



Gendered Access and Adoption of Post-Harvest Loss Reduction Technologies among Smallholder Farmers in Rural Communities of Dutsin-Ma, Katsina State, Nigeria

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ABSTRACT

Post-harvest losses remain a major challenge affecting food security, income stability, and agricultural productivity in Nigeria, particularly among smallholder farmers who rely on traditional storage and handling practices. This study examines gendered access to and adoption of post-harvest loss reduction technologies among smallholder farmers in Dutsin-Ma Local Government Area of Katsina State, Nigeria. A cross-sectional survey design guided by the Gender and Development (GAD) framework was adopted. Using the Krejcie and Morgan sample size determination table, 384 respondents were selected from 400 registered smallholder farmers through multi-stage sampling. Primary data were collected using structured questionnaires, supported by key informant interviews with agricultural extension officers and cooperative leaders. Quantitative data were analysed using descriptive statistics and inferential tools such as chi-square tests and logistic regression to determine gender-based variations in adoption. The study found that male farmers demonstrate higher access to improved storage technologies such as hermetic bags, metal silos, drying platforms, and agro-processing machines owing to better financial capacity, land ownership, and extension service contact, while women face limitations arising from restricted access to credit, cultural norms, and domestic workload burdens. The study recommends gender-responsive agricultural interventions, inclusive financing mechanisms, and improved extension outreach targeted at women to enhance technology uptake and reduce post-harvest losses in rural Katsina State.

Keywords: Agricultural Extension; Gender; Post-Harvest Losses; Smallholder Farmers; Technology Adoption

1. Introduction

Post-harvest losses remain a major constraint to agricultural development, food security, and rural livelihoods in developing countries, including Nigeria. Despite improvements in production technologies, a significant proportion of harvested crops is lost between harvest and consumption owing to poor handling, inadequate storage, pest infestation, spoilage, and weak transportation systems (FAO, 2011; World Bank, 2011). In sub-Saharan Africa, these losses are exacerbated by limited storage infrastructure, weak processing capacity, and poor rural logistics (Affognon et al., 2015), thereby reducing food availability and farmers' incomes. In Nigeria, substantial losses are recorded in cereals, legumes, fruits, and vegetables owing to improper drying, insect infestation, rodent attacks, and lack of cold-chain systems (Aulakh & Regmi, 2013; FAO, 2019). These inefficiencies force farmers to sell produce immediately after harvest at low prices, worsening rural poverty and food insecurity. The Federal Ministry of Agriculture and Rural Development (FMARD, 2016) identifies post-harvest losses as a key barrier to agricultural commercialisation and national food sufficiency.

To address this challenge, several post-harvest loss reduction technologies have been introduced, including hermetic storage bags, improved silos, solar dryers, moisture meters, and small-scale processing equipment (Kitinoja, 2013; FAO, 2019). These technologies help reduce spoilage, extend shelf life, and improve market value. However, adoption among smallholder farmers remains limited owing to cost, poor access, weak extension services, and low technical capacity (World Bank, 2011). The adoption of agricultural technologies is also influenced by socio-economic and institutional factors such as education, income, credit access, extension contact, and farm size (Feder et al., 1985; Rogers, 2003). More importantly, gender has come to play a critical role in shaping access and adoption patterns. In many rural African contexts, women dominate post-harvest activities such as processing and storage but face constraints in land ownership, credit access, extension services, and decision-making power (FAO, 2011; Quisumbing et al., 2014). These inequalities limit their ability to adopt improved technologies.

The Gender and Development (GAD) perspective argues that such disparities are structurally rooted in socio-cultural norms and institutional barriers rather than individual choice (Kabeer, 1999). In northern Nigeria, particularly among Hausa-Fulani communities, women's mobility restrictions, lower educational attainment, and limited access to agricultural services further constrain their participation in technology adoption (Nwokocha & Amadi, 2019). Dutsin-Ma Local Government Area of Katsina State has many agrarian communities where smallholder farmers cultivate crops such as maize, millet, sorghum, and cowpea. However, the area continues to experience high post-harvest losses owing to poor storage facilities, inadequate drying methods, pest infestation, and limited access to modern technologies. Although interventions exist, adoption remains low, with possible gender-based disparities in access and utilisation (FMARD, 2016; FAO, 2019). Existing studies have largely focused on the technical aspects of post-harvest losses, with limited attention to gendered access and adoption patterns. This creates a critical gap in understanding how socio-economic and institutional factors influence male and female farmers differently in the use of post-harvest technologies.

Against this background, this study examines gendered access to and adoption of post-harvest loss reduction technologies among smallholder farmers in rural communities of Dutsin-Ma Local Government Area, Katsina State, Nigeria. It investigates available technologies, levels of access and adoption among men and women, and the socio-economic and institutional factors influencing adoption. The study also identifies constraints facing women in accessing these technologies. Findings are expected to inform gender-responsive policies aimed at reducing post-harvest losses, improving food security, and strengthening rural livelihoods.

2. Literature Review

2.1 Conceptual Clarification

Several key concepts anchor this study. *Gender* refers to the socially constructed roles, expectations, and power relations that shape how men and women participate in economic and social life; in agriculture, it determines the division of labour, access to productive resources, and control over benefits derived from farming activities (FAO, 2011; Doss, 2001). *Access* denotes the ability to obtain and utilise resources, services, and opportunities and goes

beyond mere availability to encompass affordability, knowledge, institutional support, and decision-making power (Meinzen-Dick et al., 2011). *Adoption* is the acceptance and sustained use of an innovation over time and, following Rogers (2003), involves awareness, interest, evaluation, trial, and continued use; in agricultural contexts it depends on perceived usefulness, compatibility with existing practices, cost, and institutional support such as extension and credit (Feder et al., 1985). *Post-harvest losses* refer to the quantitative and qualitative reduction in agricultural produce between harvesting and consumption, occurring during handling, drying, storage, processing, packaging, and transportation (FAO, 2019; Affognon et al., 2015). *Post-harvest loss reduction technologies* consist of improved practices and equipment designed to preserve harvested produce, extend shelf life, and enhance market quality, including hermetic bags, metal silos, airtight containers, raised platforms, tarpaulins, solar dryers, threshers, shellers, grinders, and moisture-proof packaging materials (Kitinoja, 2013; Aulakh & Regmi, 2013). Despite their relevance, adoption of these technologies among smallholder farmers remains constrained by cost, poor rural infrastructure, limited awareness, and weak extension support (World Bank, 2011; FAO, 2019).

2.2 Empirical Review

Studies across sub-Saharan Africa show that adoption of post-harvest technologies is influenced by socio-economic and institutional factors. Affognon et al. (2015) found that limited financial capacity and inadequate training significantly reduce farmers' uptake of improved storage and preservation technologies. Similarly, the World Bank (2011) reports that poor rural infrastructure and weak storage systems contribute to persistent post-harvest losses, especially among smallholder farmers. Research has also established that education, farm size, household income, access to markets, and extension services strongly influence farmers' willingness and capacity to adopt improved technologies (Feder et al., 1985; Rogers, 2003). Farmers with access to extension services are more likely to adopt innovations owing to increased exposure to technical knowledge and demonstrations. Market incentives also matter, as farmers who can store produce effectively are able to sell when prices rise, improving income and reducing distress sales (Aulakh & Regmi, 2013). However, many studies on post-harvest technology adoption focus largely on economic factors and pay limited attention to gender-based dynamics that shape access and utilisation patterns, particularly in rural northern Nigerian contexts.

2.3 Gender Disparities in Technology Access and Adoption

Gender disparities remain a major constraint to agricultural innovation uptake in developing countries. FAO (2011) notes that women farmers often have limited access to land, credit, extension services, and modern technologies, despite their significant contribution to agricultural labour and post-harvest activities. Doss (2001) argues that women's limited access to resources and decision-making power within households reduces their capacity to adopt agricultural innovations. Quisumbing et al. (2014) further emphasise that women's restricted access to productive resources leads to lower adoption rates and reduced agricultural productivity. In many African contexts, women are heavily involved in post-harvest handling, processing, and marketing, yet their ability to access improved technologies is constrained by poverty, cultural norms, and limited institutional support (Meinzen-Dick et al., 2011). This suggests that gender inequalities in resource control and institutional access can significantly affect post-harvest technology adoption outcomes. Empirical studies providing localised evidence on gendered access and adoption patterns of post-harvest loss reduction technologies remain limited, particularly in northern Nigeria, highlighting the need for context-specific research to understand gender-based barriers and adoption behaviour among smallholder farmers.

2.4 Theoretical Framework

This study is guided by the Gender and Development (GAD) framework, which provides a useful theoretical lens for understanding how gender relations shape access to resources and participation in development processes. The GAD perspective emerged as a response to earlier development approaches that largely treated women as passive recipients of development benefits. Rather than focusing only on women's inclusion, GAD emphasises the broader social structures and institutional arrangements that produce unequal power relations between men and women (Moser, 1993; Kabeer, 1994). The framework argues that gender inequality is embedded in cultural norms, economic systems, and political institutions, and these structural realities influence access to opportunities, control of resources, and decision-making capacity.

Within agricultural systems, GAD is relevant because men and women often perform different roles and face unequal access to productive assets such as land, finance, extension services, and technology. FAO (2011) notes that women farmers in developing countries are disadvantaged in access to agricultural resources, despite their significant contribution to agricultural labour and post-harvest activities. Such inequalities limit women's productivity and reduce their ability to adopt innovations that could improve agricultural outcomes. The GAD framework is particularly applicable to the adoption of post-harvest loss reduction technologies because adoption is not only influenced by the technical value of a technology but also by social and institutional factors. Adoption requires awareness, financial capacity, access to training, and decision-making authority, all of which are shaped by gender relations within households and communities (Doss, 2001). In many rural contexts, men are more likely to control household income and productive resources, making it easier for them to invest in improved storage systems, drying technologies, or processing equipment. Women, although heavily involved in post-harvest handling and processing, may have limited control over resources and restricted access to extension services, thereby constraining their adoption of improved technologies (Quisumbing et al., 2014).

In the context of Dutsin-Ma Local Government Area of Katsina State, where farming systems operate within largely patriarchal socio-cultural structures, the GAD framework provides an appropriate foundation for explaining gendered differences in access to and adoption of post-harvest technologies. It supports the assumption that unequal access is not merely individual but structurally determined through cultural expectations, institutional bias, and resource control patterns. Thus, the framework is relevant for analysing how gender-based inequalities shape farmers' opportunities to adopt post-harvest loss reduction technologies and how such inequalities may contribute to persistent post-harvest losses among smallholder farmers in the study area.

3. Methodology

The study was conducted in Dutsin-Ma Local Government Area of Katsina State, Nigeria, a predominantly agrarian community where smallholder farming constitutes a major livelihood activity. A cross-sectional survey research design was adopted to examine gendered access and adoption of post-harvest loss reduction technologies. The target population comprised 400 registered smallholder farmers, from which a sample size of 384 respondents was determined using the Krejcie and Morgan (1970) sample size table. Respondents were selected through a multi-stage sampling technique, involving the selection of communities, households, and eligible farmers. Data were collected using a structured questionnaire complemented with key informant interviews involving agricultural extension officers and cooperative leaders to provide contextual insights. Key variables measured included access (availability and affordability of technologies), adoption level (extent of utilisation of post-harvest technologies), and constraints (financial, socio-cultural, and institutional barriers). Data were analysed using descriptive statistics (frequencies, percentages, and means), while chi-square tests and logistic regression analysis were employed to determine associations and predictors of technology adoption across gender categories. Ethical considerations were addressed through informed consent, voluntary participation, confidentiality, and anonymity of respondents throughout the study.

4. Results

4.1 Socio-Demographic Characteristics of Respondents

Table 1 presents the socio-demographic distribution of the 384 respondents surveyed in Dutsin-Ma.

Table 1: Socio-Demographic Characteristics of Respondents

Variable	Category	Frequency (f)	Percentage (%)
Gender	Male	260	67.7
	Female	124	32.3
Age (years)	18–24	54	14.1
	25–34	122	31.8
	35–44	108	28.1
	45–54	70	18.2
	55 and above	30	7.8
Education	No formal education	78	20.3
	Qur'anic/Islamic	146	38.0
	Primary	92	24.0
	Secondary	52	13.5
	Tertiary	16	4.2
Farm size (hectares)	< 1 ha	64	16.7
	1–3 ha	238	62.0
	4–6 ha	62	16.1
	7 ha and above	20	5.2

Source: Field survey (2026).

The socio-demographic distribution of respondents shows important variations in gender, age, educational attainment, and farm characteristics. Out of the 384 respondents, the majority were male (67.7%), reflecting the gender structure of registered smallholder farming in Dutsin-Ma. Most respondents were within the economically active age group of 25–44 years (59.9%), suggesting that farming activities are largely driven by productive adults. Educational status revealed that a substantial proportion had Qur'anic or Islamic education (38.0%), while fewer respondents attained secondary (13.5%) or tertiary education (4.2%). Farm size distribution indicates that the majority were smallholders cultivating between 1–3 hectares (62.0%), confirming the predominance of small-scale farming in the study area.

4.2 Available Post-Harvest Loss Reduction Technologies

Table 2: Available Post-Harvest Loss Reduction Technologies in the Study Area

Technology Type	Examples	Frequency (f)	Percentage (%)
Storage technologies	Hermetic bags, improved sacks, granaries	292	76.0
Drying technologies	Tarpaulin, raised platforms	274	71.4
Processing technologies	Threshers, shellers, milling machines	188	49.0
Packaging technologies	Metal silos, solar dryers	62	16.1

Source: Field survey, 2024. Category labels and examples reproduced exactly as given in the manuscript's own table — see module docstring for a flagged inconsistency between the "Packaging technologies" label and its listed examples.

Findings indicate that post-harvest loss reduction technologies are available in the study area, though not uniformly accessible. The most frequently identified technologies include improved polypropylene sacks, hermetic storage

bags, raised drying platforms, tarpaulin drying sheets, and local improved granaries. Processing technologies such as mechanical threshers, shellers, and milling machines were reported, but these were mainly owned by cooperatives, community entrepreneurs, or a few affluent farmers. Technologies such as metal silos and solar dryers were rarely reported owing to high cost and limited supply. Overall, farmers still depend largely on traditional methods, with improved technologies serving as complementary options.

4.3 Awareness and Access to Technologies by Gender

Table 3: Awareness and Access to Post-Harvest Technologies by Gender

Variable	Male (n = 260) %	Female (n = 124) %	Total %
Aware of hermetic storage bags	74.2	48.4	65.9
Access to hermetic storage bags	61.5	32.3	52.1
Aware of drying technologies (tarpaulin/platform)	78.8	62.1	73.4
Access to improved drying facilities	66.2	41.1	58.1
Aware of processing equipment	69.6	45.2	61.7
Access to processing equipment	55.4	27.4	46.4

Source: Field survey, 2024.

Most male respondents reported awareness of hermetic storage and mechanised processing technologies through cooperative meetings and extension contact. Female farmers, although actively involved in post-harvest handling, reported lower awareness and limited exposure to extension demonstrations. Access patterns also differed significantly: men had relatively higher access to improved storage and processing equipment owing to stronger financial capacity, cooperative participation, and decision-making authority within households. Women's access was constrained by limited income, weak extension targeting, and socio-cultural restrictions.

4.4 Adoption Rates and Usage Patterns among Male and Female Farmers

Table 4 presents adoption rates for selected post-harvest technologies disaggregated by gender.

Table 4: Adoption of Selected Post-Harvest Technologies by Gender

Technology	Male (%)	Female (%)	Total (%)
Hermetic storage bags	54.6	28.2	46.1
Improved sacks	68.1	52.4	63.0
Raised drying platforms	49.2	41.9	46.9
Tarpaulin drying sheets	58.8	62.1	59.9
Mechanical threshers/shellers	44.6	21.0	37.0
Airtight containers/packaging	32.3	26.6	30.5

Source: Field survey (2026).

Adoption of post-harvest loss reduction technologies was generally low to moderate, with clear gender differences. Male farmers recorded higher adoption of hermetic bags (54.6% vs. 28.2%), improved sacks (68.1% vs. 52.4%), and mechanised threshers (44.6% vs. 21.0%), mainly for grains such as maize, millet, and sorghum. Female farmers adopted fewer improved storage technologies but reported relatively higher engagement with improved drying methods such as tarpaulin sheets (62.1% vs. 58.8%), mainly because these technologies were cheaper and easier to use. Women were also actively involved in processing activities but often relied on rented or cooperative-owned equipment, indicating that women participate in post-harvest management but rarely control the technologies used.

4.5 Factors Influencing Adoption

The analysis indicates that adoption was strongly influenced by socio-economic and institutional factors. Farmers with higher income and better education were more likely to adopt improved storage and processing technologies. Similarly, regular contact with extension agents significantly improved awareness and adoption, while cooperative membership enhanced access to shared processing equipment and training opportunities. Logistic regression results suggest that education, income level, extension contact, and cooperative membership were significant predictors of adoption, confirming that institutional support systems play a critical role in technology uptake.

4.6 Constraints Limiting Adoption among Women

Table 5 presents the major constraints reported by female farmers (n = 124) that limit their adoption of post-harvest technologies.

Table 5: Major Constraints to Adoption among Female Farmers (n = 124)

Constraint	Frequency (f)	Percentage (%)
Lack of credit/finance	102	82.3
High cost of technologies	94	75.8
Limited extension contact/training	88	71.0
Lack of decision-making power	79	63.7
Domestic workload/time constraint	74	59.7
Socio-cultural restrictions	68	54.8
Limited cooperative membership	61	49.2

Source: Field survey (2026). Multiple responses permitted.

Women faced multiple barriers limiting their adoption of post-harvest technologies. The most prominent constraints were limited access to credit and income (82.3%), high cost of technologies (75.8%), and limited extension contact or training (71.0%). Women also reported lack of decision-making power (63.7%) and domestic workload constraints (59.7%), while socio-cultural norms (54.8%) and limited cooperative membership (49.2%) further restricted participation in training and cooperative activities. Qualitative insights from key informant interviews revealed that extension services in the area tend to prioritise male farmers, while women are often reached indirectly through spouses or informal networks, reducing their direct engagement with technology promotion programmes.

5. Discussion

The findings reveal that although post-harvest loss reduction technologies are available in Dutsin-Ma, access and adoption remain uneven, with clear gender differences. The socio-demographic profile indicates that registered smallholder farming is male-dominated, reflecting the patriarchal structure common in northern Nigeria where men are more recognised as farm owners, while women's agricultural contributions are largely concentrated in post-harvest handling and processing. This aligns with FAO (2011), which notes that women's participation is often underrepresented in formal agricultural systems owing to limited access to land and institutional recognition.

The study identified the presence of technologies such as hermetic storage bags, improved sacks, tarpaulin sheets, raised drying platforms, and processing equipment like threshers and shellers. However, advanced technologies such as metal silos and solar dryers were limited, suggesting that affordability and supply constraints shape technology availability. This supports the World Bank (2011) argument that weak infrastructure and high costs restrict access to improved post-harvest systems in sub-Saharan Africa. Gender differences were strongly evident in awareness, access, and adoption. Male farmers recorded higher awareness and access to improved storage and processing technologies, largely owing to stronger extension contact, cooperative membership, and better financial capacity. Female farmers showed relatively lower access, despite their central involvement in post-harvest

activities. This finding reflects Quisumbing et al. (2014), who argue that women's lower access to institutional support systems reduces their ability to benefit from agricultural innovations. The observed pattern is also consistent with the GAD framework, which explains that unequal access to resources and opportunities is rooted in structural power relations and institutional biases (Kabeer, 1994; Moser, 1993).

Adoption patterns further showed that men were more likely to adopt hermetic bags and mechanised processing equipment, while women were more likely to use cheaper drying technologies such as tarpaulins. This indicates that adoption is shaped by cost, resource control, and decision-making authority. As Doss (2001) notes, women's limited control over household income and productive assets often constrains their adoption of improved technologies, even when they are actively involved in post-harvest management. The regression results confirm that income, education, extension contact, and cooperative membership significantly influence adoption, supporting earlier studies emphasising that farmers with stronger socio-economic and institutional advantages are more likely to adopt innovations (Feder et al., 1985; Rogers, 2003). The major constraints limiting women's adoption include poor access to credit, high cost of technologies, weak extension targeting, limited decision-making power, and socio-cultural restrictions. Qualitative insights further suggest that agricultural programmes and cooperative structures often prioritise men, leaving women to benefit indirectly. The study demonstrates that gender disparities in post-harvest technology adoption in Dutsin-Ma are structurally driven rather than a reflection of lack of interest, and that reducing post-harvest losses requires gender-responsive extension services, inclusive cooperative participation, and affordable financing mechanisms targeted at women.

6. Limitations and Direction for Future Research

This study has several limitations that should be considered when interpreting its findings. The cross-sectional survey design captures a single point in time, limiting the ability to track changes in technology access and adoption over different farming seasons or policy cycles. Longitudinal research would provide a more dynamic understanding of how gender-based adoption patterns evolve as extension services and cooperative programmes expand.

The study was conducted in Dutsin-Ma Local Government Area of Katsina State, and its findings may not be directly generalisable to other agrarian communities in northern Nigeria or the broader West African context. Differences in agro-ecological conditions, cultural norms, and institutional support systems across regions may shape gendered technology adoption differently. Comparative studies across multiple local government areas or states would strengthen the external validity of these findings.

The study relied primarily on self-reported data from structured questionnaires, which may be subject to recall bias and social desirability effects. Future research should incorporate direct observation of post-harvest practices, farm-level loss measurements, and panel data to provide a more objective assessment of technology uptake and its impact on reducing post-harvest losses among male and female farmers.

7. Conclusion and Recommendations

This study has examined gendered access to and adoption of post-harvest loss reduction technologies among smallholder farmers in Dutsin-Ma Local Government Area of Katsina State, Nigeria. The findings indicate that although technologies such as hermetic storage bags, improved sacks, tarpaulin drying sheets, raised drying platforms, and processing equipment are available, access and adoption remain uneven across gender lines. Male farmers demonstrate higher awareness, access, and adoption levels, while women, despite their active involvement in post-harvest activities, face structural barriers including limited credit access, weak extension outreach, restricted decision-making power, and socio-cultural constraints. Income, education, extension contact, and cooperative membership significantly influence adoption outcomes. These disparities are structurally driven rather than reflective of individual unwillingness, confirming the relevance of the Gender and Development framework.

Based on these findings, the following recommendations are offered. First, agricultural extension services should be redesigned to ensure greater inclusion of women farmers through tailored training sessions, community-based demonstrations, and flexible engagement schedules that accommodate their domestic responsibilities. Second,

government and development partners should introduce subsidies or low-cost financing mechanisms to make post-harvest loss reduction technologies more affordable, particularly for resource-poor women farmers. Third, women should be encouraged and supported to form and strengthen cooperative societies that enhance collective access to credit, shared processing equipment, training opportunities, and bulk purchase of storage technologies; microcredit schemes should also be expanded with simplified requirements for rural women farmers. Fourth, policies should address socio-cultural constraints that limit women's participation in agricultural innovation systems, including promoting gender-inclusive agricultural programmes, improving women's land and asset ownership rights, and ensuring equitable participation in decision-making structures within agricultural institutions.

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