Annual Conference of the African Finance and Economic Association (AFEA) and Department of Economics, University of Nairobi, Kenya

Topic: Effect of livestock diversification as a strategy for adapting to climate change on multidimensional poverty among rural households in Burkina Faso.

Authors:

 ZOUNGRANA, PhD student, University of Thomas SANKARA (Burkina Faso)

Salimata TRAORE Associate Professor Faculty of Economic Sciences, Thomas Sankara University (Burkina Faso)

Esso-Hanam ATAKE Associate Professor (HDR), Faculty of Economic Sciences, Lome University (Togo)

Abstract

This research aims to provide empirical evidence of the impact of livestock diversification strategies on multidimensional poverty among households in Burkina Faso. The use of a multiple endogenous treatment effect model on a sample of 1,348 households in Burkina Faso shows that, in the face of climate shocks, households use livestock diversification to protect themselves and minimise the effects on their well-being. Indeed, the results show that variations in temperature and precipitation are positively correlated with livestock diversification. The results also show that, in general, livestock diversification is declining. However, an estimate of the different strategies shows that diversification involving poultry and small ruminants reduces multidimensional poverty by 0.219% at the 1% threshold.

In light of these results, public policies could encourage households to diversify their livestock by opting for a combination of poultry and small ruminants through measures such as advice and technical support.

Keywords: Climate change, livestock, multidimensional poverty, Burkina Faso

INTRODUCTION

Despite significant progress in reducing extreme poverty in recent decades, Sustainable Development Goal (SDG) number 1, which aims to eradicate poverty, remains a challenge worldwide, particularly in developing countries. Indeed, although progress has been made in reducing poverty, around 53% of the population in sub-Saharan Africa still does not have access to electricity and nearly 85% of households rely on rudimentary cooking methods (IEA, 2020). In addition, nearly 1.1 billion people live in acute multidimensional poverty, with the most common deprivations including lack of adequate housing, sanitation, electricity, fuel, cooking facilities, nutrition and school attendance (UNDP, 2024). Similarly, the UNDP shows that around 19.1% of the world's population was living in multidimensional poverty in 2022, 92% of whom were in developing countries. Among these poor people, almost four in 10 were deprived of non-monetary dimensions but not captured by monetary poverty. Poverty is more prevalent in rural areas than in urban areas, with rates of 83% and 17% respectively (World Bank, 2022).

Several factors could explain the persistence of poverty in developing countries, the most important of which remain climate shocks and conflicts. The literature increasingly highlights the decisive role of climate in exacerbating conflicts and poverty, making climate shocks the main source of poverty and vulnerability for households in developing countries (Burke et al., 2009; Hsiang et al., 2013).

In developing countries, the effects of climate change threaten the livelihoods of household’s dependent on agriculture and their production systems (Mouleye et al., 2020). Indeed, households' exposure to climate shocks leads to a deterioration in food security and a loss of income and well-being. The majority of poor people are households whose income comes from agriculture, which remains their main activity (Gansonre; 2023). Climate change also affects the livestock system. Water shortages lead to a decline in the quantity and quality of fodder. In addition, heat stress affects the system and leads to a decline in production and in the quality of milk, meat and eggs (Thornton et al., 2009).

Nevertheless, the livestock sector plays an important role in mitigating climate shocks because animals are more resilient to climate change than crops due to their mobility and access to food (Rojas-Downing et al., 2017).

In the face of climate shocks, the use of formal risk management strategies becomes crucial for households. However, the dysfunction of credit and insurance markets, as well as the shortcomings of ineffective social safety nets, force households to develop informal strategies to minimise the effects of these climate shocks on their well-being (Reardon et al., 1992). Among these strategies, diversification plays a central role (Barrett et al., 2001; Ellis, 2000). This practice, particularly livestock diversification, plays a decisive role in poverty reduction thanks to the income generated directly or indirectly by the sale of livestock products and by-products. Indeed, livestock is considered a form of precautionary savings in that it constitutes an asset that can be liquidated in case of need (Dercon, 2002).

Diversification is a strategy used by households to minimise income loss and ensure a minimum income level in order to guarantee a stable level of well-being (Pede et al., 2024). Abdulai and Crole-Rees (2001) consider diversification to be the allocation of productive assets between different income-generating activities, both agricultural and non-agricultural. It involves a trade-off between a low probability of failure associated with high income and a high probability of failure associated with low income, meaning that poor households are willing to accept lower income for greater security (Ellis, 2000). This essay, drawing on Ellis's (1998) definition, considers diversification as a process of building a diversified livestock portfolio that can help minimise climate risks and thereby reduce multidimensional poverty among households.

The analysis of the effect of livestock diversification on multidimensional household poverty can be framed within portfolio theory. Although this theory was developed for portfolio diversification in capital investments, it can be applied to the agricultural sector. It is analysed as part of a risk management strategy through investment in assets whose returns are not perfectly correlated (Reardon et al., 1992; Rosenzweig, 1988). The imperfect correlation between different returns helps to reduce risk-related costs, enabling households to make gains (Reardon et al., 1992). As with capital investment decisions, different livestock portfolios are unlikely to be correlated or affected by similar risks, as different types of animals react differently to climate risks. For example, a drought shock could lead to a significant loss of large ruminants, which are heavy feeders compared to small ruminants (Kibrom and Jensen, 2020). Similarly, a flood could cause more damage to poultry than to large ruminants. Thus, in the face of climate shocks, risk-averse households will seek to minimise the effects of climate change risks by diversifying their livestock portfolio. Portfolio diversification within households is a form of income diversification, helping to minimise the effects of climate risks and thereby reduce multidimensional poverty within households. Several mechanisms explain the channels through which household diversification of animal species can mitigate climate change shocks and reduce multidimensional poverty within households. First, owning several animal species improves household nutrition. Animals also play an important role in improving agricultural productivity by providing organic fertiliser. Second, diversification through the ownership of multiple animal species improves financial status, self-esteem and social status (Danso-Abbeam et al., 2024). These effects can lead to increased spending on health, education and food within households. Finally, animals owned by households constitute a financial asset.

Similarly, the expected utility theory developed by Neumann and Morgenstern (2007) assumes that households choose a combination of animal species as a strategy for adapting to climate change in order to maximise their utility, i.e. they seek to optimise the combination of animal species that provides them with the greatest utility.

Empirically, studies conducted in various countries have highlighted the relationship between livestock diversification and household well-being. Danso-Abbeam et al. (2024), using the instrumental variables method, show that livestock diversification allows households to diversify their diet through the consumption of animal products such as meat, eggs and milk. Furthermore, Ngigi, studying a sample of 360 households, found that diversification contributes to improving household well-being. Furthermore, Murendo et al. (2019) used Poisson regression and negative binomial regression and concluded that livestock diversification improves dietary diversity among households in Zimbabwe. In addition, Megersa et al. (2014) found that animal diversification improves household food security.

In summary, these various studies agree that livestock diversification contributes to improving household welfare. However, a methodological analysis of these studies shows that, in order to address the problems of simultaneity and endogeneity between diversification and the various outcome variables, authors such as Danso-Abbeam et al. (2024) and Ngigi et al. (2021) have opted for the instrumental variables method to resolve this methodological issue. However, it is difficult to find a perfect instrument that minimises the correlation between the instrument and the error term of the outcome variable, which can lead to inconsistent estimates (Crown et al., 2011). In addition, authors such as Megersa et al. (2014) and Murendo et al. (2019) measured diversification as a binary variable, which is a limitation because this method of measuring diversification provides only aggregate results. Furthermore, the effect of livestock diversification on multidimensional poverty has not been sufficiently explored in developing countries. Most studies focus on food security or household well-being.

This research differs from previous studies in that it examines the relationship between livestock diversification and multidimensional household poverty by considering diversification as a categorical variable. This allows us to see the specific effect of different combinations of animals on multidimensional household poverty. It also takes into account the risk of endogeneity associated with selection bias and the double causality between livestock diversification and multidimensional poverty. In this case, the livestock diversification variable may be endogenous (Wooldridge, 2002). To resolve the problems of endogeneity and selection bias, the multinomial endogenous treatment effect regression model is used.

In Burkina Faso, authors have examined the relationship between diversification and household poverty in the context of climate change. Sanfo (2022) analysed the effect of crop diversification on household food security in Burkina Faso. Using the Simpson index of diversification, she concluded that households that diversify are less food insecure than households that do not diversify. Lawin and Tamini (2017) also show that risk aversion negatively affects the decision to diversify crops. In addition, level of education, distance to the market and farm size are positively associated with greater crop diversification. In short, these different studies are more oriented towards crop or income diversification.

This research therefore contributes to the literature by addressing the following question: What is the effect of livestock diversification on multidimensional poverty among households in Burkina Faso? To answer this question, this research aims to analyse the effect of livestock diversification on multidimensional poverty among households in Burkina Faso. It is based on the hypothesis that livestock diversification helps reduce the level of multidimensional poverty among households in Burkina Faso in the face of climate shocks.

This research focuses on Burkina Faso for several reasons. Climate change has an impact on agricultural production and, in particular, on food security and household income. The populations of Burkina Faso, like those of other sub-Saharan African countries, face the socio-economic challenges posed by climate change. In Burkina Faso, agricultural households are small and dominate the agricultural sector, suggesting that household livelihoods are vulnerable to climate shocks. Progress has been made in eradicating multidimensional poverty. However, in 2021, the multidimensional poverty index in the different regions of the country ranged from 0.088 to 0.614 (United Nations Development Programme, 2024). At the national level, the multidimensional poverty index is 64.5%, with 38.5% of the population living in severe multidimensional poverty (United Nations Development Programme, 2024).

This essay contributes to the literature on household adaptation strategies to climate change by capturing the effect of livestock diversification on multidimensional poverty. It identifies the causal effect of the choice of animal species combination on multidimensional household poverty, as well as the potential distributional implications. Analysing the impact of diversification on multidimensional poverty in households is necessary because it helps guide policies aimed at alleviating poverty in developing countries (Barrett, Reardon, et al., 2001).

In addition, the study takes into account the risk of endogeneity associated with biases (household self-selection and selection bias) and the double causality that exists between the level of multidimensional poverty of households and the choice of diversification strategy. To address this issue, possible methods that can be used include instrumental variable methods and multinomial treatment endogenous methods. The multinomial treatment endogenous model is justified by the multinomial nature of the diversification strategy.

The rest of this research is structured as follows: Section 2 presents a review of the theoretical and empirical literature, Section 3 highlights the methodology, Section 4 presents the results and discussions, and finally Section 5 presents the conclusion along with economic policy implications.

1. Literature review of the effects of diversification on multidimensional poverty in households

This part of the present research highlights, on the one hand, the theoretical foundations of the relationship between livestock diversification and multidimensional poverty in households in the context of climate change and, on the other hand, presents empirical analyses.

1. Theoretical analysis of the relationship between animal species diversification and multidimensional household poverty

In the literature, livestock diversification is a relevant strategy for enabling farming households to adapt to climate change while maintaining their well-being. The classic economic analysis of the choices made by households in situations of risk is based on expected utility theory (Neumann & Morgenstern, 2007) and Markowitz's modern portfolio theory (1952).

Expected utility theory assumes that households choose a combination of animal species as a strategy for adapting to climate change in order to maximise their utility and thereby reduce their level of poverty. Thus, a household will decide to adopt a given combination of species when the utility resulting from that combination is greater than that of another combination considered as an alternative. Furthermore, it assumes that farming households have consistent and stable preferences, know what they want and examine the available alternatives before choosing the ones they consider best (Stanković and Petrović, 2016). On the other hand, the decision to diversify activities or income by households depends on several factors, including the need to diversify and the choice. Indeed, diversification by choice is linked to the household's voluntary decision to diversify its activities, while diversification by necessity results from desperation, i.e. the last resort of particularly vulnerable households to survive (Ellis, 2000). Furthermore, the practice of livestock farming within households is an intrinsic decision and depends on the household's intentions. It may be intended for sale, either as a guarantee in case of climate risk or for use in agriculture (Moll, 2005). Animals are a source of income, insurance and a reflection of social status (Bennison et al., 1997; Moll, 2005). The composition of livestock in households is not only linked to climatic conditions but also to the household's objective in owning animals. Households adjust their investments in livestock farming according to climatic conditions, the resilience and ease of sale of animals (Kibrom and Jensen, 2020). In fact, compared to large ruminants, small ruminants are easier to sell when managing shocks (Jalan & Ravallion, 2001).

However, some authors question the expected utility theory for two reasons: firstly, it is considered to be a descriptive model of decision-making in situations of risk and, secondly, it assumes that households know in advance the probability distributions of each option when making their choices (Stanković & Petrović, 2016). Nevertheless, expected utility theory remains an appropriate theoretical framework for analysing the diversification choices of agricultural households in the context of climate change.

Like expected utility theory, the portfolio theory developed by Markowitz (1952) can also serve as an analytical framework for assessing the effect of livestock diversification on multidimensional poverty among households in the context of climate change. In terms of risk management, diversification of the investment portfolio is preferable to individual investment (Markowitz, 1952). It is a strategy for households to adapt to climate change and thus maintain their well-being in the face of climate-related risks (Ngigi et al., 2021). The portfolio diversification strategy consists of minimising risks by investing in uncorrelated assets. According to this theory, diversifying animal species, particularly for agricultural households, enables them to minimise the shocks associated with climate change. Also, in the face of climate variability, certain species such as small ruminants and non-ruminants are more resistant than large ruminants (Ba, 2023; Kibrom and Jensen, 2020). Thus, species diversification helps to improve households' ability to adapt to climate change and consequently reduces multidimensional poverty among households.

In addition, diversifying livestock farming in situations of climate risk reduces multidimensional poverty in households through several channels, including improved nutrition, increased household spending on health and education, and improved living conditions. Indeed, livestock diversification improves the availability, consumption and diversity of animal-based foods within households, contributing to improved household nutritional status. Furthermore, in situations of climate uncertainty, animal species diversification improves household financial performance (Salvioni et al., 2020).

1. Empirical analysis of the relationship between animal diversification and multidimensional household poverty

Several empirical studies have analysed the contribution of livestock diversification to household well-being. The results converge, revealing a positive effect of livestock diversification on multidimensional poverty in households. Danso-Abbeam et al. (2024) analysed the relationship between animal diversification and household food security in Ghana. Using the two-stage instrumental variable method, they concluded that livestock diversification improves household food security. Diversification allows households to consume more livestock products such as meat, milk and eggs, thereby improving the nutritional value of their diet. The effect may be indirect in that livestock can be used on the farm or on other farms as a service to generate income and stimulate household agricultural production. However, their results reveal an upward relationship with a diminishing marginal effect between diversification and household income. In addition, Ngigi et al. (2021) examine the role of livestock diversification in risk management and improving household welfare in the context of climate risks and multiple shocks in Kenya. Based on two waves of data sets from 360 households, they conclude that animal portfolio diversification allows households to smooth their consumption. Indeed, the authors also show that small ruminants, poultry and cattle contribute significantly to household income while minimising the effects of climate risks. This result shows the need to diversify the livestock portfolio, as some animals such as poultry and small animals are less affected than large animals. By conducting an analysis of income quintiles, the authors show that small ruminants improve income in all quintiles except the fifth quintile. On the other hand, non-ruminant animals, cattle and poultry improve the income of wealthy households in the fourth and fifth quintiles.

Murendo et al., (2019) analyse the role of agricultural and animal diversification on child nutrition in Zimbabwe using a sample of 986 households in two districts. The authors use Poisson regression and negative binomial regression and conclude that livestock diversification improves food diversity and food consumption in both districts of Zimbabwe. Similarly, Megersa et al. (2014) studied the role of livestock diversification on household food security in the face of climate shocks. Based on survey data collected from 242 households, they conclude that livestock diversification was positively and significantly associated with improved household food security. Households that did not diversify their livestock were more vulnerable to food insecurity, with longer periods of food shortages than households that did diversify their livestock. They explain this result by the fact that households with a diversity of animals have higher livestock yields than those that do not diversify, thus ensuring better access to food.

Overall, the results show that different types of livestock are affected differently by climate shocks. Poultry and small ruminants can withstand climate risks and reproduce quickly, enabling households to recover and improve the resilience of their livelihoods in the face of climate change. However, these various studies have limitations. Methodologically, some authors, such as Danso-Abbeam et al. (2024) and Ngigi et al. (2021), used instrumental variable models to correct for endogeneity between diversification and the various outcome variables. However, finding a perfect instrument seems to be an almost impossible task, since researchers who try to minimise the correlation between the instrument and the error term of the outcome variable are likely to identify weak instruments, leading to inconsistent estimates (Crown et al., 2011). To address the endogeneity issue, this research uses a multinomial choice model with endogenous treatment effects, which is a more robust method than instrumental variable methods. Other studies (Megersa et al., 2014; Murendo et al., 2019) have used a binary measure of livestock diversification, which could be considered a limitation. Indeed, this measure provides more general results on the effect of livestock diversification on outcome variables, whereas in specific ways, certain species may not be beneficial to households. This research therefore disaggregates diversification into different combinations of animals, providing more detailed results and more targeted economic policy proposals.

1. Methodology

In this section, we will review the theoretical model that forms the basis of our analysis. From this, we will develop the empirical model to examine how diversifying animal husbandry as a climate change adaptation strategy impacts multidimensional household poverty in Burkina Faso.

1. Theoretical and Empirical Model

Considering livestock diversification as one of the strategies for households to manage the effects of negative shocks related to climate change on multidimensional poverty, this research falls within the sustainable livelihood’s analytical framework (Asfaw et al., 2019; Matsuura-Kannari et al., 2023).

We posit that climatic shocks influence households' decisions to choose a livestock diversification strategy to reduce their level of multidimensional poverty. Formally, multidimensional poverty is given as follows:

$Pm=f(d\left(CC, X\right), X;l)$ (1)

Where Pm is the multidimensional poverty indicator, d is the type of livestock diversification adopted by the household, X represents the household's socioeconomic characteristics, and l represents unobservable characteristics.

The model assumes that climate shocks lead households to develop strategies to cope with negative effects. Thus, we have:

$\frac{∂ (d\left(CC, X\right)}{∂CC} $> 0 (2)

We assume that diversifying livestock is a climate change adaptation strategy that mitigates the negative impact of climate change on multidimensional household poverty. Therefore, we hypothesize that:

$\frac{∂ Pm }{∂d} $< 0 (3)

The linearization of Equation 1 allows us to derive two equations. On the one hand, an equation that describes the relationship between **climate change** and the household's **livestock diversification decision**, and on the other hand, the effect of different diversification strategies on **multidimensional household poverty.** Livestock diversification is necessary for households to adjust their animal portfolio to strengthen their **resilience,** thereby minimizing the effects of climate shocks on multidimensional poverty. Also, the household chooses the best type of diversification that will provide it with the most utility. The probability of choosing a diversification type j is the probability that the utility provided to household i is higher than the utility associated with other types of livestock diversification, subject to a set of constraints such as income. The choice of diversification type j is only feasible if the maximum expected utility with its adoption ($U\_{J}$​) is better than the expected utility with any other type of animal combination. Thus, we have: $U\_{J}$>$U\_{k}$ ou $Pm\_{i}=$ $Pm(U\_{J})$-$Pm(U\_{k})$ < 0 with k representing the various types of livestock diversification and Pm being an unobservable latent variable. For each household i, the utility differential between opting for a diversification type j and the alternatives can be expressed as a function of observed characteristics Xi and unobserved characteristics, and is provided by the following equation:

$Pm\_{i}=$ $Pm(U\_{J})$-$Pm(U\_{k})$ = $γ\_{j}X\_{j}+ε\_{j}-(γ\_{k}X\_{k}+ε\_{k})$ (4)

For a household to choose combination j rather than other alternatives k, it must be that $Pm\_{ij}< Pm\_{ik}$ ​ with m≠k. This means that the expected level of multidimensional poverty is low compared to any other type of animal combination.

The equation that captures the effect of livestock diversification on household multidimensional poverty is given by the following relationship:

$P\_{mi}^{\*}=α +ω\_{i}d\_{i}+γ\_{i}X\_{i}+ε\_{i} $(5)

Where Pmi​ represents the multidimensional poverty index of household i, di​ is the type of diversification carried out by household i, X represents the socioeconomic characteristics of the household, ϵi​ is the error term, and γ, α, and ω are the parameters to be estimated.

The estimation of Equation 5 presents an endogeneity problem. There's a probability of simultaneity between livestock diversification and household multidimensional poverty. Also, households may self-select into their diversification decisions, indicating that their choices are influenced by unobservable characteristics that could be correlated with multidimensional poverty, consequently leading to selection bias (Di Falco et al., 2011). These unobservable factors might include, among others, the household's technical and livestock management capacity, the imperfect structure of the rural labor market, and information asymmetry (Abdulai and Huffman, 2014). With the presence of selection bias, using ordinary least squares (OLS) leads to inconsistent and biased results. To overcome this problem, an endogenous treatment effects multinomial choice model is employed (Deb and Trivedi, 2006). This model can address endogeneity within a decision model involving multiple choices. Furthermore, the endogenous treatment effects multinomial model accounts for selection bias arising from both observable and unobservable factors.

The estimation of the treatment effect model follows two steps. First, it involves identifying the determinants of household diversification decisions using a multiple selection logistic regression model. Then, inverse Mills ratios are estimated from the predicted probabilities of the multinomial logistic regression model. Second, this step determines the effect of each type of diversification on household multidimensional poverty, with the inverse Mills ratios included as additional covariates to correct for endogeneity. Thus, based on equations (4) and (5), the following empirical models are obtained:

Empirical Equation for Diversification Type Choice

$d\_{i}= β\_{0}+δ\_{1i}drought\_{i}+δ\_{2i}flood\_{i}+δ\_{3i}average\\_precipitation\_{i}+δ\_{4i}average\\_temperature\_{i}+γ\_{i}age\_{i}+γ\_{i}sgender\_{i}+ γ\_{i}education\_{i}++γ\_{i}household\\_size\_{i}+γ\_{i}association\\_member\_{i}+γ\_{i}​land\\_area\_{i}+ ρ\_{i}access\\_veterinary\\_care\_{i}+θ\_{J} $(6)

Empirical multidimensional poverty equation

$Pauv\_{multi}= β\_{0}+ ω\_{i}diversification\_{i}+γ\_{i}age\_{i}+γ\_{i}gender\_{i}+ γ\_{i}education\_{i}+γ\_{i}situation\_{matrimoni}\_{i}+γ\_{i}household\\_size\_{i}+γ\_{i}association\\_member\_{i}+γ\_{i}land\\_area\_{i}+ε\_{i}$ (7)

The estimation method is simulated maximum likelihood

1. Data Source and Justification for Variable Choice

 This part focuses on describing the data, as well as the variables pertaining to diversification and multidimensional poverty.

1. Data source

The data used in this study are secondary data and combine two databases. On one hand, there is data on the socioeconomic characteristics of households from the Harmonized Survey on Household Living Conditions (EHCVM, 2021). On the other hand, data on temperatures and precipitation come from the Aiddata database (2021).

For the household sociodemographic characteristics data, data collection is conducted by the General Directorate of Sectoral Studies and Statistics across the thirteen regions of Burkina Faso and covers a sample of 1,338 households. This research uses a sample size of 1,348 households. The sampling method used is the random method. The information collected from households concerns sociodemographic characteristics, agricultural production, shock adaptation strategies, livelihoods, the scale of access determining household food insecurity, income sources, experienced shocks, and finally, transfers received by the household. This data is periodically collected by the National Institute of Demography and Statistics (INSD) with the aim of better understanding household living conditions in the country and assisting public decision-makers in implementing development policies and planning.

As for the climatic data, these are geospatial remote sensing data, meaning daily historical reanalysis data of precipitation and temperatures. They come respectively from the Tropical Rainfall Measuring Mission (TRMM) and the Moderate Resolution Imaging Spectroradiometer (MODIS). TRMM data provides daily reanalysis data estimates at a resolution of 0.25 × 0.25 degrees. MODIS data, on the other hand, is collected at a resolution of 0.05 × 0.05. In this research, satellite data are used instead of data provided by the National Meteorological Agency (ANAM) because observations alone cannot provide a complete and accurate picture of the state of the Earth system across the entire globe at a given time (Gansonre, 2023).

b. Justification of Multidimensional Poverty Variables

Livestock Diversification Strategy**:** This is the variable of interest. It is categorical and takes the value 0 if the household does not diversify (i.e., only has poultry), 1 if the household diversifies with poultry and small ruminants, 2 if the household diversifies with poultry and large ruminants, and 3 if the household diversifies with poultry, small ruminants, and large ruminants. Based on descriptive statistics, we observe that the majority of households own poultry, hence the choice of poultry-owning households as the baseline (i.e., those not diversifying). In the literature, it appears that livestock diversification reduces multidimensional household poverty (Ngigi et al., 2021). Formally, we can formulate it as:

$$d\_{i}= \left\{\begin{array}{c}0 if the household only has poultry \\1 if the household has poultry and small ruminants \\2 if the household has poultry and large ruminants \\3 if the household has poultry, small ruminants, and large ruminants \end{array}\right.$$

**Education : Education level** is a categorical variable with four modalities. It takes a value of **0 if the household head has no education, 1 if the household head has a primary education, 2 if the household head has a secondary education, and 3 if the household head has a higher education.** Empirical study results consistently show that education level is a determinant of multidimensional household poverty, especially in developing countries. Most studies conclude that **education level reduces multidimensional household poverty** (Nikiema, 2024). These empirical findings confirm the predictions of human capital theory, which argues that human capital significantly increases the probability of households escaping multidimensional poverty. In line with both theory and empirical literature, this research expects that the **household head's education level will reduce multidimensional household poverty.** As for diversification, empirical study results indicate a **positive correlation between education level and diversification** (Ngigi et al., 2021).

Age: This is a continuous variable measured in years. Several authors in the literature have shown that an increase in the age of the household head has a positive effect on the household's probability of being multidimensionally poor (Nikiema, 2024). Indeed, younger individuals have significantly lower levels of multiple deprivations than older individuals. As for livestock diversification, the age of the household head has a positive effect, meaning that older household heads are more likely to invest in poultry and livestock (Ngigi et al., 2021).

 Gender: This is a binary variable, taking the value 1 if the household head is male and 0 otherwise. The literature shows that male-headed households are less exposed to multidimensional poverty than female-headed households (Nikiema, 2024). Regarding diversification, the results indicate that female-headed households are more likely to diversify their activities than male-headed households (Dagunga et al., 2020; Ngigi et al., 2021).

Household Size: This is a continuous variable measuring the number of people living in a household. Empirical literature indicates a positive correlation between household size and multidimensional household poverty (Atchi, 2022). Indeed, larger households often appear to be the most deprived as they face numerous economic challenges compared to smaller households. The increase in household expenses reduces the household's opportunities for engaging in economic activities. This contributes to a decline in their standard of living, making them vulnerable.

Membership in an Organization: This is a binary variable taking the value 1 if the household head is a member of an association and 0 otherwise. Households whose heads are members of a farmers' organization benefit from several opportunities such as training, knowledge sharing, and sometimes subsidies, thereby promoting the development of their activities.

Climatic variability: Climatic variability is measured by average rainfall, average temperatures, and the coefficients of variation for temperatures and rainfall over the five years preceding the household data collection year (2016-2020). This research uses historical climatic data from the past five years to approximate households' perceptions of weather changes, which can be significant in their decisions regarding livestock diversification. Indeed, the random nature of short-term rainfall changes better captures its effect on household multidimensional poverty (Burke and Emerick, 2016). Furthermore, it's necessary to have a modification in the distribution of rainfall and household perceptions (Alem and Colmer, 2022). Finally, using an extended historical period might underestimate the influence of past weather conditions on household multidimensional poverty because, in the long term, there are possibilities for climatic regimes to adjust. Temperatures are measured in degrees Celsius and rainfall in millimeters, respectively. After calculating the various climatic variables, household geolocation information is used to assign each household the coefficient of variation through an interpolation technique.

Income: Income is measured by various sales from agricultural production as well as other household income sources. This variable is expected to have a positive effect on diversification. Income could encourage households in their diversification activities. This research expects income to positively affect diversification, based on the work of Sanfo (2022).

Arable Land Area: This measures the farmer's land area in hectares. It is assumed to positively affect household livestock diversification. Larger farms are more able to diversify than smaller farms. Thus, the larger the proportion of land, the more the diversification index tends to improve, indicating convergence towards a high level of diversification (Sanfo, 2022).

Rainfall Irregularity and Flooding: These are binary variables. They take a value of 1 if the household reported experiencing rainfall irregularity or flooding within the last three years, and 0 otherwise. These shocks positively affect diversification because different types of livestock react differently to climatic risks (Ngigi et al., 2021).

Multidimensional poverty is the outcome variable used in this essay. Several methods can be employed to measure household multidimensional poverty, including the fuzzy set approach, the Alkire-Foster method, and Asselin's method. For this research, household multidimensional poverty is measured by an index using the methodology developed by Alkire and Foster (2011). This indicator identifies overlapping deprivations at the household level, bringing to light the incidence of poverty and the intensity of deprivations within a given population. The Multidimensional Poverty Index is built upon 10 indicators spanning three dimensions. The three dimensions used in this research are **health, education,** and **household living conditions**. The procedure for calculating the multidimensional poverty indicator is carried out in two stages. The first step is to **identify private households based on the range of deprivations they experience**, and the second step is to **aggregate the information to reflect multidimensional poverty**. Indicators are coded as 1 if the household is deprived of the indicator and 0 if not. **Equal weighting has been assigned to each indicator** based on its importance in measuring multidimensional poverty. A **deprivation score** is determined for each household by summing the different weighted deprivations, so that the deprivation score is between 0 and 1. **The higher the deprivation score, the more disadvantaged the household is.** Formally, the deprivation score is given by the following relationship:

 $c\_{i}= \sum\_{j=1}^{d}w\_{j}I\_{j}$ (8)

Where ci​ represents the deprivation score, $w\_{j}$​ is the weight of indicator 𝑗, and $I\_{j}$= 1if the household is deprived of the indicator and 0 if not.

Table 1: Dimensions, Indicators, Deprivation Thresholds, and Weights

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Dimension | Dimension Weight | Indicator | Deprivation Threshold | Indicator Weight within Dimension | Final Weight |
| Health | 1/3 | Morbidity | A household member has been sick or injured in the last 3 months, and at the same time did not consult for reasons of cost or lack of means. | 1/2 | 1/6 |
|  |  | Food Security | The household has experienced difficulties in feeding itself during the last 12 months. | 1/2 | 1/6 |
| Education | 1/3 | School Years | No household member aged 10 or older has completed five years of schooling. | 1/2 | 1/6 |
|  |  | Children's Access to Education | Any child of school-going age who is not attending school. | 1/2 | 1/6 |
| Household Living Conditions | 1/3 | Access to Toilets | If the household does not have a flush toilet or latrine, or improved pit latrines or ventilated composting toilets, or if the toilet is shared. | 1/5 | 1/15 |
|  |  | Floor Covering | If the floor of the dwelling is made of earth, planks, or anything other than cement and tiles; and if the outer walls are constructed with salvaged materials, clay, or straw. | 1/5 | 1/15 |
|  |  | Asset Ownership | The household does not own a radio, television, livestock, telephone, bicycle, motorcycle, or refrigerator. | 1/5 | 1/15 |
|  |  | Cooking Fuel | If the household uses charcoal or wood for cooking. | 1/5 | 1/15 |
|  |  | Access to Drinking Water | The household does not have access to drinking water. | 1/5 | 1/15 |

Author-inspired national report on multidimensional poverty at the local level in 2019.

A household is defined as multidimensionally poor when its deprivation score is greater than or equal to 0.33, and non-poor when its deprivation score is less than 0.33 (Nussbaumer et al., 2012). The multidimensional poverty score is given by the product of the incidence of poverty and the intensity of poverty. The incidence of poverty, also known as the poverty rate, represents the proportion of people identified as multidimensionally poor. Formally, it is given by the following relationship:

$H=\frac{q}{n}$ *(9)*

Where q is the number of people considered poor and n is the total number of households.

As for the intensity of poverty (A), it represents the average proportion of indicators across which poor households experience deprivation; in other words, it is the deprivation score for all poor individuals. Formally, it is expressed by the following relationship:

$A=\frac{\sum\_{i=1}^{n}c\_{i}(k)}{q} $ (10)

The poverty score (PS) is defined as follows

$SP=A\*H$ =$=\frac{q}{n}$*\**$\frac{ \sum\_{i=1}^{n}c\_{i}(k)}{q}$*=*$\frac{ \sum\_{i=1}^{n}c\_{i}(k)}{n}$ *(11)*

This method offers several advantages. The dual-threshold identification system prioritizes individuals experiencing multiple deprivations. It can also account for **ordinal and categorical data**, which are frequently encountered in multidimensional contexts, demonstrating that it yields identical conclusions when **monotonic transformations** are applied to variables and thresholds. Furthermore, it can be decomposed to reveal the dimensional deprivations contributing most to poverty for a given group, which is highly useful for **policy development** (Alkire and Foster, 2011).

1. Results and Discussion

In this section, we will present descriptive statistics and the results from the econometric model estimation, followed by a discussion of the findings.

1. Multidimensional Poverty Index

This research was inspired by the methodology developed by Alkire and Foster (2011). Table 2 presents the results of the estimations for poverty incidence, intensity, and the multidimensional poverty index for households in Burkina Faso. The results show that poverty incidence in Burkina Faso is 90.3%. The poverty intensity, which measures the average weighted deprivation among poor households, is estimated at 60.5%, indicating that poor households are deprived of nearly 60.5% of the weighted indicators. The multidimensional poverty rate is estimated at 54.7%. A household is considered multidimensionally poor if it is deprived of at least one-third of the weighted indicators, meaning the multidimensional poverty threshold is set at 0.33 (Nussbaumer et al., 2012).

Table 2: Estimation of Multidimensional Poverty in Burkina Faso (Multidimensional Poverty Threshold: 0.33).

|  |  |
| --- | --- |
| VARIABLES | Coefficient |
| Poverty Headcount (H) | 0.903\*\*\* |
|  | (0.010) |
| Multidimensional Poverty Index (M0) | 0.547\*\*\* |
|  | (0.008) |
| Poverty Intensity (A) | 0.605\*\*\* |
|  | (0.006) |
| Observations | 1,348 |

Author's analysis of data from the Harmonized Household Survey

1. Sensitivity test.

The study conducts a sensitivity analysis to test the robustness of the Multidimensional Poverty Index because it can be vulnerable to the threshold and weights used. To do this, the multidimensional poverty threshold (k) was modified to observe its impact on the poverty index (Nussbaumer et al., 2012). Robustness is tested by varying the multidimensional poverty threshold (k) between 0.29 and 0.37. The results are presented in Table 3. The results show that modifying the threshold does not lead to a significant change in the values of the Multidimensional Poverty Index

Table 3. Robustness Results of Multidimensional Poverty Index Measures

|  |  |  |
| --- | --- | --- |
| Poverty Threshold (k) | Incidence of Poverty (H) | Multidimensional Poverty Index (M0) |
| 0.30 | 0.903\*\*\* | 0.547\*\*\* |
| 0.33 | 0.903\*\*\* | 0.547\*\*\* |
| 0.37 | 0.903\*\*\* | 0.547\*\*\* |

Source: Author, based on data from the Harmonized Household Survey

1. Descriptive Statistics

Statistical analysis shows that across the entire sample, the age of household heads ranges from 18 to 99 years, with an average age of 49. The sample consists of 95.85% men versus 4.15% women. Across all households in the sample, the education level remains low. Indeed, only 17.28% of household heads are educated compared to 82.72% who are not. The minimum household size is one person, while the maximum size is 43 people, with an average size of eight people per household. Statistical analyses also show that 14.39% of households reported having experienced at least one flood in the last three years, and 59.57% reported observing irregular rainfall. Only 4.97% of the households in the sample are members of an association. Data analysis shows that the average livestock measured in Tropical Livestock Units is 4.075. Nearly 75.67% of households have access to at least veterinary services. Temperature and precipitation fluctuations around the mean are 0.085 and 0.56, respectively.

Table 4: Descriptive Statistics of Qualitative Variables

|  |  |  |
| --- | --- | --- |
| Variable | Modality | Proportion |
| Multidimensional Poverty | non\_multidimensionally\_poor | 12.39 |
|  | multidimensionally\_poor | 87.61 |
| Diversification Strategy | poultry | 27.45 |
|  | poultry\_smallruminant | 32.42 |
|  | poultry\_largeruminant | 9.64 |
|  | poultry\_small\_largeruminant | 30.49 |
| gender | female | 4.15 |
|  | male | 95.85 |
| Education  | none | 82.72 |
|  | primary | 12.39 |
|  | secondary | 4.67 |
|  | higher | 0.22 |
| Received Fund Transfers | no | 34.5 |
|  | yes | 65.5 |
| Association Membership | no | 95.03 |
|  | yes | 4.97 |
| Access to Veterinary Services | no | 24.33 |
|  | yes | 75.67 |
| Irregular Rainfall | no | 40.43 |
|  | yes | 59.57 |
| Flooding | no | 85.61 |
|  | yes | 14.39 |
| Sector of Activity | agricultural\_sector | 20.77 |
|  | nonagricultural\_sector | 79.23 |
|  | Total | 100 |
| Agroecological Zone | Sahelian\_zone | 13.8 |
|  | Sudanian\_zone | 44.81 |
|  | South\_Sudanian\_zone | 41.39 |

Source: Author from harmonized household living conditions survey data

Table 4: Descriptive Statistics of Quantitative Variables

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Obs | Mean | Std. Dev. | Minimum | Maximum |
| Age | 1348 | 48.943 | 15.138 | 18 | 99 |
| Height | 1348 | 7.939 | 4.437 | 1 | 43 |
| Arable Land Area | 1348 | 4.06 | 3.874 | 0.002 | 42.036 |
| Income | 1348 | 318286.83 | 196595.86 | 60662.551 | 2291961.8 |
| Livestock (TLU) | 1348 | 4.075 | 6.978 | 0.01 | 90.2 |
| Average Temperature | 1348 | 40.772 | 0.8 | 38.707 | 42.214 |
| Average Precipitation | 1348 | 920.346 | 97.738 | 663.615 | 1142.152 |

Source: Author from harmonized household living conditions survey data.

1. Determinants of Livestock Diversification Strategy Adoption

Before estimating the econometric model, several preliminary tests were conducted. First, we needed to test for the endogeneity of the livestock diversification strategy. Then, we verified the absence of multicollinearity among the variables, and finally, we tested the validity of the instruments that would be used to instrument diversification.

1. Multicollinearity Test

To prevent potential multicollinearity among the explanatory variables, it's important to test for correlations between these variables. Multicollinearity between variables can lead to consequences such as unstable and imprecise coefficients. The results in Table 5 show that the Variance Inflation Factor (VIF) values for all coefficients associated with the variables are between 1.033 and 6.294, with an average of 1.826. These results indicate that for each of the coefficients associated with the explanatory variables, the average VIF is less than 5, thus demonstrating the absence of multicollinearity among the variables (Greene, 2008). Therefore, all explanatory variables included in the model can be retained.

Table 6: Multicollinearity Test

|  |  |
| --- | --- |
| Variables | VIF |
| Average Temperature | 6.294 |
| Average Precipitation | 5.811 |
| Agroecological Zone | 1.89 |
| Diversification Strategies | 1.54 |
| Household Size | 1.49 |
| Livestock (TLU) | 1.447 |
| Arable Land Area | 1.33 |
| Income | 1.236 |
| Age | 1.205 |
| Access to Veterinary Services | 1.159 |
| Gender | 1.144 |
| Education Level | 1.109 |
| Sector of Activity | 1.107 |
| Association Member | 1.092 |
| Irregular Rainfall | 1.083 |
| Funds Received (Transfers) | 1.082 |
| Flooding | 1.033 |
| Mean VIF | 1.826 |

 S**ource**: Author from EHCVM data (2021)

Adopting a livestock diversification strategy is a complex process involving several factors. The results in the table show that the factors determining adaptation to climate change vary depending on the type of diversification strategies adopted by households. Overall, the results highlight that the **gender of the household head, household size, cultivated land area, education level, income, agro-ecological zone, rainfall and temperature history over the last five years, and access to veterinary services** are significant determinants of livestock diversification.

The climatic variables used in this study are historical rainfall and temperature data over the past five years. Estimation results reveal that the average historical rainfall significantly influences the adoption of livestock diversification at a 5% threshold. Specifically, as previous rainfall increases, the probability of households opting for diversification involving poultryand small ruminants or diversification encompassing poultry, small ruminants, and large ruminants decreases at the 5% and 1% thresholds, respectively. More precisely, an increase in rainfall over previous years reduces the likelihood of adopting these practices. This finding suggests that households are more inclined to diversify their livestock when the amount of rainfall in prior years tends to decrease, aiming to mitigate the secondary effects on their well-being. Indeed, reduced rainfall leads to the degradation of arable land, decreases productivity, and consequently lowers yields. This prompts households to consider livestock diversification to cope with the effects of these shocks. However, beyond a certain level of rainfall, the correlation becomes positive and significant. This indicates that excessive rainfall can also be considered a shock, similar to droughts, leading households to diversify their livestock to protect their well-being from such impacts. Climate shocks linked to rising temperatures have a significant and positive effect on households' decisions to diversify into poultry, small ruminants, and large ruminants. The results presented in Table 8 indicate that the occurrence of a temperature-related climate shock increases the probability of households diversifying into poultry, small ruminants, and large ruminants at a 10% significance level. This finding can be explained by the fact that rising temperatures lead to a significant decrease in the water content of arable land due to evapotranspiration. The reduction in moisture in cultivated land is often associated with a decline in household agricultural productivity, resulting in a substantial drop in agricultural yields. In response to this situation, households choose to diversify their livestock to compensate for the decrease in crop production, as animals are more resilient to temperature variability than crops. Overall, climate change compels households to diversify their livestock.This household behavior can be explained by the fact that in the face of climate shocks, households view diversification as a strategy that can help minimize the effects of these shocks on their well-being. They learn from past shocks, prompting them to diversify their livestock to protect themselves from future shocks. However, the results also show that beyond a certain temperature threshold, the effect becomes negative, indicating that further increases in temperature become unfavorable for animal development, thus discouraging households from livestock farming. Overall, climate change drives households to diversify their livestock. This household behavior can be explained by the fact that in the face of climate shocks, households consider diversification as a strategy that can help minimize the effects of these shocks on their well-being. They learn from past shocks, prompting them to diversify their livestock to protect themselves from future shocks. In the literature, these results align with those found by Matsuura-Kannari et al. (2023) and Kibrom and Jensen (2019), who found that in the face of climatic uncertainties, households consider animal production for precautionary savings and insurance purposes.

The gender of the household head has a positive effect on the adoption of diversification strategies involving poultry, small ruminants, and large ruminants. The table results indicate that when the household head is male, the probability of the household's livestock consisting of poultry, small ruminants, and large ruminants increases at the 1% threshold. This finding demonstrates that male-headed households diversify more than female-headed households. Several reasons within our context could explain this result. Firstly, it could be due to societal norms or certain cultural rules that restrict women from raising specific animals. Secondly, women face limited access to productive resources, such as land and credit, which hinders their investment in livestock farming. Finally, this outcome can be attributed to the higher vulnerability of women compared to men. This finding aligns with previous research which showed that female-headed households owned less livestock than those headed by men. However, it contradicts the findings of Dagunga et al., 2020, and Ngigi et al. (2021), who found that female-headed households were more likely to diversify their activities than male-headed households.

Household size is a key determinant in the adoption of livestock diversification strategies. Our findings indicate that household size has a significant positive influence on all three livestock diversification strategies employed to adapt to climate change, at a 1% significance level. This outcome can be attributed to the fact that household members serve as a crucial source of labor for livestock management. Furthermore, a larger number of individuals within a household incentivizes diversification of livestock to meet their substantial food and economic needs. This result aligns with findings from Dagunga et al. (2020) and Ngigi et al. (2021), who also observed a positive effect of household size on diversification.

Table 7: Determinants of Different Livestock Diversification Strategies for Households in Burkina Faso

|  |  |  |  |
| --- | --- | --- | --- |
| VARIABLES | poultry\_smallruminants | poultry\_largruminants | poultry\_small\_largruminants |
| Age | 0.0206\*\*\* | 0.0201\*\* | 0.0144\*\* |
|  | -0.00618 | -0.00852 | -0.0069 |
| gender | -0.27 | 0.895 | 2.273\*\*\* |
|  | -0.389 | -0.84 | -0.843 |
| Size | 0.163\*\*\* | 0.148\*\*\* | 0.241\*\*\* |
|  | -0.0309 | -0.0389 | -0.032 |
| Education Level | -0.21 | 0.0544 | -0.646\*\*\* |
|  | -0.168 | -0.201 | -0.199 |
| Access to Veterinary Technical Services | 1.270\*\*\* | 1.622\*\*\* | 2.242\*\*\* |
|  | -0.18 | -0.301 | -0.239 |
| Transfers Received | 0.0577 | -0.378 | -0.221 |
|  | -0.184 | -0.249 | -0.194 |
| Area | -0.0579\*\* | 0.0011 | 0.0368 |
|  | -0.0262 | -0.0312 | -0.0252 |
| Income | 8.17E-07 | 1.96e-06\*\*\* | 2.22e-06\*\*\* |
|  | -5.77E-07 | -6.64E-07 | -5.85E-07 |
| Association Member | -0.394 | 0.0985 | 0.0942 |
|  | -0.387 | -0.549 | -0.431 |
| Average Rainfall | -0.0468\*\* | -0.0441 | -0.0821\*\*\* |
|  | -0.021 | -0.0286 | -0.0278 |
| Average Rainfall Squared | 2.33e-05\*\* | 2.59E-05 | 4.39e-05\*\*\* |
|  | -1.18E-05 | -1.62E-05 | -1.61E-05 |
| Average Temperature | 28.26 | 21.16 | 42.70\* |
|  | -20.2 | -26.76 | -23.51 |
| Average Temperature Squared | -0.352 | -0.256 | -0.523\* |
|  | -0.252 | -0.334 | -0.292 |
| Irregular Rainfall | -0.247 | -0.321 | -0.169 |
|  | -0.166 | -0.245 | -0.187 |
| Flood | -0.128 | 0.507 | 0.104 |
|  | -0.236 | -0.314 | -0.266 |
| Activity Sector | -0.104 | -0.0257 | 0.451\* |
|  | -0.213 | -0.309 | -0.247 |
| Agro-ecological Zone | -0.350\* | -0.105 | -0.297 |
|  | -0.202 | -0.295 | -0.219 |
| Lambda\_poultrysmallrumin | 0.242\*\*\* |  |  |
|  | -0.0189 |  |  |
| Lambda\_poultrylargerumin |  | -0.0577\*\*\* |  |
|  |  | -0.0193 |  |
| Lambda\_poultysmllgrtrum |  |  | -0.152\*\*\* |
|  |  |  | -0.0232 |
| Constant | -544.9 | -423.6 | -839.5\* |
|  | -398.7 | -528 | -465.3 |
| Observations | 1,348 | 1,348 | 1,348 |

The variable of cultivable land area is a determinant in the adoption of each diversification strategy category. Indeed, when the cultivable land area increases, the probability of a household diversifying its livestock into poultry and small ruminants decreases at the 5% threshold. This result can be explained by the fact that in our context, when the size of a household's cultivable land area increases, the household will tend to adopt other climate risk management strategies, such as crop diversification or soil and water conservation techniques, at the expense of livestock diversification. Furthermore, this result may be linked to time and productive resource constraints, as livestock diversification requires investments in labor, time, and care, just like operating large farms. Thus, households with large land areas may deem the opportunity costs associated with diversification to be high and therefore dedicate all their resources to farming. This finding contradicts the results found by Ngigi et al. (2021).

 Education Level: This variable has a negative effect on livestock diversification across poultry, small ruminants, and large ruminants. Specifically, as the level of education increases, the probability of a household diversifying its livestock into poultry, small, and large ruminants decreases at the 1% significance level. This result appears counter-intuitive but could be explained in our context by the fact that highly educated households tend to focus on other sectors of activity, to the detriment of agriculture and livestock farming. This finding contradicts the results found by Ngigi et al., (2021).

 Access to Veterinary Services: Access to veterinary services is positively correlated with the adoption of different livestock diversification strategies at the 1% significance level. This result could be explained by the fact that contact with veterinary agents provides households with advice and technical support, which is favorable to diversifying their livestock.

 Income is a determinant factor in household livestock diversification choices. When household income increases, the probability of the household diversifying into poultry and small ruminants, or into poultry, small ruminants, and large ruminants, increases at the 5% and 1% significance levels, respectively. This result could be explained by the fact that increased income facilitates investment spending and enables households to cover animal maintenance and care expenses.

Table 7: Determinants of Different Livestock Diversification Strategies for Households in Burkina Faso

Source: Author based on EHCVM data

1. **Effect of livestock diversification strategies on household multidimensional poverty**

This section discusses the estimated effects of various livestock diversification strategies on multidimensional household poverty, presenting the results here. The multinomial endogenous treatment effects model was used to estimate both the factors influencing households' choices in livestock diversification and the impact of each diversification category on their multidimensional poverty. These econometric estimation results are shown in Table 9.

The**exogeneitytest**(λpoultry\_smallruminant​=0;λpoultry\_largeruminant​=0; λpoultry\_smallruminant\_largeruminant​=0) **rejects the null hypothesis at the 1% significance level**, which states there is a correlation between the choice of diversification strategies and multidimensional poverty (table 7). This **correlation of errors confirms the presence of endogeneity** in the diversification choice. There are unobservable factors that simultaneously affect both the choice of livestock diversification and multidimensional poverty, thus confirming the presence of endogeneity. Therefore, using an **endogenous treatment effects model is appropriate.** The **Wald test** indicates that **the model as a whole is globally significant**, as the probability is equal to zero.

Initially, we conducted a preliminary estimation using a Herfindahl-Hirschman Index (HHI) concentration index. Additionally, we performed estimations for each type of diversification to capture the individual effects of different livestock diversification strategies. The results show that, overall, livestock diversification reduces the level of household multidimensional poverty. Specifically, when a household's concentration index increases by 1%, its multidimensional poverty level rises by 3.47%. This implies that poverty decreases only when households diversify their livestock. However, the results by diversification category reveal mixed effects on household multidimensional poverty in Burkina Faso. Indeed, a livestock portfolio consisting of small ruminants and poultry significantly reduces the multidimensional poverty level for households opting for this type of diversification compared to non-diversifying households, at a 1% significance level. Indeed, when households diversify their livestock with small ruminants, their multidimensional poverty level decreases by 0.22% compared to those who only raise poultry, at a 1% significance level. This result could be explained by the fact that this type of portfolio offers several significant advantages that help reduce their multidimensional poverty level under varying climatic conditions.

Poultry and small ruminants are categories of animals that are easily accessible to households, especially those less well-off, as they require less investment. Additionally, these animals have short reproductive cycles and are easy to sell to manage certain expenses like education and health. They also contribute to reducing morbidity risks within households by providing a quick source of protein. Poultry and small ruminants demonstrate greater resilience to climate change due to their thermotolerance compared to large ruminants. They can adapt their morphological, behavioral, physiological, and genetic characteristics, allowing them to easily adjust to heat stress (Joy 2020). Small ruminants are also more tolerant of water and food scarcity and exhibit higher offspring rates in unfavorable climatic conditions.

This finding aligns with Ngigi et al. (2021), who showed that diverse livestock portfolios can offset household food expenditures during poor harvests caused by climate shocks. However, when large ruminants are included in this category, the effect on household multidimensional poverty becomes positive and significant. Indeed, when a household diversifies into poultry, large, and small ruminants, their multidimensional poverty level increases by 0.086% at the 1% threshold, compared to households that do not diversify. This result can be explained by the fact that the addition of **large ruminants**, although potentially lucrative in the long term, could increase **multidimensional poverty** within households in Burkina Faso. This type of diversification represents a significant shift that requires substantial investment in terms of maintenance, feeding, and veterinary care. Consequently, households may face resource constraints, making them less efficient. Despite the significant income large ruminants provide, adding them to household livestock might be less advantageous for vulnerable households given their susceptibility to climatic shocks. Additionally, the less frequent sale of large ruminants can limit households' ability to cover current and urgent expenses, thereby contributing to increased poverty levels. With land pressure, resource scarcity, and the adverse effects of climate change, competition between large ruminants and crops for pasture can arise, potentially reducing overall household productivity and, as a result, exacerbating multidimensional poverty within households. This result is similar to those found by Asfaw et al. (2019), who indicate that income diversification only has a positive effect for households below the 10th percentile of the income distribution, while for the rest of the farmers, it is insignificant or negative. Also, Thapa et al. (2018) find that when a household becomes more intensive in high-yield crop diversification, it may suffer from labor supply constraints, thereby limiting further diversification and its benefits.

The gender of the household head is a determinant of multidimensional household poverty. Results show that when the household head is male, the level of multidimensional poverty decreases by 0.14% compared to households headed by women. In fact, male-headed households are less likely to experience multidimensional poverty than female-headed households. This finding could be explained by the disparity in access to productive resources between men and women. Women often have limited access to productive resources such as land, credit, and education, leading to lower productivity and consequently lower incomes compared to men. Furthermore, female-headed households in our context are often single-parent households, typically due to widowhood, divorce, or male migration. These women frequently bear the sole responsibility for their families' needs. Such households generally face a labor shortage, negatively impacting their agricultural production capacity. These households are typically vulnerable as they are susceptible to climate shocks. This result is comparable to that found by Yambare and Ossouna (2020), who also concluded that female-headed households experience greater multidimensional poverty than male-headed households.

Education level is a significant factor in multidimensional poverty. The results show that the higher a household's education level, the less likely that household is to suffer from deprivation associated with multidimensional poverty. If the household head is more educated, the probability of multidimensional poverty decreasing is 0.167% at the 1% threshold. This finding could be explained by the fact that education allows individuals to gain knowledge about the risks associated with climate disruptions and to develop strategies to minimize the effects of these shocks. Additionally, vocational training, facilitated by education, enables households to diversify their income sources, thereby making them less vulnerable to climate shocks. This result is similar to that found by Yambare and Ossouna (2020), who showed that education increases human capital stock, which in turn increases labor productivity and wages. This can explain how education promotes entry into professional life, thus confirming the positive role of education in multidimensional poverty.

The variable arable land area is negatively and significantly correlated with household multidimensional poverty. The econometric estimation results reveal that an increase in the area of agricultural land exploited by households reduces the level of household multidimensional poverty by 0.008% at the 1% significance level. This result is understandable because a larger area of arable land allows households to produce more and diversify their crops. This, in turn, helps to reduce deprivations related to household food access.

Household income reduces the level of multidimensional household poverty by 3.57e-07 at the 1% threshold when the household head's income increases by 1%. This finding can be explained by the fact that income allows households to manage the various deprivation constraints associated with multidimensional poverty. This result is similar to that found by Yambare and Ossouna (2020), who concluded that as household wealth increases, the probability of being multidimensionally poor decreases.

Table 8: Effect of livestock diversification strategies on household multidimensional poverty

|  |  |  |
| --- | --- | --- |
| VARIABLES | Multidimensional Poverty[[1]](#footnote-1) | Multidimensional Poverty[[2]](#footnote-2) |
| Herfindahl Index | 3.479\*\*\* | -0.844 |
|  |  |  |
| Poultry Small Ruminant |  | -0.221\*\*\* |
|  |  | -0.0263 |
| Poultry Large Ruminant |  | 0.049 |
|  |  | -0.0352 |
| Poultry Small Large Ruminant |  | 0.0880\*\*\* |
|  |  | -0.029 |
| Age | 0.003 | 0.000913 |
|  | -0.002 | -0.000636 |
| Sex | -0.428 | -0.141\*\*\* |
|  | 0.394 | -0.0324 |
| Size | 0.038\*\*\* | -0.000633 |
|  | -0.0104 | -0.00231 |
| Education Level | -0.0104 | -0.167\*\*\* |
|  | -0.109 | -0.0245 |
| Transfers Received | -0.087 | -0.093 |
|  |  | -0.0083 |
|  |  | -0.0186 |
| Area | -0.0269\*\*\* | -0.00899\*\*\* |
|  | -0.009 | -0.00307 |
| Income |  | -3.56e-07\*\*\* |
|  |  | -5.81E-08 |
| Association Member | 0.183 | -0.000117 |
|  | -0.196 | -0.0437 |
| UBT\_Total | -0.0029 | -0.000347 |
|  | -0.00445 | -0.00111 |
| lnsigma |  | -1.892\*\*\* |
|  |  | -0.0959 |
| Constant | -1.203 | 1.202\*\*\* |
|  | -1.041 | -0.0444 |
| Observations | 1,348 | 1,348 |

Source: Author, based on EHCVM data.

1. **Robustness Test**

We conducted several sensitivity tests to evaluate the robustness of our estimations. First, we used alternative measures for the climate variable, specifically variations in rainfall and temperatures over time. For multidimensional poverty measurement, this research employed a conventional threshold based on existing literature. However, to analyze the sensitivity of our results, we used different multidimensional poverty thresholds. These various results are consistent with our main conclusions. Specifically, the findings show that fluctuations in rainfall and temperatures are positively correlated with household diversification. Additionally, livestock diversification based on poultry and small ruminants reduces households' multidimensional poverty levels, confirming the robustness of our results. All these results are presented in the annexes.

**Conclusion and Economic Policy Implications**

Livestock diversification is an approach households use to cope with the effects of climate shocks and alleviate multidimensional poverty in developing countries. Despite the empirical debate on whether households should choose between livelihood diversification and specialization to reduce poverty, a number of studies suggest greater diversification of livelihood activities, although there isn't sufficient evidence to fully support these positions. The decision-making process for agricultural households regarding livestock isn't limited to choosing between specialization and diversification, but rather opting for an optimal combination of species.

This research aimed to analyze the effect of livestock diversification strategies as a climate change adaptation strategy on multidimensional household poverty in Burkina Faso. It uses a multinomial endogenous treatment effect model and data from the Harmonized Household Living Conditions Survey (EHCVM, 2021).

The results show a positive relationship between the various climatic variables experienced by households over the past five years and the different livestock diversification strategies within households. This indicates that past shocks experienced by households encourage them to diversify their livestock in order to protect themselves from future shocks. Furthermore, it appears that among the three types of livestock diversification, the type involving poultry and small ruminants significantly reduces multidimensional household poverty in Burkina Faso. Additionally, the age of the household head, gender of the household head, household size, and marital status significantly reduce multidimensional household poverty.

Given these findings, public policies could encourage households to diversify their livestock by opting for a combination of poultry and small ruminants through actions like advice and technical support.

However, the study has limitations. Since it used cross-sectional data, it's difficult to show the temporal effect of livestock diversification on multidimensional household poverty. Therefore, future studies could conduct temporal analyses.

**Bibliography**

Abdulai, A., & CroleRees, A. (2001). Determinants of income diversification amongst rural households in Southern Mali. Food Policy, 26(4), 437‑452. https://doi.org/10.1016/S0306-9192(01)00013-6

Abdulai, A., & Huffman, W. (2014). The adoption and impact of soil and water conservation technology : An endogenous switching regression application. Land economics, 90(1), 26‑43.

Alderman, H., & Paxson, C. H. (1992). Les pauvres s’assurent-ils ? Synthèse de la littérature sur le risque et la consommation. https://books.google.bf/books?

Alem, Y., & Colmer, J. (2022). Blame it on the rain : Rainfall variability, consumption smoothing, and subjective well‐being in rural Ethiopia. American Journal of Agricultural Economics, 104(3), 905‑920. https://doi.org/10.1111/ajae.12253

Alkire, S., & Foster, J. (2011). Counting and multidimensional poverty measurement. Journal of Public Economics, 95(7‑8), 476‑487. https://doi.org/10.1016/j.jpubeco.2010.11.006

Asfaw, S., Scognamillo, A., Caprera, G. D., Sitko, N., & Ignaciuk, A. (2019). Heterogeneous impact of livelihood diversification on household welfare : Cross-country evidence from Sub-Saharan Africa. World Development, 117, 278‑295. https://doi.org/10.1016/j.worlddev.2019.01.017

Asfaw, S., Scognamillo, A., Di Caprera, G., Sitko, N., & Ignaciuk, A. (2019). Heterogeneous impact of livelihood diversification on household welfare : Cross-country evidence from Sub-Saharan Africa. World Development, 117, 278‑295.

Atchi, K. F. (2022). Effet de l’inclusion financière sur la pauvreté multidimensionnelle au Togo. La Revue Internationale des Économistes de Langue Française, 7(1), Article 1. https://doi.org/10.18559/rielf.2022.1.11

Ba, M. (2023). Essais sur le bien être et les stratégies d’adaptations des ménages ruraux mauritaniens face aux chocs pluviométriques.

Barrett, C. B., Bezuneh, M., & Aboud, A. (2001). Income diversification, poverty traps and policy shocks in Côte d’Ivoire and Kenya. Food policy, 26(4), 367‑384.

Barrett, C. B., Reardon, T., & Webb, P. (2001). Nonfarm income diversification and household livelihood strategies in rural Africa : Concepts, dynamics, and policy implications. Food policy, 26(4), 315‑331.

Bennison, J. J., Barton, D., & Jaitner, J. (1997). The production objectives and feeding strategies of ruminant livestock owners in the Gambia : Implications for policy makers. Agricultural Systems, 55(3), 425‑444. https://doi.org/10.1016/S0308-521X(97)00002-4

Burke, M. B., Miguel, E., Satyanath, S., Dykema, J. A., & Lobell, D. B. (2009). Warming increases the risk of civil war in Africa. Proceedings of the National Academy of Sciences, 106(49), 20670‑20674. https://doi.org/10.1073/pnas.0907998106

Burke, M., & Emerick, K. (2016). Adaptation to climate change : Evidence from US agriculture. American Economic Journal: Economic Policy, 8(3), 106‑140.

Dagunga, G., Ayamga, M., & Danso-Abbeam, G. (2020). To what extent should farm households diversify? Implications on multidimensional poverty in Ghana. World Development Perspectives, 20, 100264.

Danso-Abbeam, G., Ogundeji, A. A., Asale, M. A., & Baiyegunhi, L. J. S. (2024). Effects of livestock ownership typology on household food security in rural Lesotho. GeoJournal, 89(2), 63. https://doi.org/10.1007/s10708-024-11049-y

Deb, P., & Trivedi, P. K. (2006). Specification and simulated likelihood estimation of a non‐normal treatment‐outcome model with selection : Application to health care utilization. The Econometrics Journal, 9(2), 307‑331. https://doi.org/10.1111/j.1368-423X.2006.00187.x

Dercon, S. (2002). Income Risk, Coping Strategies, and Safety Nets. The World Bank Research Observer, 17(2), 141‑166. https://doi.org/10.1093/wbro/17.2.141

Di Falco, S., Veronesi, M., & Yesuf, M. (2011). Does Adaptation to Climate Change Provide Food Security? A Micro‐Perspective from Ethiopia. American Journal of Agricultural Economics, 93(3), 829‑846. https://doi.org/10.1093/ajae/aar006

Ellis, F. (1998). Household strategies and rural livelihood diversification. The Journal of Development Studies, 35(1), 1‑38. https://doi.org/10.1080/00220389808422553

Ellis, F. (2000). The Determinants of Rural Livelihood Diversification in Developing Countries. Journal of Agricultural Economics, 51(2), 289‑302. https://doi.org/10.1111/j.1477-9552.2000.tb01229.x

Gansonre, S. (2023). Welfare Impact of Rainfall Variability in Rural Niger.

Greene. (2008). Econometric analysis. https://scholar.google.com/scholar\_lookup?title=Econometric%20Analysis&publication\_year=2008&author=W.H.%20Greene

Hsiang, S. M., Burke, M., & Miguel, E. (2013). Quantifying the Influence of Climate on Human Conflict. Science, 341(6151), 1235367. https://doi.org/10.1126/science.1235367

International Energy Agency (IEA). (2020). International Renewable Energy Agency, United Nations Statistics Division, World Bank, & World Health Organisation. (2020). Tracking SDG 7 : The Energy Progress Report.

Jalan, J., & Ravallion, M. (2001). Behavioral responses to risk in rural China. Journal of Development Economics, 66(1), 23‑49. https://doi.org/10.1016/S0304-3878(01)00154-7

Kibrom, A. A., & Jensen, N. D. (2020). Access to markets, weather risk, and livestock production decisions : Evidence from Ethiopia. Agricultural Economics, 51(4), 577‑593. https://doi.org/10.1111/agec.12573

Lawin, K. G., & Tamini, L. D. (2017). Risk preferences and crop diversification amongst smallholder farmers in Burkina Faso. https://doi.org/10.22004/ag.econ.258058

Matsuura‐Kannari, M., Luh, Y., & Islam, A. H. Md. S. (2023). Weather shocks, livelihood diversification, and household food security : Empirical evidence from rural Bangladesh. Agricultural Economics, 54(4), 455‑470. https://doi.org/10.1111/agec.12776

Megersa, B., Markemann, A., Angassa, A., & Valle Zárate, A. (2014). The role of livestock diversification in ensuring household food security under a changing climate in Borana, Ethiopia. Food Security, 6(1), 15‑28. https://doi.org/10.1007/s12571-013-0314-4

Menghistu, H. T., Tesfay, G., Abraha, A. Z., & Mawcha, G. T. (2021). Socio-economic determinants of smallholder mixed crop-livestock farmers’ choice of climate change adaptation in the drylands of Northern Ethiopia. International Journal of Climate Change Strategies and Management, 13(4/5), 564‑579. https://doi.org/10.1108/IJCCSM-09-2020-0099

Moll, H. A. J. (2005). Costs and benefits of livestock systems and the role of market and nonmarket relationships. Agricultural Economics, 32(2), 181‑193. https://doi.org/10.1111/j.0169-5150.2005.00210.x

Mouleye, I. S., Diaw, A., & Hamadou Daouda, Y. (2020). Effets du changement climatique sur la pauvreté et les inégalités en Afrique subsaharienne: Revue d’économie du développement, Vol. 27(3), 5‑32. https://doi.org/10.3917/edd.333.0005

Murendo, C., Gwara, S., Mazvimavi, K., & Arensen, J. S. (2019). Linking crop and livestock diversification to household nutrition : Evidence from Guruve and Mt Darwin districts, Zimbabwe. World Development Perspectives, 14, 100104.

Neumann, J. von, & Morgenstern, O. (2007). Theory of Games and Economic Behavior : 60th Anniversary Commemorative Edition. Princeton University Press. https://doi.org/10.1515/9781400829460

Ngigi, M. W., Mueller, U., & Birner, R. (2021). Livestock Diversification for Improved Resilience and Welfare Outcomes Under Climate Risks in Kenya. The European Journal of Development Research, 33(6), 1625‑1648. https://doi.org/10.1057/s41287-020-00308-6

Nikiema, S. (2024). Effects of access to microcredit on multidimensional poverty in Burkina Faso.

Nussbaumer, P., Bazilian, M., & Modi, V. (2012). Measuring energy poverty : Focusing on what matters. Renewable and Sustainable Energy Reviews, 16(1), 231‑243. https://doi.org/10.1016/j.rser.2011.07.150

Pede, V. O., Mohammed, S., Valera, H. G., Ibrahim, M., & Antonio, R. J. (2024). Livelihood diversification and household welfare among farm households in the Philippines. Agricultural Economics, 55(6), 1040‑1056. https://doi.org/10.1111/agec.12864

Reardon, T., Delgado, C., & Matlon, P. (1992). Determinants and effects of income diversification amongst farm households in Burkina Faso. Journal of Development Studies, 28(2), 264‑296. https://doi.org/10.1080/00220389208422232

Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T., & Woznicki, S. A. (2017). Climate change and livestock : Impacts, adaptation, and mitigation. Climate Risk Management, 16, 145‑163. https://doi.org/10.1016/j.crm.2017.02.001

Rosenzweig, M. R. (1988). Risk, implicit contracts and the family in rural areas of low-income countries. The Economic Journal, 98(393), 1148‑1170.

Salvioni, C., Henke, R., & Vanni, F. (2020). The impact of non-agricultural diversification on financial performance : Evidence from family farms in Italy. Sustainability, 12(2), 486.

SANFO, Z. (2022). Analysis of the effect of crop diversification on food security in Burkina Faso. https://doi.org/10.5281/ZENODO.7322806

Stanković, J. Z., & Petrović, E. (2016). Expected utility theory under extreme risks. Facta universitatis, Series: Economics and Organization, 31‑44.

Thapa, G., Kumar, A., Roy, D., & Joshi, P. K. (2018). Impact of Crop Diversification on Rural Poverty in Nepal. Canadian Journal of Agricultural Economics/Revue Canadienne d’agroeconomie, 66(3), 379‑413. https://doi.org/10.1111/cjag.12160

Thornton, P. K., van de Steeg, J., Notenbaert, A., & Herrero, M. (2009). The impacts of climate change on livestock and livestock systems in developing countries : A review of what we know and what we need to know. Agricultural systems, 101(3), 113‑127.

UNDP (United Nations Development Programme)Nations, U. (2024). 2024 Global Multidimensional Poverty Index (MPI). In Human Development Reports. United Nations. https://hdr.undp.org/content/2024-global-multidimensional-poverty-index-mpi

World Bank. (2022). October 2022 Update to the Multidimensional Poverty Measure : What’s New. World Bank. https://doi.org/10.1596/38203

Yambare, A., & Ossouna, D. G. (2020). La pauvreté en République du Congo : Évaluation multidimensionnelle et déterminants. Revue d’économie du développement, 28(3), 99‑126. https://doi.org/10.3917/edd.343.0099

Appendix 1 : List of Animals

|  |  |  |
| --- | --- | --- |
| Animal Group | Animal Type | Weight |
| Large Ruminants | Cattle | 0.7 |
| Small Ruminants | Sheep | 0.1 |
|  | Goats | 0.1 |
| Poultry | Chicken | 0.01 |
|  | Guinea fowl | 0.01 |

**Source:** Author

Appendix 2: Estimation of Multidimensional Poverty in Burkina Faso (Multidimensional Poverty Threshold: 0.30)

|  |  |
| --- | --- |
| Variables | Coefficient |
| Poverty Index (H) | 0.903\*\*\* |
|  | (0.0107) |
| Multidimensional Poverty Index (M0) | 0.547\*\*\* |
|  | (0.00835) |
| Poverty Intensity (A) | 0.605 |
|  |  |
| Observations | 1,348 |

Standard errors in parentheses \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Appendix 3: Effect of livestock diversification strategies on household multidimensional poverty



Appendix 3: The Robustness of Livestock Diversification Strategies' Impact on Household Multidimensional Poverty



Appendix : The Robustness of Livestock Diversification Strategies' Impact on Household Multidimensional Poverty (On the verge of 0.30)



1. Result based on the Herfindahl Concentration Index [↑](#footnote-ref-1)
2. Result based on various diversification strategies [↑](#footnote-ref-2)