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Determinants of cottonseed cake adoption in pastoral and agropastoral systems in Burkina Faso: Do perceptions of climate change matter?

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Abstract

This study examines the extent to which, in the Sahelian environment – where the scarcity of forage is intensifying – climate change perceptions influence the adoption of cottonseed cake among livestock producers in the Hauts-Bassins region of Burkina Faso. Based on the subjective expected utility (SEU) framework, and a logit model estimated with survey data from 366 households, the analysis highlights the role of both perceptual and structural factors in shaping adoption decisions. The results show that herders who perceive climate change as a driver of pasture degradation have a 7.5 percentage point higher probability of adopting cottonseed cake compared to those who do not share this perception. Beyond perceptions, household resources and enabling conditions also matter. Access to credit, income and membership of producer associations significantly raise the likelihood of adoption, while pastoral status and greater distance from supply points reduce it. Education and regular contact with extension agents further strengthen adoption capacity, although with varying levels of significance. Overall, the findings suggest that adaptation decisions are not driven solely by technical or financial constraints. They are equally influenced by how producers interpret environmental changes in their production context. Policy interventions aiming to promote resilient livestock systems should therefore combine improved access to inputs and services with strategies that account for producers' perceptions of climate change.

Key words: adoption, cottonseed cake, climate change perception, pastoralism, Burkina Faso, logit model

1. Introduction

Feed shortages during the dry season represent one of the most critical constraints affecting livestock productivity in Sub-Saharan Africa (Koutou *et al*. 2017; Mouctar *et al*. 2017; Beigh *et al*. 2020; Duguma & Janssens 2021). Feeding remains not only the most critical determinant of zootechnical performance, but also the most expensive component of livestock production. Numerous studies estimate that feed accounts for between 60% and 70% of total production costs, underscoring its decisive role in determining farm profitability (Becker 2008). This predominance of feeding costs highlights the importance of optimising feed-use efficiency and adopting alternative feed resources in order to sustain competitiveness and resilience in livestock systems. This pressure is intensified by the combined effect of the limited availability of quality feed resources and high acquisition costs, which severely hinder both technical and economic performance in livestock systems (Balehegn *et al*. 2020; Sodre *et al*. 2022).

Climate change further exacerbates these challenges by reducing the availability of pasture and forage – especially during the dry season – thus amplifying the strain on animal feed resources (McGrath *et al*. 2018). This constraint is particularly acute in pastoral and agropastoral systems, which hold a significant share of national livestock herds and play a key role in supplying livestock markets and sustaining rural socio-economic structures.

In these systems, livestock feeding relies primarily on natural pastures, agricultural by-products (Kiema *et al*. 2015; Beigh *et al*. 2020), native woody plants (Zampaligré *et al*. 2013), and cultivated forages (Sanou *et al*. 2011). However, the availability of these resources remains seasonal and highly constrained over time (Maman Lawal 2014). Moreover, according to GIZ (2018), access to concentrated feed – essential for dairy cows in particular – remains extremely limited in rural areas.

This situation carries significant socio-economic implications. Feed shortages often lead to conflicts between herders and farmers, particularly during cropping and post-harvest periods (Djenontin *et al*. 2009). In addition, dairy imports continue to rise to meet national demand: in 2020, Burkina Faso imported the equivalent of 70 million litres of milk, valued at over 14 billion CFA francs (Bambio 2022). This upward trend is confirmed by FAO (2023) data, which reports imports of 690 tons in 2018, 936 tons in 2019, and 1 932 tons in 2020.

Against this backdrop of intense pressure on livestock feed resources, cotton by-products have emerged as a promising alternative for improving ruminant productivity (Warner *et al*. 2020). These by-products are widely recognised for their affordability and accessibility in bovine feeding regimes (Mullins *et al*. 2021), providing a viable pathway to strengthen feed supply chains (Montcho *et al*. 2017). In particular, cottonseed cake is a key supplement in ruminant diets (Silva *et al*. 2016; Barman *et al*. 2019; Coura de Assis *et al*. 2021), known for enhancing the economic efficiency of livestock operations, especially during the dry season (Arcanjo *et al*. 2022).

Research by Nantoumé *et al*. (2009) shows that combining cottonseed cake with crop residues results in better weight gain and improved profitability in ruminant farming. Similarly, Arcanjo *et al*. (2024) found that this by-product significantly enhances dry matter intake and body weight gain. Chabi Toko (2005) observed a marked increase in milk production with cottonseed cake supplementation, while Mullenix and Stewart (2021) report that it reduces feed costs without compromising animal performance.

Despite these advantages, the adoption of cottonseed cake remains limited among pastoral and agropastoral farmers (Deffo *et al*. 2009). The literature identifies several key factors influencing the adoption of agro-industrial by-products, including price, herd size, the number of sedentary animals, livestock experience, the herder's age and education level, access to information, geographic remoteness, and availability of storage infrastructure (Alkhtib *et al*. 2017; Baba *et al*. 2019; Mamine *et al*. 2020; Warner *et al*. 2020; Mullenix & Stewart 2021).

Moreover, the perception of climate change is playing an increasingly important role in shaping herders' adaptation strategies, particularly in herd management and feed supplementation choices (Aliyar *et al*. 2024). A growing body of research emphasises that climate perception significantly influences the adoption of agricultural technologies (Tiyo *et al*. 2015; Kassa & Abdi 2022; Chen *et al*. 2024; Oli *et al*. 2025). However, few studies have specifically examined how this perception affects the adoption of cottonseed cake.

This study aims to fill that gap. It addresses two central research questions: (i) How do pastoral and agropastoral herders in the study area perceive climate change? (ii) How does this perception affect the adoption of cottonseed cake?

The central hypothesis is that a significant share of herders view climate change as a major constraint – particularly due to its impact on the availability of forage and, in turn, on livestock productivity. It is further hypothesised that this perception positively influences their willingness to adopt alternative feed solutions, such as cottonseed cake, in response to the progressive degradation of natural pastures. The analysis is grounded in Savage's (1954) subjective expected utility (SEU) theory, which provides a framework for modelling individual decisions under uncertainty. In this context, herders decide whether or not to adopt cottonseed cake based on their subjective expectations of its benefits, reflecting adaptive rationality in the face of climatic and economic risks.

To address these research questions, the remainder of the paper is structured as follows: Section 2 reviews the literature on the determinants of the adoption of agro-industrial by-products in livestock feeding. Section 3 outlines the study's methodology, including the study area, theoretical framework and explanatory variables. Section four discusses the details about the model selected, the data and the descriptive analysis. The results and discussion are provided in Section 5, including the empirical findings from the logit model estimation. The final section, Section 6, concludes with a summary of key insights and offers policy recommendations and strategic guidance for supporting livestock systems.

2. Literature review

A substantial body of literature has examined the determinants of the adoption of livestock feed, particularly agricultural by-products (ABPs) and agro-industrial by-products (AIBPs), which are recognised for their potential to improve productivity in extensive and semi-intensive livestock systems (Deffo *et al*. 2009; Swidiq *et al*. 2012; Baba *et al*. 2019; Mamine *et al*. 2020; Mutwedu *et al*. 2022).

In the Algerian context, Mamine et al. (2020) investigated the adoption of AIBPs as innovative feed sources in a setting where the animal feed industry is heavily dependent on imported raw materials. Using a sample of 60 livestock producers and a logit model, the study highlighted the significant influence of farmers' socio-professional profiles, herd structure and type of production on the likelihood of adopting AIBPs.

In the eastern part of Democratic Republic of Congo, Mutwedu *et al*. (2022) analysed the low adoption of ABPs and AIBPs among a sample of 273 livestock producers. The results of the logit model pointed to several major constraints: lack of access to information, limited technical knowledge, inadequate or absent infrastructure, high transportation costs, storage challenges, and erratic product availability in markets.

Similarly, Deffo *et al*. (2009) examined the determinants of AIBP adoption in a context marked by structural feed deficits, surveying 61 livestock producers. Their analysis, based on a general linear model (GLM), identified several significant socio-economic factors: product price, herd size, number of sedentary animals, the farmer's experience, education level, age, and physical accessibility of the production site. Notably, the level of education was found to be positively correlated with the adoption of cottonseed cake.

In Uganda, Swidiq *et al*. (2012) surveyed 50 farms across three agroecological zones to assess the extent of crop residue and AIBP adoption. Based on non-parametric analysis, their findings revealed that inadequate training, inconsistent product quality and limited availability were among the primary barriers to adoption.

In addition, Baba *et al*. (2019) analysed the influence of socio-economic factors on the adoption of ABPs – specifically rice straw – for animal feed. Using a logit model, their study underscored the critical roles of main occupation (agriculture), contact with extension agents, the size of rice-growing land, and herd size.

Collectively, these studies converge on the identification of key recurring determinants of AIBP adoption: the socio-professional profile of the producer, herd size and composition, education level, product availability and accessibility, access to information, transport costs, storage infrastructure quality, and product price.

However, beyond these conventional variables, herders' perceptions of climate change deserve particular attention – especially in regions exposed to high climatic variability. Indeed, such perceptions are increasingly influencing adaptation strategies in pastoral and agropastoral systems, particularly in terms of herd management, feed diversification, and the adoption of supplemental feed (Aliyar *et al*. 2024). Recent studies (Tiyo *et al*. 2015; Kassa & Abdi 2022; Chen *et al*. 2024; Oli *et al*. 2025) confirm that awareness of the effects of climate change plays a key role in the adoption of agricultural technologies.

Despite this, few studies have specifically examined the effect of climate change perception on the adoption of AIBPs – and, more precisely, cottonseed cake – in pastoral and agropastoral contexts within the Sahelian zone. This gap in the literature is what the present study seeks to address by analysing how climate change perception influences the decision to adopt (or not adopt) this strategic feed resource in livestock production.

3. Methodology

This methodological section comprises six components: a description of the study area, the theoretical framework, the definition of variables, the empirical model specification, the estimation method, and the data sources used for the analysis.

3.1 Study area

The study was conducted in the Hauts-Bassins region, located in western Burkina Faso. The region consists of three provinces: Houet (capital: Bobo-Dioulasso), Kénédougou (Orodara), and Tuy

(Houndé). It includes three urban municipalities, 30 rural communes, 33 departments, 483 villages, and 45 urban sectors. The region covers an area of approximately 25 479 km² – about 9.4% of the national territory – and is home to 2 239 840 inhabitants according to recent data from INSD (2023).

The Hauts-Bassins region is characterised by a relatively diversified economy, with a notable presence of industrial and artisanal units, including SOFITEX (Société burkinabè des fibres textiles, i.e., the Burkina Faso Textile Fibre Company) and FILSAH (Filature du Sahel, i.e. the Sahel Spinning Mill). The topography alternates between peneplains, plateaus, hills and small mountains, with altitudes ranging from 250 to 700 metres (INSD 2023). The soils vary from sesquioxide-rich types – high in iron and manganese and derived from tropical ferruginous soils – to hydromorphic soils. In the Kénédougou province, soils are deep, well drained and mineral rich, but low in organic matter, making them suitable for cash crops like cotton, sesame and peanuts. In the Tuy province, approximately 50% of the land area is dedicated to agriculture. In the Houet province, hydromorphic soils overlying ancient lateritic crusts are well suited for farming (INSD 2023).

The region has a north-Sudanian climate, marked by alternating dry and rainy seasons, with annual rainfall ranging between 800 and 1 100 mm. However, the effects of climate change are increasingly evident, with rainfall patterns becoming more irregular in both spatial and temporal distribution across growing seasons (INSD 2023).

Livestock production is a fundamental component of rural livelihoods in the region. It provides income, food, nutritional support, animal traction and organic fertiliser, and serves as a socioeconomic safety net. It also plays a stabilising role for rural populations by reducing economically driven migration (FAO 2018). The growing importance of livestock in the region is reflected in herd sizes: the number of cattle rose from 1 633 924 in 2018 to 1 750 932 in 2021, while sheep numbers increased from 957 163 to 1 045 916 over the same period (INSD 2023).

Despite this upward trend, local milk production remains inadequate. Dairies face irregular supply, characterised by low, seasonal and highly fragmented milk production (Sib *et al*. 2017). This low productivity is attributed primarily to major nutritional constraints. These include the reduction in available pastures due to expanding agriculture (Liehoun *et al*. 2006), the rising cost of livestock feed (FAO 2014), and the limited adoption of forage crops – even in areas with high agricultural potential. Moreover, the Hauts-Bassins region, which accounts for 36% of the national cotton output (INSD 2023), hosts 11 cottonseed-processing facilities that produce, among other things, edible oil, household soap, livestock feed and cottonseed cake. The region also ranks second nationally in cattle (16.6%) and sheep (9.2%) populations, after the Sahel region (MRAH 2019). These features make the Hauts-Bassins region strategically important for livestock production and provide a relevant setting to investigate the adoption of cottonseed cake as a livestock feed in the context of adaptation to climate change.

3.2 Theoretical framework and definition of variables

This study is grounded in the theory of subjective expected utility (SEU), initially developed by Savage (1954). The SEU framework, widely used in decision theory, provides a robust basis for analysing individual choices under uncertainty. Unlike models based on objective probability, SEU posits that individuals construct subjective probability distributions for the outcomes associated with each decision.

In the specific context of this research, the pastoral or agropastoral livestock producer is faced with a range of ‘acts’ whose outcomes are uncertain – particularly the decision whether or not to adopt cottonseed cake for animal feeding. Suppose the producer assigns a subjective probability μ to the expected utility of adopting cottonseed cake, denoted as *f*. The expected utility of the act *f* can then be expressed as follows:

$$U(f) = \sum \mu(a(i)f(i), \quad (1)$$

where μ denotes the subjective probability assigned to act *f*, *a* represents the potential outcomes, and *i* indexes a specific farmer within the sample. This formulation allows us to model utility-maximising behaviour in an environment marked by uncertainty.

To empirically test this framework, a binary regression model was specified, using one dependent variable and several explanatory variables (Table 1).

Table 1: Summary of model variables and their descriptions

Variable	Description	Measurement	Expected sign
Dependent variable			
adopt_tc	Adoption of cottonseed cake by the livestock producer	1 if the producer adopted cottonseed cake, 0 otherwise	
Independent variables			
instruction	Education level of the household head	1 if literate (can read or write), 0 otherwise	+
age	Age of the household head	Age in years	+
pasteur	Pastoral status	1 if pastoralist, 0 if agro-pastoralist	–
productlait	Quantity of milk produced	Number of litres produced by the household	+
revenu_hf	Off-farm income	Amount of non-farm income	+
association	Membership in an organisation or social group	1 if member of a livestock group, 0 otherwise	+
Dist_LA	Distance to the cottonseed cake supply point	Distance in kilometres	–
rumin_sedent	Size of sedentary herd	Number of sedentary animals in the household	+
pecc_rpfn	Perceived impact of climate change on natural pastures	Binary variable equal to 1 if the respondent reported a decline in the availability of natural pasture attributed to climate change, and 0 otherwise.	+
agricredi	Access to agricultural credit	1 if the producer received credit, 0 otherwise	+
actifs	Number of active household members	Number of individuals aged 15 to 65 in the household	+
contact_tech	Access to technical support by livestock extension agents	1 if the producer receives technical support, 0 otherwise	+

The dependent variable (*adoption_tc*) is a binary indicator that captures whether the farmer has adopted cottonseed cake as part of their livestock feeding strategy. Adoption was defined as having used cottonseed cake at least four times over the past five years (2019 to 2023). The variable takes the value 1 if this condition is met, and 0 otherwise.

The explanatory variables include a set of socioeconomic, institutional, technical and perceptual characteristics likely to influence adoption decisions

Instruction level (*instruction*) is often a key determinant of technology adoption. Higher formal education enhances farmers' ability to understand technical recommendations and increases their responsiveness to extension services. Recent evidence confirms this pattern: for example, Sumo *et al*. (2022) find that additional years of formal schooling are strongly associated with higher demand for, and better use of, agricultural support services.

The age of the producer may also influence adoption decisions. Older farmers often possess greater farming experience, accumulated resources, or authority within their communities, which can facilitate experimentation with innovations. However, the relationship between age and adoption is not always linear, as younger farmers may be more open to risk and new technologies. Recent studies highlight this nuanced effect; for instance, Mignouna *et al*. (2011) found that, while experience enhances adoption capacity, younger farmers tend to adopt faster when technologies require significant behavioural change.

Access to agricultural credit (*agricredi*) is a critical determinant of technology adoption, especially in contexts where significant upfront investment is required. Financial liquidity – whether obtained through savings or credit – reduces cash flow constraints and enables farmers to adopt new practices and inputs. Recent evidence confirms this role: (Ullah *et al*., 2020) show that access to credit significantly increases the likelihood of adopting improved agricultural technologies in smallholder farming systems.

Membership of livestock associations (*association*) can play an important role in shaping adoption behaviour by facilitating information exchange, building social capital, and encouraging peer-to-peer learning. Such organisations provide a platform where farmers share technical advice and experiences, thereby reducing uncertainty and transaction costs. Recent studies highlight this effect: Abebaw and Haile (2013) and Ma and Abdulai (2016) show that membership of producer associations significantly increases the likelihood of adopting improved agricultural practices, largely through enhanced access to information and collective action.

Distance to supply sources (*dist_LA*) remains a critical barrier in livestock systems: greater remoteness from distribution centres significantly raises logistical constraints and transaction costs, thereby reducing the likelihood of adoption. This relationship is corroborated by Ndah *et al*. (2022), who identify market access limitations as one of the main inhibitors of forage technology uptake among smallholder farmers in Tanzania.

The number of sedentary ruminants (*rumin_sedent*) reflects livestock management practices. Farms with a larger share of sedentary animals are generally more inclined to adopt agro-industrial by-products, since such production systems are more compatible with controlled feeding, storage and regular supplementation. Recent evidence supports this view: Ben Salem and Smith (2008) highlight that sedentary or semi-intensive systems provide greater opportunities for integrating concentrate feeds and by-products into daily rations, thereby enhancing adoption compared to extensive mobile systems.

The pastoralist variable (*pasteur*) distinguishes between pure pastoral and agropastoral systems, reflecting structural differences in feeding strategies. Compared to pastoralists, agro-pastoralists usually benefit from greater access to crop residues that can be used as feed.

Milk production (*productlait*) represents an important explanatory factor, since improved feeding practices are closely linked to higher dairy yields. Several studies highlight that dietary supplementation is essential to sustain milk productivity in Sahelian contexts (Amadou & Magnani 2020).

Technical support (*contact_tech*), captured through regular interactions with extension agents, is also expected to foster adoption by improving farmers' access to information, thereby reducing uncertainty and promoting experiential learning (Adéoti *et al*. 2007).

Off-farm income (*revenu_hf*) provides an additional source of liquidity that can help overcome financial constraints. Such income flows enhance households' ability to purchase inputs and invest in feed innovations (Reardon *et al*. 2007; Diiro 2013).

Perceptions of climate change (*pecc_rpfn*), particularly regarding the decline of natural pastures, may further motivate herders to adopt alternative and more reliable feed resources, such as cottonseed cake.

The number of working-age household members (*actifs*) is often used as a proxy for available labour. Households with more active labour can more easily handle herd management tasks and are therefore in a stronger position to adopt labour-intensive practices such as feed supplementation. Nkegbe and Shankar (2014), in their analysis of technology adoption among smallholder farmers in northern Ghana, provide evidence that larger household labour endowments significantly increase the likelihood of adopting agricultural innovations.

4. Model selection and specification

4.1 Model selection

The adoption of agricultural innovations has been examined widely through econometric models aimed at formalising farmers' decision-making behaviour. Among the most commonly used approaches, qualitative response models are well suited for analysing discrete choices. However, traditional models may face limitations in capturing complex psychological or socio-demographic dimensions (Kini 2007).

The logit model is particularly appropriate for studying binary or multinomial decision outcomes. Discrete choice analysis models the likelihood that an individual selects one option from a limited set of alternatives. Contemporary applications, often grounded in random utility theory, continue to form the backbone of modelling choice behaviour (Rasanan *et al*. 2024). This type of model has been applied in a number of related contexts, including climate change perception (Habtemariam *et al*. 2016; Uddin *et al*. 2017; Kabore *et al*. 2019), the adoption of forage crops (Hamadou *et al*. 2005), and the use of agro-industrial by-products (Mutwedu *et al*. 2022).

4.2 Model specification

In this study, we employed a logit model to identify the factors driving pastoral and agropastoral household heads' decisions to adopt the use of cottonseed cake. The choice of this model aligns with the current adoption literature. As highlighted by Yuniarsih *et al*. (2024), discrete choice models are tools widely used to capture farmers' adoption behaviour. Likewise, recent theoretical reviews continue to describe the adoption process as following logistic patterns within binary outcome frameworks (Dey *et al*. 2025).

This analysis draws on the concept of decision thresholds in adoption behaviour: when agro-pastoralists face a binary choice regarding whether to adopt a technology, there is a critical threshold determined by a combination of individual and contextual variables. Adoption occurs only when the combined stimulus surpasses this threshold. Recent theoretical models in social dynamics reinforce this framework by formalising how threshold-based mechanisms drive decision-making processes (Alipour *et al*. 2024):

$$Y_i = \beta X_i + \mu_i, \tag{2}$$

where $Y_i = 1$ if the farmer adopts cottonseed cake, and $Y_i = 0$ otherwise. More precisely,

$$Y_i = \begin{cases} 1, si \;\; X_i \geq X^* \\ x, si \;\; X_i < X^* \end{cases},$$

where X^* denotes the critical threshold representing the combined effect of the explanatory variables that trigger the adoption decision.

The model thus represents a binary choice framework in which the probability of adoption ($Y_i = 1$) is a function of individual characteristics, X_i. This relationship can be expressed as:

$$Pr(Y_i = 1) = F(\beta' X_i), \tag{3}$$

$$Pr(Y_i = 0) = 1 - F(\beta' X_i), \tag{4}$$

where F denotes a cumulative distribution function. In the case of the logit model, this is a logistic function. Therefore, the probability of adoption is given by:

$$Pr(Y = 1) = \frac{e^{\beta' X}}{1 + e^{\beta' X}} \tag{5}$$

$$Pr(Y = 0) = \frac{1}{1 + e^{\beta' X}} \tag{6}$$

According to Greene (2003), the conditional expectation of the model can be written as:

$$E(Y / X) = F\left(e^{\beta' X}\right) \tag{7}$$

The estimations were conducted using STATA software, employing the maximum likelihood estimation method, which is standard in the econometric analysis of nonlinear models.

The estimated logit model is specified as follows:

$$logit(P_i) = ln\left(\frac{Pi}{1 - Pi}\right) = \alpha + \beta X_i + \epsilon_i, \tag{8}$$

where:

P_i is the probability of adoption for individual iii,
α is the intercept, and
ϵ_i is the error term.

The empirical specification of the logit model is defined as:

$$Y_i = \beta_0 + \beta_1 Dist_{LA} + \beta_2 age + \beta_3 instruction + \beta_4 actifs + \beta_5 association + \beta_6 contact_{tech} + \beta_7 rumin_{sedent} + \beta_8 agricredi + \beta_9 pasteur + \beta_{10} r_{elev} + \beta_{11} pecc_{rpfn} + \beta_{12} productlait + \mu_i, \tag{9}$$

where:

Y_i is a binary variable indicating whether the farmer adopts cottonseed cake,
β_j are the parameters to be estimated, and
μ_i is the error term.

4.3 Data and descriptive statistics

4.3.1 Data source

The data used in this study were collected through a field survey designed specifically for the purpose of this research. The selection of survey sites was guided by several criteria identified through a comprehensive literature review: (i) the importance of cotton production in the region, (ii) the presence of processing units that convert cottonseed into livestock feed – particularly cottonseed cake, and (iii) the high concentration of cattle and sheep farming in the Hauts-Bassins region of Burkina Faso.

The sample size was determined using the standard formula for estimating a sample proportion:

$$n = \frac{t^2 p(1-p)}{e^2}, \qquad (10)$$

where:

n is the required sample size,
$t = 1.96$, corresponding to the value of the Student's t-distribution at the 95% level of confidence,
$p = 0.4$, the estimated proportion of the target population, and
$e = 0.05$, the tolerated margin of error.

Based on this formula, the final sample consisted of 366 pastoral and agropastoral households. These were distributed across two provinces, Houet and Kénédougou, as detailed in Table 2 below:

Table 2: Sample distribution by province

Province	**Survey locations**	**Number of households surveyed**
Houet	Bama	89
	Farako-Bâ et Darsalamy	47
	Nasso	49
Total Houet		***185***
Kénédougou	Djigouera	56
	Kourouma	61
	Samorogouan	64
Total Kénédougou		***181***
Overall total		**366**

The questionnaire was developed and administered digitally using the KoboToolbox Collect application. This approach ensured a reliable and efficient data collection process, enabling immediate data validation and facilitating subsequent statistical analysis.

4.3.2 Descriptive analysis

The descriptive analysis of the survey data (Table 3) outlines the socio-economic characteristics of the surveyed livestock producers, explores their feeding practices, and highlights key factors likely to influence the adoption of cottonseed cake in pastoral and agropastoral systems in the Hauts-Bassins region.

The results show that the age of the household heads ranged from 18 to 77 years, with an average age of 47. This relatively young average reflects a potentially dynamic and adaptable population, underscoring the importance of public policies that support agropastoral entrepreneurship and innovation.

Milk production varies considerably across farms. While a few report annual outputs reaching up to 90 000 litres, the average was approximately 925 litres. These figures underscore the strategic role of the Hauts-Bassins region in national livestock production. According to the Ministry of Animal and Fisheries Resources (MRAH 2019), the region accounts for 24% of Burkina Faso's total milk production and is home to around 20% of its dairy-processing units. This strong performance is partly attributable to the availability of cottonseed cake, commonly used as a supplemental feed to enhance milk yields.

Nonetheless, access to cottonseed cake remains uneven. On average, farms are located 46 kilometres from supply points, with the farthest being 185 kilometres away. Such logistical barriers can hinder adoption, particularly for producers in remote areas. As noted by Deffo *et al*. (2009), longer supply chains are a major deterrent to the use of agro-industrial by-products.

Annual non-livestock income shows significant variation among the surveyed households, ranging from 225 000 CFA francs to 4 250 000 CFA francs, with a mean of 1 561 925 CFA francs and a standard deviation of 688 036 CFA francs. These disparities reflect substantial differences in the capacity of households to diversify income sources beyond livestock.

Regarding herd structure, the number of sedentary ruminants varies greatly, averaging four animals per farm, with some producers managing up to 70. Sedentarisation often implies more intensive feeding strategies during the dry season, increasing reliance on agro-industrial supplements.

From a human capital perspective, 68% of the household heads had no formal education, only 8% had completed secondary education, and just 1% had attained a post-secondary education. This low level of formal schooling may impede the uptake of new technologies, although extension services can play a compensatory role.

In terms of collective organisation, only 24% of livestock producers belonged to a professional association. These associations are vital platforms for information exchange and training, particularly in the context of adaptation to climate change. Notably, 73.5% of the respondents reported experiencing negative impacts of climate change on the availability of natural grazing resources. This perception may serve as a driver for adopting complementary feed options such as cottonseed cake.

Regarding occupational status, 20% of the respondents were exclusively pastoralists, while the majority combined livestock rearing with crop farming. Agro-pastoralists, who have access to crop residues, may be more likely to integrate agro-industrial by-products into their feeding systems.

Finally, although technical advisors are present in the region, access to their services is not yet universal. However, 89% of respondents reported having contact with at least one extension agent, suggesting strong potential for promoting the adoption of innovations. In contrast, only 10.4% of producers reported having access to agricultural credit, which limits their capacity to invest in improved feeding practices.

Table 3: Descriptive statistics of model variables

Variable	Description	Mean	Std dev.	Min	Max
Adoption_tc	1 if the farmer adopts cottonseed cake; 0 otherwise	0.39	0.49	0	1
Dist_LA	Distance to the supply point (km)	45.56	36.33	1	185
age	Age of the household head (in years)	47.41	11.13	18	77
instruction	Education level (0 = none, 4 = university)	0.67	1.07	0	4
actifs	Number of active household members (aged 15 to 65)	8.00	7.05	0	60
association	Member of a livestock producer association (1 = yes)	0.43	n/a	0	1
contact_tech	Contact with a livestock technician (1 = yes)	0.31	n/a	0	1
rumin_sedent	Number of sedentary ruminants on the farm	3.43	15.84	0	70
agricredi	Access to agricultural credit (1 = yes)	0.31	n/a	0	1
pasteur	Status as a pure pastoralist (1 = yes)	0.40	n/a	0	1
revenu	Annual non-livestock income (F CFA)	1 561 925	688 036	225 000	4 250 000
pecc_rpfn	Perception of climate change effects on pastures (1 = yes)	0.44	n/a	0	1
productlait	Annual milk production (litres)	925.55	4 849.26	0	90 000

Source: Authors' survey, June 2024.

5. Results and discussion

This study employs a logit model to investigate the determinants of cottonseed cake adoption among livestock producers operating in a pastoral context affected by climate change. The model exhibits a satisfactory fit, with a pseudo R^2 of 0.436, indicating that a substantial portion of the variance in adoption behaviour is explained (Table 4). The chi-square statistic is highly significant ($p < 0.001$), confirming the joint relevance of the included variables.

Table 4: Determinants of adoption of cottonseed cake (logit model, odds ratios)

adopt_tc	**Odds ratios (p-value)**
pecc_rpfn	5.770 (0.001)***
pasteur	0.126 (0.002)***
rumin_sedent	1.174 (0.033)**
Dist_LA	0.973 (0.000)***
instruction	2.539 (0.089)*
age	1.007 (0.781)
actifs	0.976 (0.611)
logrevenu	1.000 (0.000)***
agricredi	9.252 (0.001)***
productlait	1.000 (0.693)
association	8.472 (0.000)***
contact_tech	4.843 (0.079)*
Constant	0.023 (0.039)*
Pseudo r-squared = 0.436 Number of observations = 366 Chi-square = 81.819	Prob > chi^2 = 0.000 Akaike criterion (AIC) = 131.804 Bayesian criterion (BIC) = 182.538

Note: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively
Dependent variable: adoption of cottonseed cake, defined as the use of the product at least four times over the past five years (2019 to 2023). Coded as: 1 = yes; 0 = no.
Perception of climate change (pecc_rpfn) is measured through a binary variable equal to 1 if the respondent reported a decline in natural pasture availability attributed to climate change, and 0 otherwise.

Table 5 below presents the results as marginal effects, which indicate the change in the probability of adoption associated with a one-unit change in each explanatory variable. A positive marginal effect denotes an increase in the likelihood of adoption, whereas a negative marginal effect suggests a decrease in that likelihood.

Table 5: Marginal effects after logit estimation (Average Marginal Effects)

Variable	dy/dx (p-value)
pecc_rpfn	0.075 (0.001)***
pasteur	-0.088 (0.002)***
rumin_sedent	0.007 (0.033)**
Dist_LA	-0.001 (0.000)***
instruction	0.040 (0.089)*
age	0.000 (0.781)
actifs	-0.001 (0.611)
logrevenu	0.000 (0.000)***
agricredi	0.095 (0.001)***
productlait	0.000 (0.693)
association	0.091 (0.000)***
contact_tech	0.067 (0.079)*
Pseudo r-squared = 0.436 Number of observations = 366 Chi-square = 81.819	Prob > chi2 = 0.000 Akaike criterion (AIC) = 131.804 Bayesian criterion (BIC) = 182.538

Note: *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively
Dependent variable: adoption of cottonseed cake, defined as the use of the product at least four times over the past five years (2019 to 2023); coded as: 1 = yes; 0 = no.
Perception of climate change (pecc_rpfn) is measured through a binary variable equal to 1 if the respondent reported a decline in natural pasture availability attributed to climate change, and 0 otherwise.

5.1 Perception of climate change: A key driver of adoption

The key explanatory factor – the perception that natural pastures are deteriorating as a result of climate change – emerges with a marginal effect of 0.075, significant at the 1% level. This implies that, other conditions being equal, livestock producers who report such perceptions are about 7.5 percentage points more likely to adopt cottonseed cake than their counterparts who do not. The magnitude of this effect is both statistically robust and economically meaningful, underscoring the pivotal influence of climate risk awareness on pastoral feeding decisions.

This evidence suggests that adaptive behaviour does not arise solely from technical or economic considerations. It also depends on cognitive mechanisms through which farmers interpret signs of ecological stress in their production environment. When pasture scarcity is perceived – especially in terms of forage availability – this perception serves as a trigger encouraging the uptake of new feeding practices. Such results are in line with the work of Aliyar *et al*. (2024), Cai *et al*. (2025) and Teklay *et al*. (2025), who also highlight perception as a central factor driving farmers' adaptation strategies to climate change.

5.2 Economic resources and capacity for change

Household economic resources also appear as key factors influencing the adoption of cottonseed cake. The marginal effect associated with income is positive and significant at the 1% level, indicating that an increase in household earnings is linked to a higher probability of adoption. Although the effect size per unit is small in absolute terms, it reflects the cumulative importance of financial capacity in enabling producers to take up new practices.

Similarly, access to agricultural credit shows a strong and significant marginal effect of 0.095. Producers who secured credit displayed an adoption probability of nearly 9.5 percentage points higher than those without credit access. This result illustrates that recognising the need for adaptation is not sufficient – farmers must also have the financial means to implement change.

These findings echo those of Olutumise (2023), who highlights that credit and liquidity constraints continue to be binding barriers to innovation, particularly in settings marked by vulnerability and uncertainty.

5.3 Physical accessibility

Spatial accessibility also emerges as an important determinant of adoption. The estimated marginal effect for distance to the input point of purchase is -0.001, significant at the 1% level, meaning that each additional kilometre travelled reduces the probability of adopting cottonseed cake by about 0.1 percentage points, compared to other livestock farmers. Although this effect may appear modest in absolute value, its cumulative impact can be considerable in rural settings, where producers often face long travel distances and poor transport infrastructure.

This result underscores the fact that, even when farmers perceive an innovation as valuable and financially attainable, logistical constraints can hinder its adoption. Limited proximity to markets and high transaction costs act as structural barriers to uptake. Similar patterns have been reported by Tede *et al*. (2023), who found that shorter distances to markets increase the likelihood of technology adoption, and by Mutwedu *et al*. (2022), who stress the role of deficient infrastructure and transport costs in constraining the use of agro-industrial by-products.

5.4 Heterogeneous effects by farmer profile

Socio-professional characteristics also shape adoption patterns. The results show that being a pastoralist (extensive and mobile livestock systems) significantly reduces the probability of adoption. The marginal effect is -0.088 ($p < 0.01$), which implies that pastoralists are about 8.8 percentage points less likely to adopt cottonseed cake compared to other livestock producers. This lower likelihood likely reflects weaker integration into markets, limited capacity to store feed due to their permanent mobility, and a persistent reliance on traditional natural pastures.

In contrast, the number of sedentary ruminants has a positive and statistically significant effect, with a marginal effect of 0.007 ($p < 0.05$). Each additional sedentary animal increases the probability of adoption by around 0.7 percentage points compared to those without sedentary animals. Sedentary herds, being permanently located, generally require more structured feeding practices and imply better storage facilities and access to input suppliers. This makes them more compatible with the use of agro-industrial by-products. These results resonate with Cisse (2014), who documented how climate pressures are pushing livestock keepers toward more integrated and semi-sedentary systems, thereby increasing reliance on purchased feed during prolonged dry periods.

Finally, education level also emerges as an enabling factor. The marginal effect is 0.040 ($p < 0.10$), suggesting that educated producers are about four percentage points more likely to adopt cottonseed cake to feed ruminant animals compared to those without schooling. Education enhances awareness of the risks linked to forage scarcity and improves the understanding of the benefits of feed supplementation. Similar conclusions are drawn by Asfaw *et al*. (2012) and Oli *et al*. (2025), who highlight the role of education as a critical driver of technology adoption.

5.5 Collective structures and technical support

Beyond individual characteristics, institutional and organisational support mechanisms emerge as decisive drivers of adoption. Membership of a professional association has a strong and positive effect, with a marginal effect of 0.091 ($p < 0.01$). This means that belonging to such a group increases the probability of adoption by about 9.1 percentage points, compared to those who are not affiliated with a professional organisation. Producer organisations not only facilitate the circulation of information and strengthen trust in new practices, but they may also offer logistical support, and better access to inputs or cost-sharing arrangements. Such mechanisms of collective learning and coordination are consistent with the findings of Iyabano et al. (2022) and Wang and Xu (2025).

Similarly, contact with extension agents exerts a positive and significant influence on the adoption of cottonseed cake, with a marginal effect of 0.067 ($p < 0.10$). Producers who interact with technical staff are thus around 6.7 percentage points more likely to adopt cottonseed cake compared to those without such support. This result illustrates the practical value of agricultural advisory services when effectively delivered, as they help reduce technical uncertainty, demonstrate tangible benefits, and provide tailored guidance. Comparable evidence is reported by Baba *et al*. (2019) and Alam *et al*. (2024), who show that farmers with extension contacts have a significantly higher likelihood of adopting innovative practices.

6. Conclusion and policy implications

This study provides new insights into the determinants of adopting agro-industrial by-products in livestock systems in Sub-Saharan Africa, with a particular focus on the influence of the perception of climate change. Based on a logit model estimated from survey data of pastoral and agropastoral producers in the Hauts-Bassins region of Burkina Faso, the analysis shows that the decision to adopt cottonseed cake goes beyond the conventional structural drivers usually highlighted in the literature – such as education, farm characteristics, or access to technical support. Adoption behaviour is also shaped by producers' subjective assessments of environmental change.

The results indicate that herders who perceive climate change as contributing to the degradation of natural resources are significantly more inclined to use cottonseed cake as a complementary feed. In this sense, climate risk perception emerges as a cognitive trigger that fosters adaptive behaviour in the face of growing agroclimatic variability. This perspective broadens standard approaches to technology adoption, which often emphasise economic and technical constraints alone.

In addition, the findings underscore the relevance of several other factors: education level, livestock income, membership of producer associations, access to credit, market proximity and contact with extension services all play a positive role in adoption. Taken together, these results highlight the importance of incorporating perceptual and behavioural dimensions into extension strategies. Designing policies that acknowledge how producers interpret climate change can improve the targeting of outreach campaigns, awareness initiatives and advisory tools. Such perception-sensitive approaches may enhance the effectiveness of interventions aimed at fostering resilient feeding practices and strengthening livestock systems' adaptive capacity.

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