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The role of non-timber forest products in reducing rural poverty in Burkina Faso

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Abstract: Using data collected in 2023 on five hundred and thirty (530) randomly selected rural households in two regions of Burkina Faso, this research investigates the contribution of Non-Timber Forest Products (NTFP) exploitation to rural poverty reduction using two different approaches. Firstly, it considers NTFP income as an "exogenous transfer", which is added to total household income, and compares the Foster, Greer and Thorbecke (FGT) poverty indices calculated with and without NTFP income. Secondly, it considers NTFP income as a "potential substitute" for other household income and simulates the counterfactual of what rural household income and poverty would be in the absence of access to NTFPs. The results show that in the absence of NTFPs, rural poverty would be much higher and deeper. These results suggest that rural development policies focused on the sustainable exploitation of these products are potentially feasible.

Keywords: Non-timber forest products, poverty, rural household, Burkina Faso

Introduction

Poverty reduction is at the heart of the Sustainable Development Goals (SDGs) (UN, 2023). This issue is particularly topical in sub-Saharan African countries, where, in 2019, 35% of the population was still living in extreme poverty, while those rates had dropped to 9% in South Asia and 1% in East Asia and the Pacific (World Bank, 2023). Burkina Faso is no exception, with 41.2% of its population living below the national poverty line estimated at 296.7 euros (€) per person per year (INSD, 2022). As in most sub-Saharan African countries, poverty affects rural households much more than other social groups in Burkina Faso. Indeed, it is estimated that 44.6% of the rural population is poor, compared with only 10% in urban areas, and that 93.3% of the total number of poor people live in rural areas (INSD, 2022). These rural areas are known to be the sites of major production of forest resources such as non-timber forest products (NTFPs). Consequently, sustainable exploitation of NTFPs can be a solution to poverty in these rural areas (Ouédraogo et al., 2013; Sawadogo et al., 2023).

NTFPs can be plant parts (leaves, flowers, fruit, bark, roots, non-lignified stems, sap, gum, resins, etc.) or their by-products. They fulfil several functions in rural livelihoods, such as household income formation, nutrition and disease treatment (Sawadogo et al., 2023; Shackleton and Pullanikkatil, 2019). In 2011, NTFPs were worth $88 billion to the world's population, including $6.3 billion to rural households in Africa (FAO, 2014). In Burkina Faso, the total value added from the commercialization of NTFPs derived from nine local woody

species was estimated at 420.5 million euros (€) in 2016, representing 3.8% of the national gross domestic product (GDP) (DGEVCC, 2018).

Theoretically, the role of NTFPs in poverty reduction has been the subject of controversy among researchers. According to Neumann and Hirsch (2000), Campbell et al. (2002) and Angelsen and Wunder (2003), NTFPs are undoubtedly important in enabling many poor people to survive, but they are less important in helping people escape poverty. For these researchers, NTFP exploitation constitutes a poverty trap. In contrast to this pessimistic view of the potential of NTFPs, other researchers such as Sunderlin et al. (2005) and Shackleton et al. (2007) believe that NTFPs can alleviate poverty (by supplementing incomes and functioning as safety nets) or reduce poverty (by providing high incomes or enabling households to accumulate assets).

Understanding the effects of NTFP exploitation by rural households on their poverty status is essential to minimize the negative effects associated with the exploitation of these products, while optimizing the benefits in terms of well-being. However, although the level of understanding of the link between the exploitation of NTFPs and poverty has improved in recent years, a gap remains on the distributional implications of the exploitation of these products in sub-Saharan African countries (Fonta and Ayuk, 2013; Luswaga and Nuppenau, 2022). Indeed, very little research has focused on the relationship between poverty and NTFP exploitation in this part of the world (Fonta and Ayuk, 2013). The results of the few studies that have analyzed this issue in sub-Saharan Africa are rather mixed. For example, in Zimbabwe, Cavendish and Campbell (2008) showed that including forest income in poverty estimates did not significantly alter poverty analysis compared with standard data. In contrast, Worku et al. (2014), in Ethiopia, found that including forest income in poverty estimates enabled 24% of households to remain above the poverty line.

These contradictory results call for additional, context-specific research to better understand the relationship between NTFP exploitation and poverty (Shackleton and Pullanikkatil, 2019). With this in mind, we adopt a new empirical and methodological approach, proposing to analyze the role of NTFPs in rural poverty reduction in Burkina Faso. To the best of our knowledge, this is the first study to examine the contribution of NTFPs to poverty reduction in Burkina Faso. Moreover, it is the first study to consider the potentially substitutable nature of the exploitation of these products in relation to other sources of income, and to highlight its impact on rural poverty, using econometric estimates and income simulation.

The remainder of this research is organized into four sections. The first section deals with the literature review on the relationship between NTFP exploitation and poverty. The second section presents the methodology and econometric techniques used. The third section presents, interprets and economically discusses the results obtained. The fourth section provides concluding remarks and implications for economic policy.

Literature review

The meaning given to NTFPs has evolved considerably over time. These products were most often limited to spontaneous forest plant resources for food and medicinal use (Loubelo, 2012). The scope of this definition has broadened to include all products of biological origin (other than wood), derived from forests, other wooded land and trees outside forests (FAO, 1999). In this research, NTFPs are defined as any good of biological origin other than wood and wildlife, derived from forests, other wooded land and trees outside forests, including spontaneous and domesticated trees (MECV, 2010).

The overall role of NTFPs in improving the livelihoods of rural households has three main components (Angelsen and Wunder, 2003; Belcher, 2005; Neumann and Hirsch, 2000; Sunderlin et al., 2005). Firstly, NTFPs support everyday consumption. This is the case when these products are used by households to meet current consumption needs, as an integral part of their livelihoods (Belcher, 2005). NTFPs may enter the household diet directly as condiments or as complements to agricultural produce. Households may also include NTFPs in their diets,

thanks to the income they earn from selling these products, which enables them to purchase other food groups (Sawadogo, 2023). Secondly, NTFPs are used as "safety nets". Households use these products in emergencies (droughts, floods, crop failures, disease, etc.) to prevent their situation from worsening. Thirdly, NTFPs offer rural households a way out of poverty. Rural households are lifted out of poverty thanks to the income they derive from NTFP exploitation (Shackleton and Pullanikkatil, 2019).

The third function of NTFPs in household livelihoods, namely the ability of NTFPs to lift households out of poverty, has been the subject of controversy among researchers. On the one hand, there is the pessimistic view that NTFP exploitation is a source of poverty, and on the other, the optimistic view that NTFP exploitation contributes to poverty reduction.

The pessimistic view is that NTFP harvesting is not an economically profitable activity, but a low-return activity that contributes to maintaining poverty. Thus, according to Neumann et Hirsch (2000), NTFPs are very important for the survival of poor rural households, but they rarely provide the means for socio-economic advancement. In other words, NTFPs do not enable rural households to accumulate wealth to lift themselves out of poverty. For Angelsen and Wunder (2003), it is the lack of assets to access more valuable resources that pushes poor households towards "employment of last resort" with marginal economic returns. Angelsen and Wunder (2003) point to the under-utilization of the land factor. They estimate that the gains from NTFP harvesting are small compared to the gains offered by other alternative uses of this factor. Belcher (2005) also believes that many NTFPs have little or no market value. For him, NTFPs are accessible to poor households precisely because no one else wants them. For this author, many NTFPs are inferior goods that are replaced by higher-quality products when household income rises. As for the FAO (2003), it shows that households can be condemned to poverty through the exploitation of NTFPs. Indeed, according to FAO (2003), NTFPs offer low returns due to (i) their low value, (ii) high transport costs between harvesting sites and markets, (iii) limited markets and (iv) the fact that they are substitutable if their prices rise too high (FAO, 2003).

For proponents of the optimistic these, collecting forest resources is an economically profitable activity. Thus, for Chou (2018), the value of NTFPs is mainly hidden in subsistence use (direct consumption). For this author, the economic value of NTFPs needs to be rediscovered by taking into account both subsistence uses and sales. Shackleton et al. (2007) agree with Chou (2018) when they state that the returns from NTFP exploitation activities far exceed the returns from many other rural activities if the number of hours worked is taken into account. According to Shackleton et al. (2007), most studies that have concluded that NTFP harvesting is a low-return activity have not considered returns per unit of labor. As for Shackleton and Pullanikkatil (2019), they note that NTFPs are able to lift households out of poverty by providing employment opportunities, playing an important role in income generation and functioning as safety nets in the event of food shocks. In addition, according to these authors, NTFP exploitation can enable poor households to accumulate assets to engage in other activities, or to specialize in existing ones.

These theoretical developments have been the subject of empirical verification. However, it has to be said that most of the empirical work that has explored the issue of poverty reduction has dealt mainly with forest resources in a general way, with mixed results.

On the one hand, researchers have found that including environmental income in poverty estimates did not significantly alter poverty analysis compared with standard data in Zimbabwe (Cavendish and Campbel 2008) and South Africa (Paumgarten et al. 2018) indicating that a poverty trap situation could potentially exist for households that dependent on these products. On the other hand, researcher have found that the exploitation of forest products significantly reduced rural poverty in Ethiopia (Babulo et al. 2009) and Nigeria (Fonta and Ayuk 2013).

These contrasting results from the empirical studies reviewed are attributable not only to differences in data collection methodologies, but also to their spatio-temporal contexts (Shackleton and Pullanikkatil, 2019). However, to the best of our knowledge, all existing empirical studies have considered income from forest products solely as an exogenous/supplementary income in addition to other household resources. While this approach provides a straightforward measure of the impact of forest product harvesting on poverty, it does not address the economic question of what forest product harvesters would bring to their respective households had they not been involved in forest product harvesting activities. In other words, this approach implies an assumption of independence in participation in various activities, which is not always justified. However, if there is substitutability between participation in forest product harvesting activities and participation in another productive activity, the decomposition of poverty indicators made in these existing empirical studies is biased. The main limitation of previous work is therefore the failure to take account of interactions in participation in various productive activities. The present research attempts to remedy this shortcoming. Unlike most existing research, which has dealt with forest products in general, this research focuses specifically on NTFPs.

Methodological approach

This section comprises three sub-sections. The first sub-section presents the conceptual framework of the analysis. The second sub-section describes the analysis methodology. The third sub-section presents the data used.

Conceptual framework for analysis

The present research adopts the sustainable livelihoods approach developed by Chambers and Conway (1992) and Scoones (1998) to analyze the impact of NTFP exploitation on poverty. While agricultural household theory provides a framework for studying the behavior of rural households that are different from traditional economic households because they produce some of the commodities that they consume, and they supply some or all of the labor used on the farm, the sustainable livelihoods framework provides a conceptual framework for understanding the multiple and interrelated causes of rural poverty. The sustainable livelihoods approach is based on the premise that rural households possess five types of assets: natural capital, physical capital, financial capital, human capital and social capital. Rural households use these five assets to define a livelihood strategy that will enable them to improve their ability to earn a living. To do this, they usually engage in multiple production activities, depending on the portfolio of assets at their disposal.

Figure 1 below shows how this research applies the sustainable livelihoods framework, focusing on three aspects: assets, strategies and outcomes. Assets determine the livelihood activities in which households engage (Chilongo, 2014). Thus, rural households' access to and control over various livelihood assets can influence their participation in NTFP harvesting (Kimengsi et al., 2020). In other words, NTFP harvesting may be part of activities under chosen livelihood strategies (Chilongo, 2014). Indeed, NTFP harvesting can help rural households achieve their livelihood goals such as increasing their income and alleviating or eliminating poverty (Kuuwill et al., 2022). The framework also includes dynamic feedback loops, as shown by the arrows (Figure 1). The exploitation of NTFPs can have direct consequences for access to and availability of assets in the future (Chilongo, 2014). For example, if NTFP exploitation by rural households leads to an increase in their income, these households may acquire more assets by reinvesting income from NTFP exploitation in other livelihood activities (e.g. livestock) (Ellis, 2000). This can further contribute to poverty reduction in the long term.

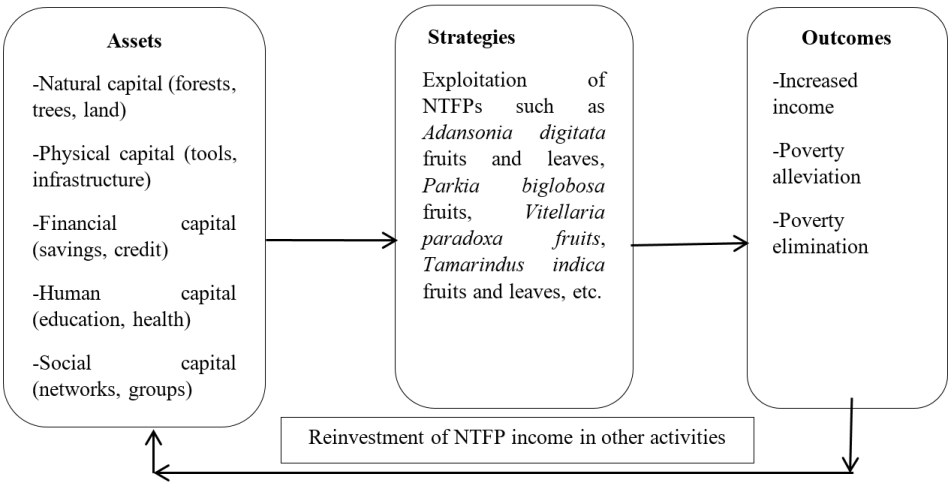

Figure 1: Conceptual framework analyzing the relationship between NTFP exploitation and poverty (Source: Authors, based on Kimengsi et al. (2020) and Kuuwill et al. (2022))

Analysis methodology

The impact of NTFP exploitation on poverty can be assessed using two methods. On the one hand, NTFP income can be conceived as an "exogenous transfer" of income that is added to the household's pre-existing total income, and its effects on poverty are examined using Foster-Greer-Thorbecke (FGT) index decomposition techniques. Although this approach is used in the present research, it does not always allow us to estimate the net impact of NTFP exploitation on poverty. If there is substitutability between participation in NTFP exploitation activities and participation in other productive activities, the decomposition carried out in this first approach is biased. On the other hand, by considering NTFP income as a "potential substitute" for locally generated household earnings, it is important to compare the level of household income to that which would be expected in the absence of NTFPs, using income simulation techniques.

First approach: decomposition of FGT poverty indices

This research adopts the monetary approach to poverty and uses the three variants of the FGT index, namely poverty incidence, poverty depth and poverty severity, to examine the impact of NTFP exploitation on rural poverty. It is based on the national poverty line estimated at €296.70 per person per year (INSD, 2022). Any household whose annual per capita income is below this national threshold is therefore considered poor in this research.

The FGT index of Foster et al. (1984) has the following general form:

$$P_\alpha(y;z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^\alpha \qquad (1)$$

where n represents the total population concerned by the study; q represents the number of households living below the poverty line; α is a poverty aversion parameter; y_i represents the per capita income of household i; z is the poverty line. When α=0, we obtain P_0, which is the poverty incidence index. P_0 corresponds to the proportion of households that are poor. When α=1, we obtain P_1, which is the poverty depth index. P_1 measures the distance separating the average poor household from the poverty line. When α=2, we obtain P_2, which is the poverty severity index. P_2 measures income inequality among the poor.

In this first approach, we calculate the three variants of the FGT index with and without NTFP income in order to examine the magnitude and direction of changes in poverty levels. A Hotelling test is used to check the statistical significance of any differences in poverty indices.

Second approach: simulation of household income

One of the most remarkable contributions of the present research is the treatment of NTFP income as a potential substitute for household earnings and/or the integration of their indirect effects. This methodological option involves comparing the observed distribution of household income with an economically interesting counterfactual income distribution, i.e. the absence of NTFPs. The principle of the method is to replace household income from NTFPs with the value of the income that these NTFP-using households would have had if they had not engaged in NTFP exploitation.

In this second approach, we examine the impact of NTFP exploitation on poverty in three stages. First, we estimate household income equations based on observed values. Next, we simulate the income that households would have obtained in the absence of NTFPs. Finally, we compare the FGT indices of this simulated income with those of the observed income and examine the impact of NTFP exploitation on poverty.

Estimation of income equations using the endogenous switching regression model

The income that a household earns from a given activity depends on two factors: firstly, whether the household participates in the activity in question, and secondly, the net income that the household obtains if it participates in this specific activity. Given that households participating in the economic exploitation of NTFPs are not randomly and uniformly distributed in the sample, the estimation of income equations runs up against an endogeneity problem which, if not taken into account, leads to biased results. Either participation in the economic exploitation of NTFPs is voluntary, or some households are better placed than others to participate. For example, households with more NTFPs in their fields or that are closer to NTFP harvesting sites are more likely to participate in the economic exploitation of NTFPs than others. Thus, self-selection in participation in NTFP economic exploitation is the main source of endogeneity.

In order to correct the potential selection bias and allow comparability between the two groups, several methods have been developed in the economic literature. In addition to the limitations specific to each method, most of them are unable to correct the selection bias linked to the endogeneity of the treatment variable (Diamoutene and Jatoe, 2021; Khonje et al., 2015). One method adapted to this situation is the endogenous switching model (Lokshin and Sajaia, 2004). This model consists of the simultaneous estimation of a selection equation that defines the status of participation in NTFP economic exploitation or non-participation, and two outcome equations that give the total household income in accordance with this status. It is used to solve self-selection and treatment effect estimation problems when there is a non-random allocation of subjects between treatment and non-treatment groups (Diamoutene and Jatoe, 2021). It corrects for selection bias by integrating the inverse of the Mills ratios calculated from the selection equation into the income equations.

Following the example of Khonje et al. (2015) and Diamoutene and Jatoe (2021), the present research uses a random utility model in which a household's decision to participate in NTFP exploitation is modelled as a discrete comparison of the expected utility in terms of income, whether or not it participates in the economic exploitation of NTFPs. Let I_i* be the difference between utility when participating in NTFP exploitation (U_{i1}) and utility when not participating in NTFP exploitation (Ui_0). Household i will choose to participate in the economic exploitation of NTFPs if $U_{i1} - U_{i0} > 0$. Since both utilities are unobservable, they can be expressed in terms of observable characteristics using the latent model below:

$$\mathbf{I}_{\mathbf{i}}^{\bullet} = \alpha Z_i + \varepsilon_i \tag{2}$$

$\mathbf{I_i}$* is an unobserved continuous latent variable that determines the household's participation or non-participation status in the economic exploitation of NTFPs. α is a vector of parameters to be estimated, Z is a vector representing the socio-economic and environmental characteristics of household i and ε is the random error term. In order to identify the endogenous switching model, Khonje et al. (2015) and Diamoutene and Jatoe (2021) propose including variables in Z as selection instruments. In this research, we establish the validity of these instruments by performing a simple falsification test described in Di Falco et al. (2011). Indeed, an instrumental variable is valid if it affects the decision to participate in the economic exploitation of NTFPs but does not affect total household income.

The observed dichotomous realization I_i of the latent variable $\mathbf{I_i}$* indicating whether or not household i participates in economic exploitation of NTFPs has the following form:

$$\mathbf{I}_i = \begin{cases} \mathbf{1}\ si\ \mathbf{I}_{\mathbf{i}}^{\bullet} > \mathbf{0} \\ \mathbf{0}\ sinon \end{cases} \tag{3}$$

The two outcome equations under the condition of participating or not in economic exploitation of NTFPs are expressed in two regimes as follows:

Regime 1: households involved in economic exploitation of NTFPs ($I_i = 1$)

$$y_i^{\bullet} = \beta^{\bullet} X_i + \mu_i^{\bullet} \tag{4}$$

Regime 2: households not involved in economic exploitation of NTFPs ($I_i = 0$)

$$y_i^{\bullet} = \beta^{\bullet} X_i + \mu_i^{\bullet} \tag{5}$$

In outcome equations (4) and (5), y_i^1 and y_i^0 respectively represent the total per capita income of household ***i*** if it participates in economic exploitation of NTFPs and if it does not, X_i is a vector of exogenous variables intended to determine income; β^1 and β^0 are vectors of parameters to be estimated; and μ_i^1 and μ_i^0 are random error terms.

Following Lokshin and Sajaia (2004), the error terms ε_i, μ_i^1 and μ_i^0 are assumed to follow a trivariate normal distribution with a zero mean vector and a covariance matrix Ω.

$$\Omega = cov\left(\varepsilon_i \bullet \mu_i^{\bullet} \bullet \mu_i^{\bullet}\right) = \begin{bmatrix} \sigma_{\varepsilon}^{\bullet} & \sigma_{\varepsilon\bullet} & \sigma_{\varepsilon\bullet} \\ \sigma_{\varepsilon\bullet} & \sigma_{\bullet}^{\bullet} & \bullet \\ \sigma_{\varepsilon\bullet} & \bullet & \sigma_{\bullet}^{\bullet} \end{bmatrix} \tag{6}$$

where $\sigma_{\varepsilon}^{\bullet} = var\left(\varepsilon_i\right)$, $\sigma_{\bullet}^{\bullet} = var\left(\mu_i^{\bullet}\right)$, $\sigma_{\bullet}^{\bullet} = var\left(\mu_i^{\bullet}\right)$, $\sigma_{\varepsilon\bullet} = cov\left(\varepsilon_i \bullet \mu_i^{\bullet}\right)$ et $\sigma_{\varepsilon\bullet} = cov\left(\varepsilon_i \bullet \mu_i^{\bullet}\right)$.

The variance σ_ε^2 is assumed to be equal to 1. The covariance between μ_i^1 and μ_i^0 is not defined, as y_i^1 and y_i^0 are never observed simultaneously. The error term ε_i in the selection equation is correlated with the error terms in the outcome equations (4) and (5). The expected values of μ_i^1 and μ_i^0 conditional on sample selection are non-zero and expressed as follows:

$$E\left(\mu_i^{\cdot} / I = \bullet\right) = \sigma_{\varepsilon\cdot} \frac{\varnothing\left(\alpha Z_i\right)}{\Phi\left(\alpha Z_i\right)} = \sigma_{\varepsilon\cdot} \lambda_{\cdot i} \quad (7)$$

$$E\left(\mu_i^{\cdot} / I = \bullet\right) = \sigma_{\varepsilon\cdot} \frac{\varnothing\left(\alpha Z_i\right)}{\Phi\left(\alpha Z_i\right)} = \sigma_{\varepsilon\cdot} \lambda_{\cdot i} \quad (8)$$

Where $\varnothing$ is the standard normal probability density function, Φ the standard normal cumulative density function, $\lambda_{\cdot i} = \frac{\varnothing\left(\alpha Z_i\right)}{\Phi\left(\alpha Z_i\right)}$ and $\lambda_{\cdot i} = \frac{\varnothing\left(\alpha Z_i\right)}{\bullet - \Phi\left(\alpha Z_i\right)}$ with λ_1 and λ_0 the inverse of the Mills ratios calculated from the selection equation and included respectively in equations (4) and (5) to correct for selection bias in a two-stage estimation procedure.

Following Lokshin and Sajaia (2004) and Greene (2008), the maximum likelihood method is used to estimate the endogenous switching regression model efficiently. It enables the selection equation and the two income equations to be estimated jointly. Table 2 in Appendix describes the different variables used and their expected effects.

Income simulation

Having estimated the income equations, we can simulate the income that households participating in economic exploitation of NTFPs would have had in the absence of NTFPs. To do this, we predict the income obtained in the absence of NTFPs for all households, using equation (5) estimated above:

$$\hat{y}_i^{\cdot} = \hat{\beta}^{\cdot} X_i + \hat{\gamma}^{\cdot} \lambda_{\cdot,i} \qquad \text{for all households} \qquad (9)$$

where $\hat{y}_i^{\cdot}$ corresponds to the estimated income from equation (5), $\hat{\beta}^{\cdot}$ represents the vector of estimated values of the parameters assigned to the different explanatory variables in equation (5), X_i represents the vector of explanatory variables introduced into equation (5), $\hat{\gamma}$ corresponds to the estimated value of the parameter assigned to the inverse of the Mills ratio, $\lambda_{0,i}$ represents the inverse of the Mills ratio calculated from the selection equation for the group of households not involved in economic exploitation of NTFPs.

Equation (9) gives the observable portion of household income in the absence of NTFPs, i.e. the portion that can be explained by exogenous variables. However, the distribution of this estimated income cannot be considered as that of income in the absence of NTFPs for two reasons (Zhu and Luo, 2005). Firstly, in general, variation in the estimated value is less volatile than that of income in the absence of NTFPs. Secondly, unobserved terms, i.e. the residual, can play an important role in the income distribution. It is therefore necessary to generate a more complete distribution of household income in the absence of NTFPs. For households not involved in NTFP exploitation activities ($\mathbf{I}_i = \bullet$), their total income can be expressed as:

$$y_i^{\cdot} = \hat{y}_i^{\cdot} + \mu_i^{\cdot} \qquad \text{for } \mathbf{I}_i = \bullet \cdots \quad (10)$$

where y_i^0 and $\hat{y}_i^{\cdot}$ represent observed and simulated income respectively, μ_i^0 is the residual. For households participating in economic exploitation of NTFPs (I_i=1), we do not know the unobservable part, i.e. the residual. It is therefore necessary to simulate the residual for each household that exploits NTFPs. Equation (10) is used to calculate the variance of μ_i^0 for the group of households not involved in economic exploitation of NTFPs (I_i=0), denoted σ_0^2. Let's

assume that: (i) the variance of μ_i^0, σ_0^2 is constant, and (ii) the variance of μ_i^0 for households not involved in economic exploitation of NTFPs and those involved in economic exploitation of NTFPs are identical. Under these two assumptions, we simulate the residual of each household that participates in economic exploitation of NTFPs (I_i=1) using the Monte Carlo method (Zhu and Luo, 2005):

$$\mu_i^0 = \sigma_0 \Phi^{-1}(r) \quad (11)$$

where r represents a random number between [0,1] and Φ^{-1} is the inverse of the cumulative probability function of the normal distribution. Thus, μ_i^0 follows a normal distribution with parameters (0, σ_0^2). We define the income obtained in the absence of NTFPs as follows:

$$y_i^0 = \begin{cases} y_i & I_i = 0 \\ y_i - \mu_i^0 & I_i = 1 \end{cases} \quad (12)$$

Having simulated the income obtained in the absence of NTFPs, we can now study the impact of NTFP exploitation on poverty. To do this, we first calculate the FGT indices for observed incomes. Next, we calculate the same indices for simulated incomes in the absence of NTFPs. Finally, we compare the FGT index values of observed incomes with those of simulated incomes to capture the impact of NTFPs on rural poverty.

Variables used and their justifications

In the present research, the explanatory variables mobilized for the estimation of total per capita household income equations can be classified into two groups, namely the socio-economic characteristics of the household head and the socio-economic and environmental characteristics of the household.

The socio-economic characteristics of the household head include gender, age, marital status and education level. Authors such as Biyase and Zwane (2017) and Yambare and Ossouna, (2021) have found that female-headed households are more likely to be poor than male-headed households. Thus, we assume that a female-headed household has a generally lower per capita income than a male-headed household because women are discriminated against in access to productive resources at the rural level. Age explains household living standards. Older people have more experience and knowledge of rural productive activities. However, younger household heads may be more involved in productive activities than older household heads, as they are more active and stronger, and can therefore cope with the generally labor-intensive demands of rural activities (Majeed and Malik, 2015). Thus, the age of the household head could have an indeterminate effect on household per capita income (Biyase and Zwane, 2017). The marital status of the head of household often explains the household's standard of living. Aïssoun and Agbo (2017) found that households headed by single heads are more likely to be poor compared to those headed by heads in couples. Education appears to be an important variable in explaining the standard of living of rural households. Mirroring the findings of Noufé (2018), we hypothesize that households with educated heads have higher per capita incomes compared to households with illiterate heads.

Household socio-economic and environmental variables include household size, number of household assets, access to credit, size of land owned by the household, participation in gold panning activities and distance between the household home and the nearest market. Numerous empirical studies on the determinants of household living standards have concluded that

household size has a positive effect on the probability of being poor. This is the case of Afera (2015), Biyase and Zwane (2017) and Yambare and Ossouna (2021). Intuitively, the number of active household members would have a positive effect on household living standards, as active people are permanently involved in field work and thus contribute to increased agricultural production (Zhu and Luo, 2005). Access to credit is an important determinant of the standard of living of rural households. Indeed, access to credit helps strengthen the capacity of rural households to acquire production equipment and increase their production and income (Noufé, 2018). The area of land owned by a household is a key factor in the analysis of rural household poverty. Indeed, Aubron et al. (2015) have shown that rural poverty is explained by an unequal distribution of land. The distance between the household's home and the nearest market positively explains the likelihood of households being poor (Teka et al., 2019). Gold panning is also a determining factor in the standard of living of rural households in Sahelian countries (Sidibé and Camara, 2020).

In addition to these variables, other variables such as the distance between the household home and the NTFP gathering site, the membership of at least one household member in a forest management group, the number of months of food deficit experienced by the household and the household head's perception of NTFP prices are used as instruments in the selection equation. The results of the falsification test as described in the work of Di Falco et al. (2011) show that these four variables can be considered as selection instruments, as they are jointly statistically significant factors in the selection equation, but not in the household income equations. Table 2 in Appendix summarizes the information on the explanatory variables used in estimating the income and selection equations.

Data collection and processing methodology

The data used are primary data collected during the months of July and August 2023. The study area covered two (2) regions and four (4) communes, with two (2) communes per region, as the material and financial resources allocated to the research were limited. The regions covered by this research are the Centre-Ouest region and the Hauts-Bassins region. The rural communes selected were the rural communes of Sapouy and Léo for the Centre-Ouest region, and the rural communes of Houndé and Karangasso-Vigué for the Hauts-Bassins region. The choice of regions and rural communes was based on two main criteria, namely (i) the availability of NTFPs, and (ii) the accessibility of the area in the context of terrorism. Thus, these two regions and four selected communes are of particular interest for the study of NTFPs in the sense that their agroecological zones are reputed to be the locations of major NTFP production and sales. According to the DGEVCC (2019), the average number of trees per hectare of species providing the main NTFPs is estimated at 21.94 and 25.99 respectively in the Centre-Ouest and Haut-Bassins regions, compared with 17.56 at national level.

In addition to NTFP exploitation, agriculture and livestock breeding are the two major activities carried out by the resident populations of the two selected regions. While the two regions have in common the pre-eminence of agro-sylvo-pastoral activities, they are nevertheless in different economic situations. Indeed, the Centre-Ouest region is ranked among the poorest regions, with an estimated poverty incidence rate of 53.9%, while the Haut-Bassins region is ranked among the richest regions, with an estimated poverty incidence rate of 34% (INSD, 2022). This divergence in economic performance between the two regions is thought to be linked to the fact that the Haut-Bassins region enjoys relatively good rainfall compared with the Centre-Ouest region.

The sample is made up of 530 households selected on a random and stratified basis, with the twelve villages constituting the strata. The sample size was determined using the Yamane (1967) formula described in equation (13) below.

$$n = \frac{N}{\bullet + N \bullet\bullet \dot{} \bullet} \tag{13}$$

Where n = sample size, N = total study population and e = margin of error (normally set at 5%).

After calculating the total sample size, we proceeded to determine the number of households to be surveyed per village. This second step took into account the weight of each village. The proportional probability sampling method was used. To do this, we collected secondary data on the number of households per village and calculated the sample size per village. The sample size per village was calculated using the following formula:

$$NHS_i = \frac{NH_i}{TNH} \times n \tag{14}$$

Where NHS_i = number of households to be surveyed per village, NH_i = number of households in village i, TNH = total number of households in the twelve villages, and n = the size of the total sample.

After determining the number of households to be surveyed per village, we proceeded to randomly select the households to be surveyed in each village. To carry out the random selection, a census of all resident households was undertaken in the twelve villages covered by the present research to constitute the sampling frame. At the end of this census, which acted as a pre-survey, we obtained a sampling frame with the identifiers of each household. This enabled us to make a random selection of households to be surveyed by village, using the RAND function in Excel.

Income data were calculated from primary data. Rural household income generally comes from several sources, which we have grouped into four income categories: crop production income, livestock income, NTFP exploitation income, and other income. Income from crop production, livestock and NTFPs was assessed on the basis of operating accounts for each activity as suggested by Ouédraogo et al. (2013). Activity income is defined as the difference between the gross product of the activity and the associated production costs.

Income from NTFPs consists solely of the value of the NTFPs (sold and unsold), as NTFP harvesting in rural areas does not require specific inputs or equipment. NTFP quantities are evaluated in local units of measurement (bag, tine, plate, box, heap, dish, bunch, bowl). Product prices are related to local units of measurement. Products traded on markets are valued at market prices. Self-consumption is also valued at the market price of the given NTFP if the household declares having sold part of this good.

This research focuses on NTFPs derived from local species with high socio-economic potential. Species of interest include *Parkia biglobosa, Vitellaria paradoxa, Tamarindus indica, Adansonia digitata, Saba senegalensis, Bombax costatum, Balanites aegyptiaca and Acacia macrostachya.*

Per capita household income was calculated according to Angelsen et al. (2014). According to Angelsen et al. (2014), all children under 15 and adults over 65 are assigned a weight of 0.5, while other individuals in the household are assigned a weight of 1. In addition, all monetary values were converted to euros using the conversion rate of 655.975 CFA francs to one euro (OANDA, 2023).

Presentation of results

This section presents the statistical and econometric results relating to the analysis of the impact of NTFP exploitation on poverty.

Descriptive statistics

Table 1 provides details of the descriptive statistics. According to the results recorded in this table, male-headed households represent 89.62% of the sample, while female-headed households account for only 10.38%. The low representation of women can be explained by the social organization in rural areas, which generally does not allow women to remain alone and be head of household. In terms of marital status, some 93.58% of heads of household live in couples, and 36.98% of heads of household are polygamous.

Households in the study area are made up of 47.55% natives versus 52.45% migrants (Table 1). The average age of the heads of households in the sample was 43.92 years. The youngest head of household in the sample was 20, while the oldest was 96. The average household size in the study area is around 9 people, with a minimum of 1 and a maximum of 30. Only 11.32% of households in the sample have access to credit. The majority of heads of household in the study area are illiterate. In fact, only 7.36% of heads of household in the sample have ever been to school.

The main activity of heads of household is agriculture, which occupies 81.51% of households in the sample, followed by livestock farming, the main activity of 9.06% of households (Table 1). 76.42% of households in the study area are involved in the economic exploitation of NTFPs as a secondary activity, and 26.42 practice gold panning as a secondary activity. To collect NTFPs, households travel an average of 2.78 km. Generally speaking, the households in the sample face food deficits that last about a month, particularly in August. The household most exposed to food insecurity experienced 7 less food deficits.

Statistical analysis of household income reveals that the average annual household income is €2853.33. It is made up of 59.66% income from agriculture (€1702.18), 7.95% income from livestock (€226.71), 12.17% income from NTFPs (€347.24) and 20.23% income from other sources (gold panning, trade, civil service, handicrafts, etc.) (€577.20). Rural households derive substantial income from NTFP exploitation. Indeed, NTFPs provided an average annual income of €347.24 per household, with a maximum of €23031.97 per household. The average share of NTFP income in total household income is estimated at 22% 5 (Table 1). These statistical results show that NTFPs are an important source of income for rural households.

Finally, the statistical results show that income from NTFP exploitation increases with household wealth. Indeed, Table 1 in Appendix shows that average NTFP income is €186.51 for households in the first income quartile, €283.85 for the second quartile, €360.08 for the third quartile and €559.649 for the last quartile. The non-parametric Kruskal-Wallis test shows that the difference in non-timber forest income between quartiles is significant at the 1% threshold. NTFPs are therefore a productive source of income for both poor and rich households.

Table 1. Household characteristics and income

QUALITATIVE VARIABLES			
VARIABLE	MODALITY	FREQUENCY	PERCENT
Gender of the head of household	Male	475	89.62
	Female	55	10.38
Marital status of the head of household	Not in couple	34	6.42
	Monogamous couple	300	56.60
	Polygamous couple	196	36.98
Residence status of the head of household	Native	252	47.55
	Migrant	278	52.45
Education of the head of household	Illiterate	491	92.64
	educated	39	7.36
Access to credit for at least one household member	Yes	60	11.32
	No	470	88.68
Household's main activity	Agriculture or crops	432	81.51
	Livestock	48	9.06
	Other (trade, civil service, craft, etc.)	50	9.43
NTFP exploitation as a secondary household activity	Yes	405	76.42
	No	125	23.58
Gold panning as a secondary household activity	Yes	140	26.42
	No	390	73.58

QUANTITATIVE VARIABLES					
VARIABLE		MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
Age of head of household (in years)		43.92	13.98	20	96
Household size (person)		8.54	5.59	1	50
Duration of food deficit (months)		0.50	0.92	0	7
Distance from residence to NTFP site (in kilometer)		2.78	3.58	0	25
Household income (in euros)	Agriculture or crops	1702.18	8651.77	0	191980.9
	Livestock	226.71	562.31	0	4490.57
	NTFP	347.24	1038.17	0	23031.97
	Other sources	577.20	1486.28	0	15701.82
	Total income	2853.33	8870.57	26.68	192841.2
Share of NTFP income in total household income (%)		0.22	0.25	0	1

NTFP income as an exogenous transfer

Under the assumption that income from the economic exploitation of NTFPs is an exogenous transfer, we present the results of the decomposition of the FGT poverty index in Table 2. Three FGT index variants were calculated, including and excluding NTFP income in household income accounts. Rates of change are calculated relative to the initial situation and indicate the effects of participation in NTFP economic exploitation. A negative sign implies a reduction in poverty.

The results show that in terms of poverty incidence (P_0), 63.02% of rural households are classified as poor according to the conventional measure of income, while the inclusion of NTFP income reduces poverty incidence to 53.77%, a drop of 9.25 percentage points. The reduction in the depth of poverty (P_1) and the severity of poverty (P_2) is much greater. Indeed, the depth of poverty and severity of poverty fell by 10.56 and 9.37 percentage points respectively. The Hotelling test shows that all differences are statistically significant at the 1% level.

The results in table 2 also show that the effects of NTFP income on poverty are much greater in the Hauts-Bassins region than Centre-Ouest region, with a drop in poverty incidence of 9.59

percentage points in the Hauts-Bassins region versus 8.61 percentage points in the Centre-Ouest region. The reduction in the depth and severity of poverty was also much greater in the Hauts-Bassins region than in the Centre-Ouest region. Indeed, the inclusion of NTFP income reduces the depth of poverty and the severity of poverty by 10.75 and 9.74 percentage points respectively in the Hauts-Bassins region, versus 10.22 and 8.68 percentage points in the Centre-Ouest region.

Table 2. Comparison of FGT poverty indices calculated with and without NTFP income

FGT poverty indices and NTFP income Parameter	With NTFP income (1)			Without NTFP income (2)			Difference between (1) and (2)		
	P_0	P_1	P_2	P_0	P_1	P_2	P_0	P_1	P_2
Centre-Ouest	55.91	23.77	13.17	64.52	33.99	21.85	-8.61***	-10.22***	-8.68***
	(3.65)	(2.02)	(1.47)	(3.52)	(2.36)	(1.98)	(2.06)	(1.28)	(1.17)
Hauts-Bassins	52.62	23.95	14.14	62.21	34.70	23.88	-9.59***	-10.75***	-9.74***
	(2.70)	(1.57)	(1.17)	(2.62)	(1.86)	(1.61)	(1.59)	(0.97)	(0.95)
Total sample	53.77	23.89	13.80	63.02	34.45	23.17	-9.25***	-10.56***	-9.37***
	(2.17)	(1.24)	(0.92)	(2.10)	(1.46)	(1.25)	(1.26)	(0.77)	(0.74)

*Notes: Standard errors in brackets; * Significant difference at 10%; ** Significant difference at 5%; *** Significant difference at 1%.*

NTFP income as a potential substitute for locally generated household earnings

This section first presents the results of estimating the income and NTFP participation equations, then presents and discusses the results of comparing FGT poverty indices calculated on the basis of observed incomes and those calculated on the basis of simulated incomes in the absence of NTFPs.

Estimation of participation and income equations

The Wald test statistic is significant at the 1% level (Wald chi2(10) = 51.80; Prob > chi2 = 0.00), indicating the good fit of the endogenous switching model (Table 3). This test suggests that there is an endogeneity problem; consequently, the use of the endogenous switching model is justified. Furthermore, the results of the likelihood ratio test of the independence of the participation and income equations show that the likelihood ratio statistic is significant at the 1% threshold (chi2(2) = 9.38; Prob > chi2 = 0.00) (Table 3). The results of this test imply that the three equations of the endogenous switching model could not be estimated separately. The econometric estimates are therefore satisfactory and can be used for economic interpretations.

Nine variables were found to be significant in explaining participation in NTFP exploitation (Table 3). These were marital status, level of education, household size, area of land owned, distance from home to market, duration of food deficit, perception of NTFP prices, membership of a NTFP exploitation association and distance from home to NTFP harvesting site. The negative sign of the household head's education status indicates that households headed by educated household heads are less likely to participate in economic exploitation of NTFPs than households headed by illiterate household heads, ceteris paribus. This result is thought to be linked to the fact that education opens other employment opportunities (Mulenga et al., 2014). The positive sign of the area of land owned suggests that the larger the area of land a household owns, the higher the probability that it will exploit NTFPs, all other things being equal. Indeed, owning a large area of land could occasion greater access to NTFPs, as the potential trees saved in the cropping system is a function of the size of the fields owned by the household (Ouédraogo et al., 2013). The negative sign of the distance between the household's home and the nearest market for NTFPs means that households that are further away from NTFP marketing markets are less likely to exploit NTFPs compared with households that are close to these markets, ceteris paribus. This result is similar to that found in the work of Nguyen et al. (2020). It can be

explained by the fact that long distances are synonymous with high transaction costs. The positive sign of food deficit duration indicates that, the longer the duration of the food deficit experienced by the household, the more tempted it is to engage in NTFP exploitation to alleviate its food insufficiencies, since most of the NTFPs studied are food NTFPs. This result confirms the gap-filling or safety-net role of NTFPs (Sunderlin et al., 2005). The positive sign of the NTFP price appreciation level suggests that a high NTFP market price is associated with a high probability of participation in NTFP exploitation, all other things being equal. This result confirms the incentive role of prices in the supply of goods and services. The negative sign of the distance between home and NTFP gathering site indicates that, the further the household is from forest areas or NTFP gathering sites, the lower the probability that it will harvest NTFPs, all other things being equal. Thus, households living closer to forests or NTFP-providing trees benefit from a more secure and accessible supply compared to households further away, as explained by Fonta and Ayuk (2013). The positive sign of membership of a NTFP exploitation association is not surprising insofar as organization into associations helps to reduce transaction costs through the development of partnerships between harvesters, processors, traders, researchers, state institutions and non-governmental organizations (NGOs).

For households that economically exploit NTFPs, four variables are significant in predicting income: area of land owned, household size, access to credit and gold panning (Table 3). The positive sign for access to credit implies that the fact that a household has access to credit increases its income compared to a household where no member has access to credit. Indeed, access to credit helps to strengthen the capacity of rural households to acquire production equipment and increase their production. Land-rich households have higher incomes. Indeed, the positive sign of land area owned suggests that the fact that a rural household owns a large area of land increases its income compared with a household that owns less land area. Thus, natural capital is a key determinant of the standard of living of rural households. As expected, household size reduces earning potential. The positive sign for gold panning indicates that a household that practices gold panning increases its income compared to a household that does not.

For households that do not exploit NTFPs, three variables are significant in predicting income. These were education, area of land owned and gold panning (Table 3). The previous paragraphs have shown that education has a negative effect on participation in the economic exploitation of NTFPs. However, the effects of education on income are positive for households that do not exploit NTFPs. This suggests that a household with an educated head is less likely to participate in NTFP exploitation but more likely to have a higher income than a household headed by an illiterate head. This result confirms the theoretical predictions between investment in human capital and standard of living. In the rural context, it could be explained by the fact that, in addition to the contribution of education to improving agricultural productivity, educated heads of household are more likely to be employed in high-yield non-agricultural activities.

Table 3. Regression coefficients for the endogenous switching model

VARIABLES	INCOME (REGIME 1)		INCOME (REGIME 0)		NTFP EXPLOITATION	
	COEFFICIENTS	Z	COEFFICIENTS	Z	COEFFICIENTS	Z
Gender	0.038	(0.22)	-0.480	(1.58)	0.064	(0.29)
Age	-0.003	(0.76)	0.009	(1.21)	0.007	(1.30)
Marital status	0.430	(1.61)	-0.372	(1.14)	0.779***	(2.75)
Education	0.172	(0.93)	1.124***	(3,45)	-0.461*	(1.85)
Household size	-0.040**	(2.57)	-0.038	(1.04)	0.050*	(1.93)
Land area	0.053***	(6.05)	0.051**	(2.36)	0.049***	(3.45)
Access to credit	0.262*	(1.87)	-0.204	(0.61)	0.264	(1.16)
Number of active people	-0.016	(0.60)	-0.081	(1.34)	0.002	(0.04)
Distance to market	0.009	(1.56)	0.014	(1.14)	-0.015*	(1.85)
Gold panning	0.489***	(4.73)	0.501**	(2.25)	-0.006	(0.04)
Food deficit					0.490***	(4.18)
Price of NTFPs					0.885***	(5.50)
Forest association					-0.530***	(3.63)
Distance-NTFP					-0.043***	(2.42)
Constant	11.155***	(33.1)	12.246***	(31.9)	-1.058***	(2.75)
/lns0	0.060					0.72
/lns1	-0.080*					1.76
/r0	0.383					1.40
/r1	0.719***					3.78
Log likelihood			-916.03347			
Wald test chi2 (10)			51.80***			
LR test of indep. eqns. chi2(2)			9.38***			
Number of observations			530			

*Note: Absolute value of student's z statistics in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%.*

These econometric estimates of the endogenous switching model make it possible to impute the standard of living that households currently engaged in the economic exploitation of NTFPs would have had in the absence of these products.

Impact of NTFP exploitation on rural poverty

We relax the strong assumption on the independence of participation in NTFP economic exploitation and participation in other income-generating activities and consider NTFP income as a potential substitute for non-NTFP household earnings. Indeed, given that the opportunity cost of rural labor is not zero, participation in NTFP exploitation and participation in other rural activities can be considered as non-independent. So, having simulated the income households would have in the absence of NTFPs, we can compare the FGT poverty indices of this simulated income with those of the observed income. Table 4 shows the results.

In rural areas, the economic exploitation of NTFPs reduces the incidence of household poverty by 3.96 percentage points (from 57.74% to 53.77%), representing a relative reduction of 6.86% in the poverty ratio. On the other hand, the reduction in poverty gaps is much greater. Indeed, the depth of poverty fell from 30.33% to 23.89% (a relative drop of 21.27%) as a result of the existence of NTFPs. As for the severity of poverty, it drops from 18.95 to 13.80% (a relative drop of 27.12%) following the existence of NTFPs. In fact, these results are not

surprising, given the relative scale of NTFP exploitation activities in rural areas, and the upward trend in demand for NTFPs both nationally and internationally.

Table 4. Comparison of FGT poverty indices calculated from observed and simulated income

PARAMETER	AVERAGE HOUSEHOLD INCOME PER CAPITA (€)	FGT POVERTY INDICES		
		P_0	P_1	P_2
Observed income (1)	529.75 (54.80)	53.77 (2.17)	23.89 (1.24)	13.80 (0.92)
Simulated income (2)	423.72 (22.44)	57.74 (2.13)	30.33 (1.36)	18.95 (1,13)
Difference (1)-(2)	106.03*** (56.03)	-3.96* (2.57)	-6.45*** (1.46)	-5.14*** (1.19)
Percentage Change (Relative)	25.02%	-6.86%	-21.27%	-27.12%
Number of observations	530			

Discussion of results

Based on descriptive analyses, this research has shown that NTFPs are an important source of income for the majority of rural households in the study area. This result is in line with the findings of Sawadogo et al. (2023) and Nugroho et al. (2023) that rural households lack resources at different times of the year and adopt NTFP exploitation as a strategy for diversification of income sources. Indeed, rural households face shocks, such as climatic hazards, that negatively impact their main subsistence activity, namely agriculture. To cope with these covariant shocks, households align several strategies, including NTFP exploitation. The descriptive analyses also showed that wealthier households extract more NTFPs in terms of quantity and therefore derive more income from NTFPs than poorer households. This result indicates that NTFP harvesting is not necessarily a low-yield activity or a form of employment of last resort that asset-rich households avoid, but a productive source of income for both rich and poor households (Narain et al., 2008). It confirms the results found in the work of Heubach et al. (2011). However, it contradicts the thesis put forward in the work of Belcher (2005) that NTFPs are accessible to the poor precisely because nobody else wants them.

This research used two approaches to analyze the role of NTFPs in reducing rural poverty in Burkina Faso. The first approach was to consider income from NTFP exploitation as an "exogenous transfer" that adds to pre-existing total household income, while the second approach was to consider income from NTFP exploitation as a "potential substitute" for other locally-generated household earnings. In the first approach, we found that in the study area, NTFP exploitation contributes to a significant reduction in Foster et al.'s (1984) three poverty indices, namely poverty incidence, poverty depth and poverty severity. These results imply that NTFPs are able not only to alleviate poverty by preventing households from deteriorating into deeper poverty, but also to reduce poverty by raising household incomes above the poverty line. They confirm those obtained in the studies by Fonta and Ayuk (2013) and Babulo et al. (2009), who worked on forest products in general without distinguishing between timber and non-timber products. They are also consistent with the findings that NTFPs play gap filling and safety net roles for vulnerable households (Chilongo, 2014). On the other hand, they contradict the thesis put forward in the work of Angelsen and Wunder (2003) that NTFP exploitation can only alleviate poverty.

The strong impact of NTFP income on poverty depth suggests that participation in NTFP exploitation reduces the income gap separating the poor from the poverty line. As for the strong impact of NTFP income on poverty severity, which assigns greater weight to the poorest of the poor, it suggests that participation in NTFP exploitation improves the well-being of the poorest disproportionately. In other words, the gain in poverty reduction due to participation in NTFP harvesting disproportionately benefits the poorest households. These results show that NTFP harvesting is a pro-poor activity. Indeed, NTFPs are abundant in rural forest ecosystems and are generally accessible without requiring major financial investments, making them particularly attractive to poor rural households (Belcher, 2005; Wunder et al., 2014). The results of the first approach also showed that the effects of NTFP exploitation on poverty are much greater in the Hauts-Bassins region than in the Centre-Ouest region. This result is linked to the fact that the Hauts-Bassins region is relatively better endowed with species that provide the main NTFPs than the Centre-Ouest region. It supports the thesis that the importance of NTFPs varies significantly from one region to another, reflecting differences in the natural potential of the environment and in people's demand for NTFP (Shackleton and Pullanikkatil, 2019).

To our knowledge, all existing empirical studies have been limited to this first approach. However, insofar as participation in different activities interacts with each other, it seems more appropriate to examine the impact of NTFP exploitation on poverty, considering income from NTFP exploitation as a potential substitute for households' non-NFP earnings. In this respect, the second approach, simulating the income households would have in the absence of NTFPs, confirmed the results of the first approach. In other words, in the second approach, we also found that in the study area, NTFP exploitation contributes to a significant reduction in poverty incidence, poverty depth and poverty severity. These results contradict the pessimistic view that NTFPs are a poverty trap (Angelsen and Wunder, 2003; Byron and Arnold, 1999; Neumann and Hirsch, 2000), and mean that in the study area, NTFP harvesting plays a role in alleviating and eliminating poverty. The implication of these results is that NTFP harvesting is not only an economically rational activity (Schreckenberg, 1996), but also a source of asset accumulation for rural households (Nugroho et al., 2023). Since credit and insurance markets are virtually non-existent in rural areas, and the labor market is less than perfect, smoothing income and/or consumption becomes the primary objective of rural household livelihood strategies (Chilongo, 2014). Thus, rural households may adopt year-round NTFP exploitation due to the diversity of these NTFPs and their overlapping seasonalities (Sawadogo et al., 2023). Food NTFPs may be collected by rural households to support current consumption or to fill food shortages during lean periods (Leßmeister et al., 2018; Ouédraogo et al., 2013). As for commercial NTFPs, they can be sold on markets to meet basic needs such as modern healthcare and schooling for children (Sawadogo et al., 2023). In addition, as an alternative source of income, revenues from NTFPs can be used to invest in agriculture, livestock and human capital, which can further reduce poverty in the long term.

Contrary to some conclusions that NTFPs are inferior products with very low prices (Angelsen and Wunder, 2003), the survey conducted as part of this research revealed that prices for many NTFPs have risen considerably. This is the case for baobab pulp, locust bean seeds and shea kernels, which have become highly prized in rural areas due to their strong and growing demand, both nationally and internationally. Indeed, the household survey revealed that the price of baobab pulp has risen from 53.36 to 121.96 euros (€) per bag over the past five years. Prices for shea kernels and locust bean seeds have risen from 22.87 to 45.73 euros (€) per bag and from 30.49 to 68.6 euros (€) per bag respectively over the same period.

Finally, there are growing markets for a wide range of NTFPs, including medicinal, cosmetic and food products. Some of these markets are niche markets (organic products) where prices are very attractive. Indeed, the NTFP sector has evolved considerably in recent years, thanks to a shift in consumer tastes from chemical to organic products. As a result, particular attention is now being paid to processing, creating added value and developing new products. This means that some households may even specialize in NTFP exploitation (planting species that provide

the main NTFPs, processing NTFPs, marketing NTFPs) in order to seize the tempting economic opportunities offered by these new growth markets. NTFP exploitation activities should therefore no longer be seen as low-yield activities that keep the poor in poverty, but as rational activities that offer opportunities for employment, income generation and asset accumulation to lift people out of poverty.

Conclusion

The aim of this research was to examine the impact of NTFP exploitation on rural poverty. To achieve this, two different approaches were used. The first was to consider NTFP income as an exogenous transfer, and the second as a potential substitute for other household income. The results of the first approach, based on the decomposition of income sources and FGT index decomposition techniques, show that NTFP exploitation contributes to significantly alleviating and reducing rural poverty. As for the results of the second stage, based on econometric estimates and a simulation of the income households would have had in the absence of NTFPs, they confirm those obtained in the first approach. These results mean that NTFPs offer an additional option for rural households to escape poverty, which for some may be complementary to other options, while for others it may be a substitute. They suggest that policies to reduce rural poverty based on the sustainable use of NTFPs are potentially feasible. Consequently, the NTFP sector deserves to be recognized and supported in development policies through political or financial investments to create favorable environments for their sustainable exploitation. This may involve forest development initiatives through the domestication of species that provide the main NTFPs and actions to promote processing and market access for these products.

This research relied on a single point-in-time household surveys to assess the contribution of NTFPs to rural poverty reduction. However, household incomes, and therefore poverty status, can fluctuate significantly over time, due to multiple factors such as droughts, floods, job losses, disease, price shocks, etc. This research therefore represents a static view of poverty and NTFP exploitation. Thus, the analysis of the impact of NTFP exploitation on rural poverty could be strengthened in future research by taking into account long-term incomes rather than current incomes, given the strong fluctuations of the latter in rural areas.

Statements and Declarations

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Competing Interests

The authors of this research declare that they have no relevant financial or non-financial interests to disclose.

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Author Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Ouédraogo Issoufou, W. H. Eugenie Maiga and Lars Esbjerg. The first draft of the manuscript was written by Ouédraogo Issoufou and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data transparency

The data used in this research are original data collected from rural households. The authors declare that the database is available and can be transferred at any time.

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Appendix

Table 1: Income from NTFPs by quartile of total household income

Total household income quartile		**Income from NTFPs (€)**	
		Average	Standard deviation
1st quartile		186.51	182.45
2nd quartile		283.85	271.63
3rd quartile		360.08	336.59
4th quartile		559.65	2013.68
	Centre-Ouest	267.80	311.7791
	Hauts-Bassins	390.20	1266.706
	Total sample	347.24	1038.17
Kruskal-Wallis test (P-value)		0.0001	

Table 2: Variables in the income and participation equations and their expected signs

variables	**Measurement**	**Signs**
Dependent variables		
Per capita income (y)	Quantitative variable corresponding to the ratio between total household income and the number of household members	
Participation in NTFP economic exploitation (I)	Qualitative variable taking the value 1 if the household sells NTFPs and 0 otherwise	
Explanatory variables		
Sex (*sex*)	Qualitative variable corresponding to the gender of the head of household: 1 = female, 0 = male	-
Age (*age*)	Quantitative variable corresponding to the age of the head of household (in years)	+/-
Marital status (*married*)	Qualitative variable corresponding to head of household's marital status: 1 = couple, 0 = single	+
Level of education (*educ*)	Qualitative variable designating the level of education of the head of household: 1 = educated, 0 = otherwise	+/-
Household size (*household_size)*	Quantitative variable designating the number of people in the household	+/-
Number of active people (*active*)	Quantitative variable corresponding to the number of household members between 15 and 65 years of age	+
Access to credit (*credit*)	Qualitative variable taking the value 1 if at least one household member has access to credit and 0 otherwise	+/-
Gold panning (*gold*)	Qualitative variable taking the value 1 if at least one household member has earned income from gold panning activities and 0 otherwise	+/-
Land area (*land_size*)	Quantitative variable capturing the area of land owned by the household (in hectares)	+/-
Distance to nearest market (*dist_mark*)	Quantitative variable corresponding to the distance between the household's home and the NTFP sales market (in km)	-
Distance to nearest NTFP gathering site (*dist_NTFP*)	Quantitative variable corresponding to distance between household home and NTFP gathering site (in km)	-
Food deficit (*food_def*)	Quantitative variable corresponding to the number of months of food deficit experienced by the household (in months)	+
NTFP management group (*NTFP_assoc*)	Qualitative variable capturing the membership status of at least one household member in a NTFP exploitation or forest management group: 1 = membership, 0=no membership	+
NTFP price perception (*price_appreciat*)	Qualitative variable capturing the level of appreciation of NTFP selling prices: 1 = satisfactory, 0 = otherwise	+