularly through the effects of their exploitation (Abdulla, 2013; Suleiman et al., 2017; Sawadogo, 2023; Sawadogo et al., 2025) and the effects of their sales (Widianingsih et al., 2019; Thiombiano, 2025).

With regard to the effects of NTFP exploitation, Abdulla (2013) uses a binary logistic regression model to show that NTFP exploitation has a positive impact on household income and food security in Ethiopia. He explains this result by the fact that NTFP collection contributes to subsistence food production and that the monetary income derived from NTFPs allows households to invest in food crops. Furthermore, Suleiman et al. (2017) in the case of Nigeria, find through the ANOVA (analysis of variance) method that households exploit NTFPs mainly for subsistence rather than to generate cash income. Furthermore, Sawadogo (2023), using binary logistic regression and ordered multinomial logistic regression, shows that NTFP exploitation improves food security in Burkina Faso. Other studies show that NTFP exploitation reduces poverty levels among rural households (Sawadogo et al., 2025).

With regard to the effects of NTFP sales, the study of Widianingsih et al. (2019) show, using an ANOVA method, that the sale of NTFPs contributes to household income in Indonesia. Using an ordered logit model for municipalities in Burkina Faso, Thiombiano (2025) finds that short and medium marketing channels significantly improve household food security compared to long channels. He explains these results by the fact that reducing the number of intermediaries in the sale of NTFPs significantly increases the income of selling households. An in-depth analysis of this work

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reveals an unexplored link between the effects of sales and the effects of NTFP exploitation on household food consumption expenditure.

3- Research methodology

This section details the data analysis method, as well as the source and method of data collection.

3-1 Data analysis method

The section is structured around two points: the theoretical model and the empirical model.

3.1.1- Theoretical model

The theoretical model adopted is in line with Singh et al. (1986), which allows for the analysis of household production and consumption decisions. It assumes that agricultural households maximize their utility (a function of consumption and leisure) under constraints of time, income, and production. This framework is complemented by the approach of Huffman et al. (1991) for the allocation of labor in agricultural households, applied in particular by Zereyesus et al. (2017), Seng (2015), and Owusu et al. (2011). According to this approach, a farming household allocates his time to different activities to maximize its utility, subject to time, budget, production, and non-negativity constraints.

The utility function is expressed as follows:

$$U = U\ (C, l) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where 'l' represents leisure activities and 'C' represents household consumption of goods such as food.

In the case of NTFP exploiting, farming households divide their total time allocation between agricultural work, NTFP exploiting, and leisure activities. Thus, the household's time constraint is:

$$T = L_0 + L_{1E} + l\ , L_0 \geq 0, L_{1E} \geq 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where T represents total household time allocation, l represents leisure time, L_0 represents time spent on agricultural work, and L_{1E} represents time spent on NTFP exploiting.

Based on the studies of Zereyesus et al. (2017), Seng (2015), and Owusu et al. (2011), the theoretical model is as follows:

$$\mathrm{P_c C} + \mathrm{w_r} l = \mathrm{w_r T} + \Pi + \mathrm{w_{ex} L_{1E}} + \mathrm{M} \ldots\ldots\ldots\ldots \quad (3)$$

The key variables in the model are defined as follows: $\mathrm{P_c}$: the unit price of food consumer goods. $\mathrm{w_r}$: the household reservation wage rate (the minimum income that a household member would need to earn in order to accept a job outside their current activities). $\mathrm{w_{ex}}$: the wage rate for work specifically dedicated to the exploitation of Non-Timber Forest Products (NTFPs).

By subtracting total household consumption expenditure, we obtain:

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$P_cC = w_r(T - l) + \pi + w_{ex}L_{1E} + M$ ……. (4)

- P_cC, represents household food consumption expenditure
- $w_{ex}L_{1E}$, represents total remuneration obtained from the exploitation of NTFPs**.**
- Π represents agricultural profit
- $w_r(T - l)$, is income from other productive activities.
- M, exogenous income.

In the case of sales, household food consumption expenditure is expressed as follows:

$P_CC = w_r(T - l) + \pi + w_{ven}L_{1ven} + M$ ……. (5)

- $w_{ven}L_{1ven}$, is the income generated from the sale of NTFPs.

3.1.2- Empirical model

This research uses the endogenous switching model (ESR) to test the individual effects of NTFP exploiting 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. Based on the results of this Probit equation, the inverse Mill's ratio (IMR) values are calculated. These IMRs are crucial because they capture potential selection bias. The second step involves 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 are 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 is to use these estimates to calculate the specific treatment effects.

The estimation of the Endogenous Switching Regression (ESR) model is crucial for analyzing the impact of a treatment by correcting for selection bias. Rather than using Two-Stage Least Squares, we favor the Maximum Likelihood Method with Full Information (MVIC), as it allows for 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

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effects of the treatment on 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 estimate an ESR model on the effects of NTFP exploitation on household food consumption expenditure and an ESR model on the effects of NTFP sales on the same expenditure. Equations (6), (7), and (8) present the selection and outcome model on the effects of NTFP exploitation, and equations (9), (10), and (11) present the effects of NTFP sales.

- The selection model on the effects of NTFP exploitation is presented by equation (6), with equations (7) and (8) being the respective outcome equations for households that exploit NTFPs and households that do not.

$$\text{Expl. PFNL} = \beta_0 + \beta_1 \text{Labor} + \beta_2 \text{Wealth} + \beta_3 \frac{\text{Inactive}}{\text{Active}} + \beta_4 \text{Plot} + \beta_5 Sex + \beta_6 AGE + \beta_7 \text{Plot\_loc} + \beta_8 \text{credit} + \beta_9 \text{Plowing} + \beta_{10} \text{Trees} + \text{v} \ldots (6)$$

$$lnDep.cons = \alpha_0 + \alpha_1 \text{Labor} + \alpha_2 \text{Wealth} + \alpha_3 \frac{\text{Inactive}}{\text{Active}} + \alpha_4 \text{Plot} + \alpha_5 Sex + \alpha_6 AGE + \alpha_7 Plot_{loc} + \alpha_8 \text{credit} + \alpha_9 \text{ lowing} + \varepsilon_1, if\ Expl.PFNL = 1 \ldots \ldots (7)$$

$$lnDep.cons = \alpha_0 + \alpha_1 \text{Labor} + \alpha_2 \text{Wealth} + \alpha_3 \frac{\text{Inactive}}{\text{Active}} + \alpha_4 \text{Plot} + \alpha_5 Sex + \alpha_6 AGE + \alpha_7 \text{Plot}_{\text{loc}} + \alpha_8 \text{crédit} + \alpha_9 \text{Plowing} + \varepsilon_0, if\ Expl.PFNL = 0 \ldots \ldots (8)$$

- The selection model on the effects of NTFP sales is presented by equation (9), while (10) and (11) are respectively the equations for the results of households that sell NTFPs and those that do not.

$$\text{Sale PFNL} = \gamma_0 + \gamma_1 \text{Labor} + \gamma_2 \text{Wealth} + \gamma_3 \frac{\text{Inactive}}{\text{Active}} + \gamma_4 \text{Plot} + \gamma_5 Sex + \gamma_6 AGE + \gamma_7 \text{Plot\_loc} + \gamma_8 \text{credit} + \gamma_9 \text{Plowing} + \gamma_{10} \text{Expl. PFNL} + \gamma_{11} \text{Trees} + \text{u} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (9)$$

$$lnDep.cons = \theta_0 + \theta_1 \text{Labor} + \theta_2 \text{Wealth} + \theta_3 \frac{\text{Inactive}}{\text{Active}} + \theta_4 \text{Plot} + \theta_5 Sex + \theta_6 AGE + \theta_7 \text{Plot}_{\text{loc}} + \theta_8 \text{credit} + \theta_9 \text{Plowing} + \theta_{10} \text{Expl. PFNL} + \mu_1, if\ \text{Sale PFNL} = 1 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (10)$$

$$lnDep.cons = \theta_0 + \theta_1 \text{Labor} + \theta_2 \text{Wealth} + \theta_3 \frac{\text{Inactive}}{\text{Active}} + \theta_4 \text{Plot} + \theta_5 Sex + \theta_6 AGE + \theta_7 \text{Plot\_loc} + \theta_8 \text{credit} + \theta_9 \text{Plowing} + \mu_0, if\ \text{Sale PFNL} = 0 \ldots \ldots \ldots \ldots \ldots (11)$$

After estimating the selection equations and outcome equations, the treatment effects (T) in each case are 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.

$ATT = E(Y0 - Y1|T = 1)$, with Y0= lnDep.cons, if T=0 et Y1= lnDep.cons, if T=1

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- Average Treatment Effect on 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 summarizes the variables used in the different models.

Variables	Measurements
Food consumption expenditure (Dep.cons)	Amount of money in CFA francs
Decision to exploit NTFPs (Expl. PFNL)	1 if the household exploit 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 head of household has a high level of wealth, 0 otherwise
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
Mechanized plowing (Plowing)	1 if mechanized plowing, 0 otherwise
Paid labor (Labor)	1 if the household employed labor, 0 otherwise

Source: Authors

3.2- Data source and collection method

This research is based on data from the Permanent Agricultural Survey (EPA) for the 2018-2019 agricultural season in Burkina Faso, conducted by the Directorate General for Sectoral Studies and Statistics (DGESS) of the Ministry of Agriculture and Hydro-Agricultural Development (MAAH). The survey covered a sample of households spread across the entire country. Sampling was carried out using a two-stage stratified survey, with administrative villages as the primary units and agricultural households as the secondary units. The first-stage stratification determines the second-stage stratification. The primary units were selected using unequal probability sampling without replacement, resulting in a sample of 887 villages, with the probability of a village being selected

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proportional to its size in terms of number of households. The secondary units were selected by simple random sampling without replacement, resulting in a sample of 5,322 agricultural households for the Southwest region. Households in the same primary unit have the same probability of appearing in the sample. Data collection took place from June 2018 to December 2019 (INSD, 2019). As part of this research, three EPA 2018-2019 data files were merged using Stata software, which provided data on the variables used in the model. After merging, outliers were removed, resulting in a sample size of 2,381.

4- Presentations and discussions of econometric results

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

4.1- Descriptive analysis

Table 2 presents descriptive statistics for qualitative variables, revealing several characteristics of households. A large majority (79.21%) of households exploit Non-Timber Forest Products (NTFPs), while 20.79% do not. With regard to commercialization, 54.81% of households sell NTFPs, compared to 45.19% that do 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%) do not employ paid labor, and 39.40% have farms located far from their place of residence. Finally, access to credit is limited, with only 22.22% of households having access to it, and 43.18% practicing mechanized 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
Labor	yes=1	19,21
	No=0	80,79
Wealth	High level =1	15,25
	Low level =0	84,75
Plowing	Mechanized plowing =1	43,181.76
	Manual labor =0	56,82
Credit	yes	22,22
	No	77,78

Source: Authors

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Table 3 compares the descriptive statistics of quantitative variables between NTFP operators and non-operators. The average age of household heads is 50, with a significant difference (51 for operators versus 48 for non-operators). The average dependency ratio (inactive/active) is 2, with no significant difference between the groups. The average farm size is 6.116 hectares, with a significant difference in favor of operators (6.480 ha compared to 5.796 ha). Farmers' farms also have more agroforestry trees (68 compared to 52). Regarding food consumption expenditure, the average is 1,088 CFA francs, but curiously, non-farmers spend 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 (2381)			Operators (1 886)	Non-Operators (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***
Dep. Cons	1087.73	0	10954	1025.59	1104.039	78.44881
Trees	59,468	0	358	67,698	52,207	-15,491***

Source: Authors

Table 4 compares the descriptive statistics of quantitative variables between households that sell NTFPs and those that do not. Heads of households that sell NTFPs are significantly older (51.42 years old compared to 47 years old) and own larger farms (6.63 ha compared to 5.55 ha), with significant differences at 1%. The number of agroforestry trees is similar (around 60 trees in both groups), and the average dependency ratio is 2, with no significant difference. Notably, food consumption expenditure (dep. Cons) is much higher among NTFP sellers (2014,297 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 ***
Dep. Cons	1087.73	0	10954	2014,29	746,292	-1268 ***
Trees	59,468	0	358	60	59	-1***

Source: Authors

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4.2- Presentation of econometric results

This section, divided into two parts, details the results of this research. The first part analyzes the effects of NTFP exploitation on household food consumption expenditure, while the second focuses on the effects of NTFP sales on this same expenditure. Before presenting the results, a multicollinearity test was performed (Appendix 1). The values of the Variance Inflation Factor (VIF) for all explanatory variables are less than 10, and their average is less than 2. These indicators confirm the absence of multicollinearity between the variables in the model, ensuring the reliability of the estimates (Deressa et al., 2009).

4.2.1- Results on the effects of NTFP exploitation on household food consumption expenditure

This section focuses on analyzing the results equations concerning food consumption expenditure and the associated treatment effects. Table 5 presents the results on the effects of NTFP exploitation on household food consumption expenditure. Columns (1), (2), and (3) present the results on consumption expenditure for households that do not exploit NTFPs, those that do exploit NTFPs, and the results on households' decisions to exploit NTFPs, respectively.

Analysis of Table 5 shows that the model fits well, as evidenced by the Wald test (74.10***), which rejects the null hypothesis of zero coefficients. Independence tests confirm a significant dependence between the outcome and selection equations, with an LR test (1279***) rejecting the hypothesis of independence. The significance of the covariance terms (rho0=−3.796*** and rho1=3.745***) validates the presence of selection bias, justifying the use of an endogenous switching model. The results in column (3) reveal that the number of agroforestry trees, the demographic dependency ratio (non-working population to working population), the gender of the head of household, the level of wealth, and access to credit 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 exploit NTFPs or not. For households that do not exploit NTFPs, a high level of wealth is associated with higher food consumption expenditure. In contrast, among households that exploit NTFPs, a high level of wealth is linked to lower food consumption expenditure. For wealthier households that exploit NTFPs, the reduction in food expenditure could be explained by diversification of income sources or by self-consumption, making them less dependent on external purchases. In addition, these households may prioritize

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allocating additional funds to non-food expenditures (education, health, investments) once their basic food needs are met, rather than continuously increasing their food consumption.

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, highlighting the constant demographic pressure on household budgets, regardless of their involvement in NTFP exploitation. Furthermore, the results indicate that the location of cultivated plots has a different influence on food expenditure. For households that do not exploit NTFPs, having plots in the bush or camp (further away) significantly increases their food consumption expenditure. This distance could generate increased transport and logistical costs for the production and delivery of agricultural products, thus directly affecting their food budget by increasing their food purchases. Conversely, this location has no significant effect on the expenditure of households exploiting NTFPs, suggesting that their activity, often linked to these areas, has led them to develop strategies or self-consumption to compensate for the constraints of remoteness.

Access to agricultural credit has a divergent effect on household food consumption expenditure. For households that do not exploit NTFPs, this credit acts as a cash supplement, enabling them to directly increase their food expenditure to meet immediate needs or improve their diet. Conversely, among households that exploit NTFPs, access to agricultural credit is associated with a decrease in food expenditure. This group appears to allocate borrowed funds to productive investments (related to NTFPs or other agricultural activities), thereby reducing their dependence on food purchases. The results also show that among households exploiting NTFPs, mechanized plowing leads to a significant decrease in their food consumption expenditure. For this group, mechanization appears to be a strategic investment which, by improving the overall efficiency of their agricultural activities, enables them to reduce their dependence on food purchases. This effect is not significant for households that do not exploit NTFPs.

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

	(1)	(2)	(3)
VARIABLES	Ln Dep.cons0	Ln Dep.cons1	Expl. NTFP
Trees			0.001**
			(0.001)
Wealth	0.208*	-0.822***	-0.148**
	(0.109)	(0.268)	(0.058)
Inactive/Active	0.033**	0.122***	0.018***
	(0.016)	(0.031)	(0.007)
Plot	0.063	-0.078	-0.034
	(0.088)	(0.154)	(0.035)
Sex			0.204***
			(0.036)
AGE	-0.006	0.012	0.002
	(0.004)	(0.008)	(0.002)
Plot_loc	0.287**	-0.351	-0.075
	(0.115)	(0.245)	(0.056)
Credit	0.511***	-0.580**	-0.164***
	(0.128)	(0.229)	(0.049)
Labor	0.254	-0.199*	
	(0.064)	(0.103)	
Constant	2.134***	-1.071**	-0.522***
	(0.206)	(0.452)	(0.092)
lns0	0.943***		
	(0.038)		
lns1	1.495***		
	(0.057)		
rho0	-3.796***		
	(0.669)		
rho1	3.745***		
	(0.173)		
Observations	Total		2 381
LR test	Chi 2		1279***
Wald test	Chi 2		74.10***

*** 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 -0.787. The ATT represents the average difference between the food consumption expenditure observed among households exploiting NTFPs and what they would have spent if they

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had not chosen this activity. A value of -0.787 means that, by exploiting NTFPs, these households reduce their food consumption expenditure by an average of 78.7% compared to a scenario where they would not have exploited these products. More specifically, their participation in NTFP exploiting led to an average decrease of 78.7% 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 & 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 -0.86. This means that if non-exploiting households began exploiting NTFPs, they would also reduce their food consumption expenditure by 86%. This result highlights the current dependence of non-exploiter on food purchases at the market. By integrating NTFP exploiting into their subsistence strategy, these households could ease their budgets by reducing their need for cash to purchase food, thanks to 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 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 -0.85. It estimates the average impact of non-timber forest product (NTFP) exploiting 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 exploiting would lead to a reduction of 0.85 units in food consumption expenditure for a randomly selected household in the population. In

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the Southwest region, where approximately 79% of households exploit NTFPs, this phenomenon supports the idea of prioritizing 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 on the effects of NTFP exploitation treatments

Variables	Coefficients (%)	p-values
ATT	-0,787	0.0000
ATU	-0,86	0.0000
ATE	-0,85	0.0000

Source : Authors

4.2.2- 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 (84.34*), which rejects the null hypothesis of zero coefficients. Independence tests confirm a significant dependence between the outcome and selection equations, with an LR test (852.28*) rejecting the hypothesis of independence. The significance of the covariance terms (rho0=−3.232*** and rho1=−0.296***) validates the presence of selection bias, justifying the use of an endogenous switching model.

The results in column (3) reveal that the number of agroforestry trees, the wealth level of the household head, the area of land cultivated by the household, the demographic dependency ratio (inactive/active), the age of the household head, access to credit, and the exploitation of NTFPs are the variables that significantly influence the sale of NTFPs.

With regard to the results equations, the results indicate that household wealth has a negative and statistically significant effect on food consumption expenditure in households selling NTFPs. This result could be explained by the fact that wealthier households selling NTFPs may be less dependent on NTFP income to meet their basic food needs. Their wealth allows them to use NTFP income for other purposes, thereby reducing the direct link between their overall wealth and their food expenditure. In addition, wealthy households prefer to smooth their food consumption over time without having to spend proportionally more money as their wealth increases. On the other hand, the results indicate that for households that do not sell NTFPs, a larger cultivated area has a positive and statistically significant effect on their food consumption expenditure. Indeed, expanding cultivated

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land increases the production of staple crops for direct household consumption, while crop surpluses can be sold to generate income to purchase a variety of foods that they cannot grow themselves.

The analysis in Table 7 also reveals that the age of the head of household has a positive and statistically significant effect on food consumption expenditure, both for households that sell Non-Timber Forest Products (NTFPs) and those that do not. This result suggests that, in both groups, households headed by older heads tend to spend more on food. Indeed, older heads of households often head large households, with a potentially higher number of dependents. A larger household means greater food needs and, consequently, higher expenditure to meet those needs. Furthermore, the results show that for households that do not sell NTFPs, access to agricultural credit has a positive and statistically significant effect on their food consumption expenditure. This indicates that credit provides them with additional liquidity that is mainly used to increase or improve their food consumption. Indeed, in the absence of income from the sale of NTFPs, agricultural credit probably serves as a lever to meet immediate food needs or to diversify their diet, acting as a temporary or complementary substitute for other agricultural or non-agricultural sources of income. Conversely, among households that sell NTFPs, access to agricultural credit has a significant negative effect on their food consumption expenditure. Rather than financing immediate food purchases, these households appear to use this credit for agricultural investments. By strengthening their agricultural production capacity, they reduce their dependence on food purchases due to the availability of agricultural products for self-consumption.

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 or supplements to purchased foods. In addition, the income derived from the sale of NTFPs by these households can be strategically reinvested. Rather than spending it on more food consumption, it can be allocated to improving NTFP exploiting (tools, processing techniques), investing in other income-generating activities, or non-food expenditures deemed to be priorities.

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

VARIABLES	(1) lnDep.cons0	(2) lnDep.cons1	(3) Sale PFNL
Trees			0.002*
			(0.001)
Wealth	-0.250	-0.999***	0.184**
	(0.175)	(0.130)	(0.073)
Labor	-0.277	-0.101	0.094
	(0.167)	(0.225)	(0.069)
Inactive/Active	0.023	0.029	0.015*
	(0.019)	(0.024)	(0.008)
Plot	0.273***	0.102	-0.155***
	(0.099)	(0.156)	(0.042)
Sex			0.072
			(0.048)
AGE	0.034***	0.022***	-0.015***
	(0.005)	(0.007)	(0.002)
Plot_loc	-0.069	0.138	0.039
	(0.133)	(0.179)	(0.056)
Credit	0.646***	-0.565***	-0.217***
	(0.176)	(0.147)	(0.069)
Expl. PFNL		-0.579***	6.170***
		(0.130)	(0.118)
Plowing	0.196***	-0.071	
	(0.062)	(0.176)	
Constant	-0.605**	3.045***	0.778***
lns0	0.911***		
	(0.057)		
lns1	1.061***		
	(0.037)		
rho0	-3.232***		
	(0.169)		
rho1	-0.296***		
	(0.102)		
Observations	Totales		2 381
LR test	Chi 2		852.28***
Wald test	Chi 2		84.34***

*** 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

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(ATT) is significant and amounts to 0.333. This means that households that derive income from the sale of NTFPs spend, on average, 33.3% 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 0.138, and this result is statistically significant. This means that, for households that do not currently sell Non-Timber Forest Products (NTFPs), if these households began selling NTFPs, their food consumption expenditure would increase, on average, by 13.8% compared to their actual food consumption expenditure. This result is particularly important because it sheds light on the potential impact of NTFP commercialization 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. This would enable them to improve the quantity, quality, or diversity of their diet. This result corroborates the observations of Somé & Kambiré (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 at 0.241. This result means that, on average, the sale of NTFPs would lead to a 24.1% increase in food consumption expenditure for a randomly selected household in the southwestern region of Burkina Faso. This result suggests that the sale of NTFPs acts primarily as a driver of improved food consumption for the overall population. 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

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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 is often limited for smallholders (Balana and 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 maximize 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	0,335	0.000
ATU	0,138	0.0000
ATE	0,241	0.0000

Source : Authors

5- Conclusion and economic policy implications

The objective of this research is 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 is 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 analyzing 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 favors an impact assessment method using the endogenous switching model. The Maximum Likelihood Method with Complete Information (MVIC) is 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 head of household, the level of wealth, and access to credit. As for the sale of NTFPs, it is significantly determined 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 head of household, access to credit, and the exploitation of NTFPs itself.

Analysis of the effects of treatment on food consumption expenditure reveals distinct impacts depending on households' involvement in NTFP activities. On the one hand, NTFP exploiting has a

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significant negative effect on food consumption expenditure, both for current harvesters and potential non-harvesters, suggesting that exploiting 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 commercialization 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 professionalizing 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 valorization activities.

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Appendix 1

Variables	VIF	1/VIF
Trees	1.90	0.525
Plot	1.86	0.538
Expl. PFNL	1.45	0.691
Sale PFNL	1.33	0.752
Plot_loc	1.16	0.859
Sex	1.13	0.885
AGE	1.07	0.937
Wealth	1.06	0.943
Credit	1.01	0.986
Inactive/Active	1.00	0.997
Mean VIF	1.30	

Source : Authors

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