Perceptions of Rural Smallholder Farmers on Modern Warehouses and Factors Influencing Choice for Maize Storage: Evidence from Karaga District, Ghana.

Ibrahim Imrana Bambila[1]*, Nasiru Ibrahim[2]

[1]Department of Agribusiness, University for Development Studies, P.O.Box TL 1882, Nyankpala Campus, Tamale-Ghana

[2]Department of forestry Economics and Policy, Beijing Forestry University. No. 35 Qinghua East Road, Haidian District, Beijing, China

[*]Corresponding Author

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ABSTRACT

Modern warehouse storage systems represent a viable approach to reducing post-harvest losses, especially in rural Ghana, where smallholder agriculture predominates. This study examines rural smallholder farmers' perceptions of the efficiency and affordability of modern warehouses, as well as the factors influencing their preference for maize storage, drawing on evidence from the Karaga District of Northern Ghana. Primary data were collected from a randomly sampled 400 smallholder maize farmers through surveys and focus group discussion. Data analysis employed descriptive statistics and a binary logistic regression model. Findings reveal that farmers generally expressed slightly positive perceptions of modern warehouse storage systems, with an overall perception index of 3.25. Efficiency perception index averaged 3.33, whiles the affordability index was 3.18. Highlighting the efficiency level and cost effectiveness perceived by smallholder farmers regarding modern warehouses. However, physical access to warehouse facilities remains a barrier for some farmers, particularly those in remote communities. The overall risk perception index was 3.08, suggesting a neutral stance on the risks associated with modern warehouse storage systems. Rodent attacks and inadequate documentation emerged as the most significant risk factors. Empirical analysis identified gender, years of formal education, means of transport, income, and access to credit as significant determinants of farmers' decisions to utilize modern warehouses for maize storage. The study recommends upgrading existing district warehouses to improve efficiency and constructing additional community warehouses to enhance access and affordability. Additionally, strengthening extension delivery services is advised to increase farmers' awareness of the benefits of modern warehouse facilities.

Keywords: Modern Warehouse, Maize Storage, Rural Smallholder Farmers, Perceptions, Post-harvest Losses

INTRODUCTION

Post-harvest food losses are a significant obstacle to global food security and economic sustainability (World Bank, 2011). The Food and Agriculture Organization of the United Nations (FAO-UN) estimates that nearly one-third of global food production, approximately 1.3 billion metric tons valued at nearly US$1 trillion, is lost annually, with a considerable portion of these losses occurring in developing countries (FAO, 2011). According to the World Bank (2011), post-harvest losses (PHLs) in sub-Saharan Africa (SSA) account for nearly 30% of total agricultural food crop production, resulting in annual economic losses of approximately US$4 billion. It is further estimated that post-harvest losses for cereals in SSA range between 10% and 20%, with higher losses recorded in smallholder-dominated systems where traditional storage methods prevail (World Bank, 2014). For instance, Darfour & Rosentrater (2016) reported that annual maize PHLs in Ghana range from 5% to 70%, further diminishing already suboptimal yields. This highlights the significant contribution of post-harvest losses to food insecurity and economic livelihoods in the region.

Maize (Zea mays L.) is one of the most important staple crops in Ghana, serving as a primary source of calories and income for many households (Wahab et al., 2022). According to the Statistical Research and Information Directorate of the Ministry of Food and Agriculture (SRID-MoFA), maize accounts for over 50% of cereal production in Ghana, with average potential yields of 5.5 metric tons per hectare (SRID-MoFA, 2024). Maize production is predominantly undertaken by smallholder farmers who rely on rain-fed agriculture and operate under resource-constrained conditions (Kotu et al., 2022; Sadiq et al., 2019). Despite the crop's significance to food security and many household livelihoods in the country, post-harvest losses remain substantial due to the continued use of traditional storage structures such as cribs, mud silos, and polypropylene bags, which offer limited protection against pests, moisture, and fungal contamination (MoFA, 2017). Consequently, modern warehouse storage systems have become a viable solution to reduce these losses and to improve market participation among smallholder farmers, thereby enhancing food security and household livelihoods (Jarman et al., 2023; Kofi & Grace, 2025). These storage systems typically involve improved infrastructure, better ventilation, pest control mechanisms, and, in some cases, integration with warehouse receipt systems that allow farmers to store produce and access credit using stored commodities as collateral (FAO, 2009).

Empirical research suggests that modern storage facilities can significantly reduce quantitative and qualitative grain losses, improve grain quality, and enable farmers to engage in more strategic marketing by delaying sales to take advantage of favorable market opportunities (Ariong et al., 2023; Manandhar et al., 2018; Urugo et al., 2024). However, the adoption and utilization of such storage innovations by smallholder farmers seem to remain uneven and often limited. A growing body of literature highlights that farmers' decisions to adopt agricultural technologies are not solely determined by their technical efficiency or economic benefits but are also shaped by their perceptions, preferences, and risk considerations (Martey et al., 2020; Wahab et al., 2022). Kotu et al. (2022) explained that preferences reflect farmers' valuations of different attributes, such as cost, accessibility, reliability, and potential economic returns. These subjective assessments may significantly influence adoption behavior, even when objective benefits are well established. Understanding farmers' perceptions and preferences is therefore essential for designing effective and inclusive policy proposals that address farmers' needs and constraints for enhanced adoption of modern warehouses, in line with Ikerd (2026) recommendation for policy proposals to create more sustainable agrifood systems through local community empowerment.

Against this background, this study examines smallholder farmers' perceptions and factors influencing their choice of modern warehouses for maize storage in the Karaga District of the Northern Region, Ghana. Specifically, the study seeks to (i) assess smallholder farmers' perceptions about the affordability and efficiency of modern warehouses for maize storage, (ii) determine the risk perceptions of smallholder farmers in using modern warehouses for maize storage, and (iii) analyze the factors influencing smallholder farmers' choice of modern warehouse for maize storage. Providing empirical evidence for these objectives enables the study to contribute to the design of context-specific, farmer-centered storage policies and interventions aimed at reducing post-harvest losses, improving food security, and enhancing the livelihoods of rural smallholder farmers in Northern Ghana.

LITERATURE REVIEW

Post-harvest losses in maize storage in SSA are estimated to range from 15% to 30%, posing significant challenges to achieving food security and improving livelihoods (Stathers et al., 2025). In Ghana, these losses are especially pronounced among smallholder farmers who primarily rely on traditional storage methods, including polypropylene sacks, mud silos, cribs, and household granaries (A. A. Adams et al., 2025). Sugri et al. (2021) noted that increasing concern over post-harvest losses has prompted greater policy and scholarly attention toward modern storage technologies, such as warehouse storage systems, hermetic storage, metal silos, and warehouse receipt systems. Modern warehouse systems aim to enhance grain preservation by improving ventilation, regulating moisture, controlling pests, and implementing structured management practices. In addition to reducing both quantitative and qualitative losses, it also facilitates delayed sales, strengthens bargaining power, and contributes to market stabilization for smallholder farmers (Bidzakin et al., 2022). Nevertheless, the adoption of modern warehouse systems among smallholder farmers in Northern Ghana remains limited, indicating that factors beyond technical efficiency affect adoption decisions (A. Adams et al., 2020; A. A. Adams et al., 2025).

Empirical studies on post-harvest management consistently indicate that traditional maize storage systems remain predominant among smallholder farmers, despite growing awareness of improved storage technologies (A. A. Adams et al., 2025; Owach et al., 2017; Tibaingana et al., 2024). For instance, A. A. Adams et al. (2025) found in their study in the Sissala East District of the Upper West Region that traditional storage facilities are most commonly used due to their affordability, familiarity, and accessibility, even though these methods are associated with significantly higher post-harvest losses. Similarly, Bidzakin et al. (2016) reported that most farmers in the Upper East Region of Ghana store maize in polypropylene or jute sacks within household storage structures, resulting in substantial losses due to insects, rodents, and grain molds. Modern storage systems are often viewed as technically superior in preserving grain quality and reducing spoilage (Issah et al., 2019). This highlights the critical role that farmers' perceptions may play in their willingness to adopt improved storage systems. Studies such as Darfour & Rosentrater (2022) and Nyarko et al. (2021) have shown that hermetic bags, metal silos, and warehouse systems significantly reduce insect infestation, moisture loss, and grain deterioration compared to conventional methods. Nevertheless, positive perceptions of technical efficiency do not necessarily result in adoption, as decisions are also influenced by factors such as affordability, accessibility, institutional trust, and operational understanding.

Several studies have identified socioeconomic factors as important determinants of farmers' adoption or choice of improved storage techniques (A. A. Adams et al., 2025; Affoukou et al., 2025; Akumbole et al., 2018; Benimana et al., 2021; Ngwenyama et al., 2023; Owach et al., 2017). For instance, education consistently emerges in the studies by Affoukou et al. (2025) and Owach et al. (2017) as a positive factor in the adoption of improved storage in Ghana, Kenya, Nigeria, and Uganda, respectively. The educated farmers may be generally better equipped to process technical information and recognize the long-term economic benefits of modern technologies. Access to credit and higher household income were also found to be significant by A. A. Adams et al. (2025) and Akumbole et al. (2018) in facilitating adoption by enhancing farmers' financial capacity to cover storage-related expenses. Transportation access and market connectivity further influence warehouse utilization, since centralized storage systems often require farmers to transport produce over considerable distances (FAO, 2021). Institutional factors are also critical in shaping farmers' perceptions and use of modern storage systems (Owach et al., 2017).

Research on warehouse and collective storage systems underscores that trust in management, transparency in documentation, and confidence in institutional arrangements significantly affect participation (Armah & Asante, 2006; Peprah, 2004; Safo, 2017). Farmers may avoid public warehouse systems if they perceive deficiencies in grain monitoring, documentation, or accountability mechanisms. Additionally, concerns about theft, poor management, pest infestation, and inadequate supervision have been identified as barriers to participation in collective storage systems (Bidzakin et al., 2016). Some studies argue that limited income, limited access to credit, and high transaction costs constitute the major barriers preventing farmers from adopting improved storage systems. Others contend that cultural attachment to traditional storage practices, low institutional trust, and limited technical knowledge are equally important determinants. Evidence from Northern Ghana suggests that many farmers continue to rely on indigenous storage systems not only because they are cheaper, but also because they are familiar, locally controlled, and embedded within household farming practices (Abdulai & Abdulai, 2023; A. A. Adams et al., 2025; Arthur et al., 2022).

There is limited empirical research on smallholder farmers' perceptions of modern warehouse storage systems in the specific context of the Karaga district in Ghana's Northern Region. Moreover, few studies have concurrently examined perceptions, risk considerations, and the factors influencing smallholder farmers' decisions to use modern warehouse systems in the area, where maize production is significant and a major staple crop produced by over 90% of farm households (Karaga District Assembly, 2020). This study addresses these gaps by providing an empirical analysis of smallholder maize farmers' perceptions of modern warehouse storage systems, the perceived risks associated with their use, and the socioeconomic factors influencing adoption in the Karaga District of Northern Ghana.

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METHODOLOGY

Study Area

Karaga District in Northern Ghana is the study area. The study focused on this area because it is one of the highest food-growing districts in Ghana, with over 90% of households engaged in agriculture (Karaga District Assembly, 2020). The district is approximately between latitudes 9030' S and 10030' N, and longitudes 00 E and 450 W, on the north-eastern side of Northern Ghana, with a land area of 2,844 km², located 94 miles from Tamale, the regional capital (Figure 1). The estimated population in the area is 114,225, with 48.70% males and 51.30% females, and an annual growth rate of 2.7%.

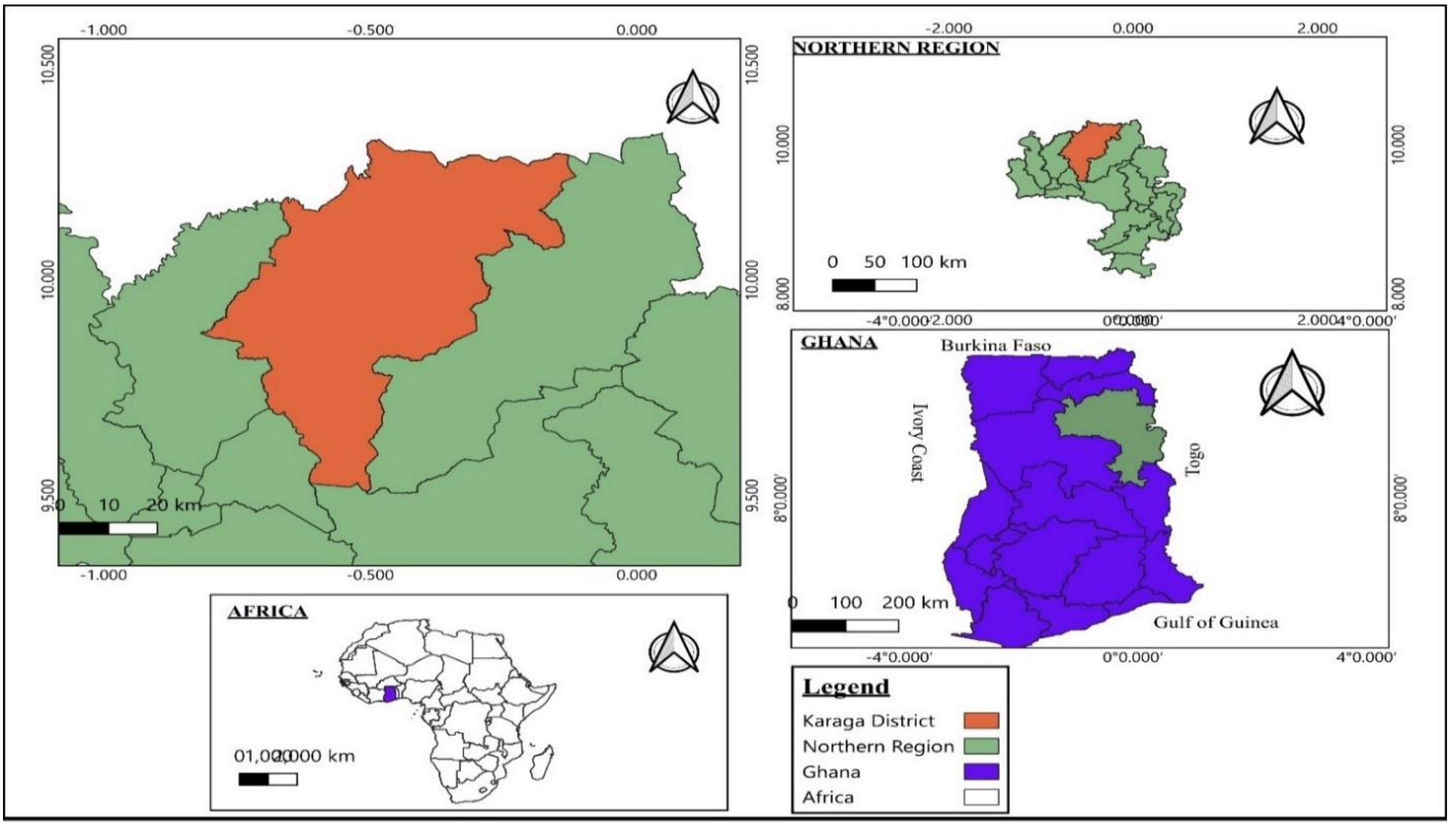

Figure 1: Map of the Study Area

Source: Authors (2026)

The place is predominantly rural, with only 26.1% urban. The average household size is 5.8 people, and the population density is 40.2 persons/sq km (GSS, 2021). The district experiences an average annual temperature of 30.3ºC and precipitation of 48.67 millimeters, with September having the most rainfall, accounting for an average of 89.15 days of rainfall per year. The remaining 275.85 days are usually dry, indicating a savanna climate. The mean annual humidity is relatively low, characterized by extended periods of arid heat and sporadic episodes of heavy rainstorms.

Sampling Criteria and Data Collection

The sample population will comprise all smallholder maize farmers in the Karaga district of Northern Ghana. The exact number of smallholder maize farmers in the district is unknown. Consequently, the Cochran (1977) formula was employed to determine the appropriate sample size. This approach is suitable for sample-size estimation when limited information about the population is available. The formula is stated as:

$$n = \frac{Z^2 p.q}{e^2} \quad (1)$$

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Where: n = required sample size, Z = Z-score corresponding to the desired confidence level (1.96 for 95%), p = estimated population proportion (adopting 50% for good representation), q = 1 - p (thus 0.5), and e = margin of error (0.05). This method ensures a statistically representative and suitable sample size for econometric analysis, with final adjustments made for non-response and logistical constraints.

$$\text{Therefore, } n = \frac{(1.96)^2 0.5(1-0.5)}{0.05^2} = 384.16 \qquad (2)$$

The sample size is estimated at three hundred and eighty-four (384) respondents. However, the final sample size was increased to four hundred (400) for easy data collection and analysis.

A multi-stage sampling technique was utilized to select farmers for the study. Initially, the district was stratified into four zones. Subsequently, a simple random sampling method was applied to select two communities from each zone, yielding a total of eight communities. Finally, smallholder maize-farming households within these communities were randomly chosen (see Table 1). The data collection was done from January to March, 2026. Data were collected through one-on-one survey interviews using a structured questionnaire. Furthermore, Eight Focus Group Discussions (FGDs) were conducted to obtain broader perspectives and also validate the information collected through the survey questionnaires. Kobo Toolbox was used for the data collection, which enabled researchers to track the data collection process and tracing the location of respondents through GPS coordinates for any further clarification and insights.

Table 1: Summary of the Sample Size.

Operational Zone	Selected Communities	Number of respondents
Karaga	Karaga	50
	Shelilanyili	50
Namburugu	Namburugu	50
	Zandua	50
Pishigu	Pishigu	50
	Sung	50
Yemo-Kariga	Yemo-Kariga	50
	Komoayili	50
Total	**8 communities**	**400 smallholder farmers**

Source: Authors (2026)

Data Analysis

Data analysis was performed using Stata Version 14, and the results were presented in tables, figures, frequencies, and percentages. Respondents' perceptions regarding modern warehouses for maize storage and the risks of adoption were captured using a 5-point Likert scale: (1) strongly disagree, (2) =disagree, (3) =neutral, (4) =agree, and (5) =strongly agree. Following the approach of Adjei-Baiden et al. (2025), Nimoh et al. (2024), and Prah et al. (2023), the mean score (MS) for each perception statement was calculated as follows:

$$MS = \frac{(f_{sd}X1) + (f_d X2) + (f_n X3) + (f_{sa} X4) + (f_a X5)}{X} \qquad (3)$$

Where fsd, fd, fn, fa and fsa = frequency of Strongly Disagree, Disagreement, Neutral Agreement, Agree, and Strongly Agree, respectively. X= number of farmers who responded to the specific perception statement. Then, the perception index (PI) was calculated as:

$$PI = \frac{\sum(MS)}{n} \qquad (4)$$

where MS is the mean score for each perception theme, and n is the number of perception statement themes.

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A Binary logistic regression model is employed to analyze factors influencing farmers' decision-making regarding their preference for modern warehouse storage of maize. This model is suitable because the dependent variable is dichotomous: 1 if the farmer chooses a modern warehouse for maize storage and 0 otherwise. A similar approach was used by A. Adams et al. (2020) and Akumbole et al. (2018). The logistic model is specified as follows:

$$P(Y_1 = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n)}} \qquad (5)$$

Where: $P(Y_1 = 1)$= Probability of farmers' choice for a modern warehouse, e=base of natural logarithm, β_0 =intercept, X_1- X_n = explanatory variables, and β_1 – β_n= Parameters to be estimated. This regression technique was performed using influential factors (explanatory variables), which include sex, age, educational level, years of farming, household income, average yield per acre, extension service access, market distance, farmland ownership, Farmer-Based Organizations (FBO) membership, access to market information, credit access, sell immediately after drying maize, buy and sell maize as independent variables (see Table 2). The marginal effects were estimated as:

$$\frac{\partial \mathrm{P_i}}{\partial \mathrm{X_i}} = \mathrm{P_i}(1 - \mathrm{P_i})\beta_i \qquad (6)$$

Where $\mathrm{P_i}$ = predicted probability, β_i = estimated coefficient, and $\frac{\partial \mathrm{P_i}}{\partial \mathrm{X_i}}$ = maginal effect

Table 2: Variable Description and their Expected Signs

Variable code	Description	Measurement	Expected sign
Decision to choose modern warehouse		Dummied as 1 =yes; 0 = no	
Sex	Sex of respondent (if male)	Dummied as 1 =yes; 0 = no	+/-
age	Age of farmer in years	Continuous	+/-
edu	Education of respondents in years	Continuous	+
Hshldsize	Household size (Number of people)	Continuous	+
F-size	Farm size (acres)	Continuous	+/-
tyield	Average yield per acre (kg)	Continuous	+/-
Extservice	Access to extension services	Dummied as 1 =yes; 0 = no	+
Owntrsp	Ownership of transport means	Dummied as 1 =yes; 0 = no	+
HhsIncome	Average monthly income (GH₵)	Continuous	+/-
Credit	Access to credit	Dummied as 1 =yes; 0 = no	+
F_exp	Number of years in farming maize	Continuous	+
Mocp	Main occupation (farming=1)	Dummied as 1 =yes; 0 = no	+
FBO	Membership in farmer-based organization	Dummied as 1 =yes; 0 = no	+

Source: Authors (2026)

RESULTS AND DISCUSSION

Descriptive Statistics of Respondents

Table 3 presents descriptive statistics for the sampled smallholder maize farmers in the Karaga District. The socioeconomic characteristics of respondents are central to this analysis, as previous studies have shown that these factors can shape perceptions of grain storage technologies, influence risk assessments, and affect preferences for improved storage methods (Heve et al., 2025). The results indicate that the mean gender (Male = 1) was 0.91, meaning approximately 91% of respondents were male. This demonstrates that maize farming in the study area is predominantly male-dominated. Similar findings of gender imbalance were also reported by Ibrahim (2025) . The predominance of male farmers is likely due to customary land tenure systems and gendered access to productive resources in Northern Ghana, where men generally have greater control over land

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ownership, agricultural decision-making, and market participation (GSS, 2025).

Table 3: Descriptive Statistic of Variables

Variable	Respondents(N)=400	
	Mean	**SD**
Gender (Male = 1)	0.91	0.05
Age of household head (Years)	39.8	1.32
Formal education (Years)	7.00	1.12
Household size	6.40	0.59
Farm size (acres)	3.90	0.37
Total farm yield (Kg)	92.14	85.54
Access to extension service (Yes = 1)	0.86	0.06
Transport means (Yes = 1)	0.34	0.08
Annual average income (GHC)	1326	170.97
Access to credit (Yes = 1)	0.54	0.09
Farming experience (Years)	15.4	1.43
Main occupation (maize farming = 1)	0.57	0.08
FBO (Yes = 1)	0.60	0.08

Source: Field Survey Data (2026)

The average age of household heads was approximately 39.8 years, indicating that most sampled farmers are within the economically active and productive age group. This age profile suggests that respondents are likely to have the physical capacity and decision-making authority to adopt new storage technologies. Previous studies, such as Alem et al. (2026), have shown that middle-aged farmers are often more responsive to agricultural innovations because they combine farming experience with greater openness to change than older farmers. However, age may also influence risk attitudes, as older farmers are sometimes more conservative in adopting unfamiliar technologies. Respondents had an average of 7 years of formal education, indicating that most farmers possessed at least a basic education. According to Mohammed et al. (2019), farmers with higher levels of education are more likely to understand the economic benefits of improved storage technologies, such as reduced post-harvest losses and better market timing. The moderate educational level observed among respondents may therefore positively influence awareness and evaluation of warehouse storage innovations.

The findings further reveal that the average household size was approximately 6.4 persons, which is typical of rural farming households in Northern Ghana, where extended family structures and reliance on family labour are common. Larger households may influence storage preferences by producing greater quantities of maize, increasing the need for improved storage facilities, and by experiencing higher consumption demands, which heighten concerns about food preservation and post-harvest loss reduction (A. A. Adams et al., 2025; de Jager et al., 2022). The average farm size was 3.9 acres, confirming the predominantly smallholder nature of maize farming in the study area. This aligns with Ghana's broader agricultural structure, where smallholder farmers account for most agricultural production (SRID-MoFA, 2024). The average total farm yield of 92.14 kg further highlights relatively low production levels, which may constrain market participation and affect the perceived economic viability of warehouse storage systems.

Approximately 86% of respondents reported having access to extension services, suggesting relatively strong interaction between farmers and agricultural advisory systems in the district. Farmers with greater extension access are therefore more likely to possess knowledge regarding the benefits and operational mechanisms of modern warehouse systems. In contrast, only 34% of respondents reported having access to transportation. Limited transportation access may significantly affect farmers' ability to utilize centralized warehouse facilities,

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particularly where warehouses are located far from farming communities. The average annual income of respondents was GHC 1,326, indicating relatively low income among the sampled households. Low household income may limit farmers' ability to pay storage fees or participate in formal warehouse systems, thereby influencing both perceived risks and adoption preferences. Approximately 54% of respondents reported access to credit facilities. Access to credit is essential for enabling investment in improved technologies and effective management of post-harvest operations (Abdul-Jalil, 2015; S. Mohammed et al., 2013).

The results further indicate that respondents had considerable farming experience, averaging approximately 15.4 years. Such experience contributes to the accumulation of indigenous knowledge and practical understanding of post-harvest losses, storage challenges, and market fluctuations (Bawa, 2025). Experienced farmers may therefore be better equipped to evaluate the comparative advantages and risks of modern warehouse systems. Additionally, 57% of respondents identified maize farming as their main occupation, indicating that maize production is a primary livelihood activity for most sampled households. This suggests that decisions regarding maize storage are economically significant and directly linked to household welfare and income security. Approximately 60% of respondents belonged to farmer-based organizations (FBOs). Membership in FBOs is associated with improved access to information, training, collective marketing opportunities, and institutional support (S. Mohammed et al., 2013). Farmer organizations may facilitate awareness and acceptance of modern warehouse systems by reducing information asymmetry and strengthening trust in collective storage arrangements.

Smallholder Maize Farmers Perceptions about the Affordability of Modern Warehouse

The first objective of this research was to examine maize farmers' perceptions of modern warehouse storage systems. Farmers' opinions were categorized into two thematic areas: efficiency and affordability, with responses ranked from strongly disagree (1) to strongly agree (5). The efficiency dimension included questions on the availability of modern storage systems, storage capacity, assurance of grain quality, prevention of chemical contamination and mold, and the impact on grain shelf life. The affordability aspect evaluated whether farmers could afford service charges for commercial storage or the acquisition of their own modern storage systems. The results, as shown in Table 4, indicate that respondents generally regard modern warehouse systems as efficient, with an overall efficiency perception index of 3.25.

Table 4: Respondents' Perception of the Modern Warehouse Storage System

Variable	Statement	D	SD	N	A	SA	Mean
Efficiency	The modern warehouse storage system is readily available to access.	45 (11.2%)	132 (33.0%)	42 (10.5%)	122 (30.5%)	59 (14.8%)	3.05
	The modern warehouse storage system is big enough to store all my yield after harvest.	37 (9.3%)	106 (26.5%)	48 (12.0%)	151 (37.7%)	58 (14.5%)	3.22
	The modern warehouse storage system ensures the quality of maize as compared to the local storage system.	16 (4.0%)	72 (18.0%)	26 (6.5%)	164 (41.0%)	122 (30.5%)	3.76
	This storage method reduces the risk of food poisoning attributed to chemicals.	86 (21.5%)	88 (22.0%)	32 (8.0%)	160 (40.0%)	34 (8.5%)	2.92
	Grains stored with this storage method do not get damaged or mouldy.	10 (2.5%)	114 (28.5%)	54 (13.5%)	196 (49.0%)	26 (6.5%)	3.29
	Grains stored with this storage method are more tasty/palatable.	5 (1.3%)	101 (25.2%)	69 (17.2%)	196 (49.0%)	29 (7.3%)	3.36
	Grains stored with this storage method reduce the discoloration	16 (4.0%)	96 (24.0%)	45 (11.3%)	201 (50.2%)	42 (10.5%)	3.40

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	of maize.						
	Grains store better and longer with this storage method.	16 (4.0%)	72 (18.0%)	32 (8.0%)	198 (50.0%)	82 (20.5%)	3.65
	Perception Index for Efficiency						3.33
Affordability	The fee charged to acquire a modern warehouse storage system is moderate.	46 (11.5%)	110 (27.5%)	32 (8.0%)	164 (41.0%)	48 (12.0%)	3.15
	I can pay the storage fee being charged to use the modern warehouse storage system.	10 (2.5%)	132 (33.0%)	53 (13.2%)	167 (41.8%)	38 (9.5%)	3.22
	Perception Index for Affordability						3.18
Overall Perception Index							**3.25**

(SD) strongly disagree=0-1.49; (D) disagree=1.5-2.49; (N) neutral=2.5-3.49; (A) agree=3.5-4.49; (SA) strongly agree= 4.5-5

Source: Field Survey Data (2026)

Farmers particularly agreed that modern warehouses preserve maize quality more effectively than traditional systems (Mean = 3.76) and enable longer storage durations (Mean = 3.65). These results demonstrate recognition of the ability of improved storage systems to reduce post-harvest losses and maintain grain quality. The findings are consistent with the findings of Ariong et al. (2023), who reported that improved storage technologies significantly reduce spoilage, pest infestation, and quality deterioration.

The affordability perception index had a mean of 3.18, reflecting neutral perceptions regarding the cost of using modern warehouse systems. Some respondents considered storage fees manageable (Mean = 3.22), while others expressed uncertainty about affordability due to limited household incomes. These findings suggest that smallholder maize farmers in the Karaga District generally maintain neutral to slightly positive perceptions of modern warehouse storage systems, with an overall perception index of 3.25. Although farmers acknowledge certain benefits of modern storage systems, concerns related to knowledge, accessibility, and affordability continue to shape their overall evaluations. During the focus group discussions in Pishigu, one farmer stated:

“When maize is properly stored in the warehouse, it remains in good condition for a long time and can be sold when prices improve.”

Another participant corroborated this view but highlighted a significant challenge:

“The warehouse system is useful, but distance and transportation costs make it difficult for some farmers.”

While some respondents considered warehouse storage fees manageable, others expressed uncertainty about their ability to consistently afford them. This finding underscores the broader financial constraints experienced by smallholder farmers, whose limited incomes often restrict investment in improved post-harvest technologies. Similar patterns have been observed in developing-country contexts, where resource limitations hinder farmers’ capacity to adopt agricultural innovations despite recognizing their benefits (Guo et al., 2023; Lukman, 2020). The results also indicate that physical access to warehouse facilities remains a challenge for some farmers, particularly those in remote communities. Transportation difficulties and limited operational familiarity may further discourage utilization, even among farmers who recognize the technical advantages of improved storage systems.

Smallholder Maize Farmers Perceptions on risks associated with Modern Warehouses

The second research objective focused on smallholder maize farmers’ perceptions of risks associated with modern grain storage systems, such as rodent infestations, theft, inadequate documentation in public commercial storage, and other storage losses compared to local systems. It also used rated opinions using a five-point Likert scale ranging from strongly disagree, disagree, neutral, agree to strongly agree (see Table 5). Many expressed concerns about pest and rodent infestations in modern warehouse systems. The statement, "there is a possibility of rats and other similar animals eating maize grains to a larger extent than the local storage systems," received a mean score of 3.49, suggesting that pest-related losses are perceived as a significant risk. This perception may stem from previous experiences in other jurisdictions with inadequate storage management or poor maintenance of communal facilities. In rural settings, farmers' confidence in storage systems is often influenced by the facility's effectiveness in preventing pest infestation and maintaining grain quality (Makinya et al., 2021; Ngwenyama et al., 2023).

Table 5: Smallholder Maize Farmers Risk Perceptions about Modern Warehouses

Variable Statement		Agreement Scale					Mean Value
		SD	**D**	**N**	**A**	**SA**	
Risk	The is a possibility of rats and other similar animals eating maize grains to a large extent than the local storage systems	11 (2.7%)	100 (25.0%)	38 (9.5%)	185 (46.3%)	66 (16.5%)	3.49
	There is the possibility of losing my maize to theft	71 (17.8)	157 (39.2%)	50 (12.5%)	82 (20.5%)	40 (10.0%)	2.66
	There is the possibility of losing my maize to a fire outbreak or other natural disaster	58 (14.5%)	148 (37.0%)	45 (11.3%)	120 (30.0%)	29 (7.2%)	2.78
	There is a possibility of poor documentation in storing maize in the public modern warehouse hereby compromising safety	22 (5.5%)	62 (15.5%)	66 (16.5%)	180 (45.0%)	70 (17.5%)	3.54
	There are high storage losses associated with modern storage systems as compared to local storage systems	88 (22.0%)	87 (21.8%)	32 (8.0%)	159 (39.7%)	34 (8.5%)	2.91
Overall Risk Perception Index							**3.08**

(SD) strongly disagree=0-1.49; (D) disagree=1.5-2.49; (N) neutral=2.5-3.49; (A) agree=3.5-4.49; (SA) strongly agree= 4.5-5

Source: Field Survey Data (2026)

Respondents also identified inadequate documentation and management practices as significant concerns. The statement regarding the "possibility of poor documentation in storing maize in public modern warehouses, thereby compromising safety" received a mean score of 3.54, indicating general agreement. This finding underscores apprehensions about institutional accountability, transparency, and trust in warehouse operations. Smallholder farmers may be reluctant to use collective storage facilities if they perceive deficiencies in record-keeping, monitoring, or grain-handling procedures (Heve et al., 2025; Tibaingana et al., 2024). In contrast, respondents expressed lower concern about theft and natural disasters. The possibility of maize loss due to theft had a mean score of 2.66, and the risk of fire outbreaks or other natural disasters had a mean of 2.78, both reflecting neutral perceptions. These results suggest that while some farmers remain cautious, most do not consider these risks severe. A lower perception of theft risk may indicate greater confidence in the physical security of warehouse systems than in traditional household storage methods (Heve et al., 2025).

The findings further indicate that respondents were generally uncertain about whether modern warehouses experience higher storage losses than local systems, as reflected by a mean score of 2.91. This suggests that many farmers do not perceive modern storage systems as riskier than traditional methods for grain losses. Rather, their concerns are more closely related to operational management and accessibility than to the technical effectiveness of the storage systems, as observed by Heve et al. (2025) and Tibaingana et al. (2024). Insights from the focus group discussions in Yemokaraga reinforced these findings. One participant stated:

"If the warehouse is properly managed, it can protect maize better than local storage, but farmers worry about how the system is controlled."

This perspective was supported by one of the participants who is also a group leader. He explained:

"Some farmers fear problems with documentation or management because once the maize is stored, it is no longer directly under their control."

These findings indicate that institutional trust, effective warehouse management, and transparent documentation systems are essential for increasing farmers' confidence in modern warehouse storage systems, as Stathers et al. (2020) also highlighted. According to Kutyauripo et al. (2021) and Ngwenyama et al. (2023), strengthening supervision, farmer education, and accountability mechanisms may enhance acceptance and utilization of improved storage facilities. The overall risk perception index was 3.08, reflecting a generally neutral view of the risks associated with modern warehouse storage systems. This indicates that while farmers recognize some benefits of modern storage facilities, they also express concerns about potential operational and security-related risks.

Factors Influencing smallholder Farmers' decision to use Modern Warehouse for maize storage

Table 6 presents the results of a binary logistic regression examining factors influencing smallholder maize farmers' decisions to adopt modern warehouse storage systems in the Karaga District. The model achieved statistical significance at the 1% probability level (Prob > chi² = 0.0000), indicating that the explanatory variables collectively influenced farmers' decisions regarding the use of modern warehouse storage systems. The pseudo-R^2 value of 0.3538 indicates that approximately 35.4% of the variation in storage decisions was explained by the variables included in the model.

Table 6: Factors Influencing Farmers' Choice of Modern Warehouses for Maize Storage

Variable	Coefficient	SD	Average Marginal Effect (dx dy)	SD
Gender (Male = 1)	0.863***	0.489	0.166	0.069
Age (Years)	-0.026	0.024	-0.007	0.006
Formal education (Years)	0.075***	0.039	0.055	0.055
Household size	0.020	0.035	0.005	0.009
Farm size (acres)	0.045	0.072	0.011	0.018
Farm yield (50Kg bag)	0.000	0.001	0.000	0.000
Extension service (Yes = 1)	0.439	0.411	0.094	0.077
Transport means (Yes = 1)	0.735***	0.423	0.225	0.148
Annual average income (GHC)	0.0003*	0.000	0.0004	0.000
Access to credit (Yes = 1)	1.831*	0.448	0.606	0.138
Farming experience (Years)	0.010	0.022	0.002	0.005
Main occupation (maize farming = 1)	-0.428	0.474	-0.106	0.117
FBO (Yes = 1)	0.011	0.157	0.003	0.039
Number of observations	400			
Wald/LR chi2(13)	57.47			
Prob > chi2	0.0000*			
Log likelihood	-52.487			
Pseudo R2	0.3538			
*** = 1% significant level; ** = 5% significant level; and * = 10% significant level.				

Source: Field Survey Data (2026)

Gender was found to positively and significantly influence farmers' decisions to use modern warehouse storage

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systems at the 10% significance level. The positive coefficient (0.863) indicates that male farmers were more likely than female farmers to use modern warehouse systems. The marginal effect shows that being male increased the probability of using modern warehouse storage by approximately 16.6%. This result likely reflects gender disparities in access to productive resources, market participation, and decision-making authority within rural farming systems. Similar findings have been reported by Zaato et al. (2025), N-yanbini & Owusu-Ansah (2024) , and Azumah et al. (2022), emphasizing that gender inequalities continue to shape access to agricultural innovations among smallholder farmers. In Northern Ghana, men typically have greater control over land, farm income, and post-harvest marketing decisions, which may facilitate their engagement with formal storage systems (Adu et al., 2021; Snider et al., 2024; Vercillo, 2020).

Formal education exhibited a positive and statistically significant effect on farmers' decisions at the 10% significance level. The coefficient (0.075) indicates that higher levels of education increased the likelihood of adopting modern warehouse systems. According to Safo (2017), Education enhances farmers' capacity to process information, understand the benefits of improved technologies, and engage with institutional systems such as warehouse storage arrangements. Farmers with higher educational attainment are more likely to recognize the economic benefits of reduced post-harvest losses and improved market timing (Akumbole et al., 2018; Asante et al., 2024; Kwawu et al., 2022). This finding aligns with the technology adoption literature, which identifies education as a key determinant of innovation uptake.

Access to transportation positively and significantly influenced farmers' decisions to use modern warehouse systems at the 10% significance level. The marginal effect indicates that farmers with access to transport were approximately 22.5% more likely to use modern warehouses than those without such access. This result underscores the importance of physical accessibility and rural infrastructure in facilitating participation in centralized storage systems. Because warehouse facilities are often located outside farming communities, the availability of transportation reduces transaction costs and enables farmers to move produce more efficiently after harvest (A. A. Adams et al., 2025; Safo, 2017). Annual average income was found to positively influence farmers' decisions at the 1% significance level. Although the coefficient magnitude was relatively small, the positive relationship indicates that higher-income farmers were more likely to use modern warehouse storage systems. Farmers with greater financial capacity are better able to pay storage fees, transport produce, and delay immediate sales in anticipation of improved market prices. This finding aligns with the FAO (2009) report, which argues that liquidity constraints often limit smallholder farmers' adoption of improved agricultural technologies.

Access to credit emerged as one of the strongest determinants of farmers' decisions to use modern warehouse systems. The coefficient (1.831) was positive and statistically significant at the 1% level, and the marginal effect indicates that access to credit increased the probability of using modern warehouse storage by approximately 60.6%. Access to credit enhances farmers' financial flexibility, enabling them to cover storage-related costs and avoid distress sales immediately after harvest (A. A. Adams et al., 2025; Akumbole et al., 2018; Safo, 2017). This finding indicates that financial inclusion is critical for promoting the use of improved post-harvest storage systems among smallholder farmers. In contrast, variables such as age, household size, farm size, farm yield, farming experience, main occupation, extension access, and membership in farmer-based organizations (FBOs) were not statistically significant. The lack of significance for age and farming experience suggests that decisions to use modern warehouse systems depend more on institutional and financial factors than on demographic characteristics. Similarly, the non-significance of farm size and yield implies that both smaller and larger maize farmers may face similar considerations regarding warehouse utilization.

The insignificance of extension services and FBO membership may indicate that existing extension systems and farmer organizations in the study area have not sufficiently emphasized warehouse storage systems or provided adequate practical support for their use. This finding highlights the need for stronger institutional engagement in post-harvest education and awareness campaigns on warehouse management.

CONCLUSIONS

This study investigated smallholder maize farmers' perceptions and preferences regarding modern warehouse storage systems in the Karaga District, focusing on perceptions of these systems, perceived risks associated with their use, and factors influencing adoption decisions. The findings indicated that farmers generally held neutral to slightly positive perceptions of modern warehouse storage systems. Respondents acknowledged that modern warehouses preserve grain quality, reduce spoilage, and extend maize storage duration compared to traditional methods. Farmers, especially, viewed modern storage systems as effective at minimizing moisture damage and maintaining grain quality, reflecting growing awareness of improved post-harvest management practices. However, despite these positive perceptions, operational knowledge of warehouse systems remained limited, suggesting that increased awareness does not necessarily translate into practical understanding or use. The study also found that farmers perceived specific risks related to modern warehouse systems, particularly concerns about inadequate documentation, management inefficiencies, and potential pest infestations. These concerns reflected broader issues of institutional trust and accountability within collective storage arrangements. In contrast, respondents expressed less concern about theft and natural disasters, indicating that modern warehouses were not viewed as inherently insecure. Overall, the findings suggest that farmers' risk perceptions are shaped more by management and operational issues than by doubts about the technical effectiveness of warehouse systems.

The econometric analysis demonstrated that gender, formal education, access to transport, annual income, and access to credit significantly influenced farmers' decisions to use modern warehouse storage systems. Male farmers with higher education, transport access, higher incomes, and greater credit availability were more likely to use modern warehouse facilities. These results underscore the importance of financial capacity, mobility, and information access in shaping storage decisions. Conversely, variables such as age, farm size, farming experience, extension access, and membership in farmer-based organizations were not statistically significant, indicating that institutional and economic factors are more influential than demographic characteristics in determining warehouse utilization. Overall, the study concludes that while smallholder maize farmers in the study area generally recognize the potential benefits of modern warehouse storage systems, their utilization is constrained by limited technical knowledge, financial barriers, accessibility challenges, and concerns about transparency in management. The findings suggest that enhancing farmer education on post-harvest management, strengthening institutional accountability, improving rural transportation, and expanding access to affordable credit could significantly increase the adoption and use of modern warehouse storage systems among smallholder maize farmers in Northern Ghana.

This study focuses exclusively on the Karaga District in Northern Ghana, which may restrict the generalizability of its findings to other regions with distinct socioeconomic and agricultural characteristics. Additionally, the results may be influenced by recall bias, as data collection largely relied on smallholder farmers' perceptions and opinions. Future research should include multiple districts and regions to improve the generalizability of findings across diverse rural agricultural contexts.

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