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## **ECONOMIC DIMENSIONS OF POST-HARVEST LOSSES AND HOUSEHOLD FOOD SECURITY AMONG COWPEA FARMERS: EVIDENCE FROM TARABA STATE, NIGERIA**

### **ABSTRACT**

*This study examines the economic dimensions of post-harvest losses and household food security among cowpea farmers in Taraba State, Nigeria. Using a cross-sectional survey of 384 farm households and employing Structural Equation Modeling (SEM), the study explores the causal linkages between post-harvest losses and food security. Results indicate that 21.1% of total cowpea output was lost post-harvest, with storage losses accounting for 76.3% of total losses. SEM results reveal that post-harvest losses significantly increased food insecurity ( $\beta = 0.782, p < 0.001$ ), while household income had a mitigating effect ( $\beta = 0.392, p < 0.001$ ). The study concludes that economic vulnerability induced by post-harvest inefficiencies undermines household food security and welfare. Policy recommendations cowpea farmers should priorities the use of Purdue Improved Cowpea Storage (PICS) while government or NGO-led subsidy programs should be implemented to make PICS or super grain bags affordable for smallholder farmers, as these are highly effective against bruchids without chemicals. Government should support local manufacturing and distribution networks for steel drums and metallic silos, which are highly effective alternatives to traditional, less secure storage methods. Government should integrate cowpea post-harvest loss reduction directly into national agricultural and food security strategies by formalizing targets in agricultural policies to aligned with national food security and international goals*

**Keywords:** Food Security, Post-Harvest Losses & Structural Equation Modeling, Taraba State.

### **1. INTRODUCTION**

Food security remains a defining challenge of the twenty-first century. Food security is commonly understood to comprise four important components: food availability, food access, food consumption (usage), as well as a constant and sustained assurance of access to it. The United Nation's Food and Agricultural Organization (FAO, 2019) estimated that 842 million people globally are undernourished; out of which an estimated 98 percent are said to be living in developing or third world countries. In Sub-Saharan Africa, over one-third of the food produced is lost before it reaches consumers (FAO, 2019). Postharvest losses of food grains provide a global barrier to achieving the sustainable development goals of zero hunger and responsible consumption and production

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practices. Research indicates that around one-third of the food produced globally each year for human consumption is lost or wasted (Aktas, et al, 2019; Bogale, 2021; McLean, 2021). Food losses and waste amount to around \$680 billion in developed nations and around \$310 billion in impoverished nations (Sawicka, 2020). In Sub-Saharan Africa (SSA), postharvest losses are significant not only because to low yields but also because around 374 million individuals are projected to face extreme food insecurity (FAO, IFAD, UNICEF, WFP & WHO, 2018).

In Nigeria, more than 100 million people are food insecure, despite substantial agricultural output (WFP, 2024). Taraba State exemplifies this paradox, possessing rich agricultural resources yet constrained by significant post-harvest losses and low household incomes. Nigeria's food insecurity has sharply worsened, driven by escalating conflict (insurgency, banditry, farmer-herder clashes), severe economic hardship (high inflation, rising food prices), and climate shocks (floods, droughts), impacting millions with acute hunger, especially in the North-East, North-West and North-Central regions, straining food systems and necessitating urgent aid for displaced populations and vulnerable communities (World Food Programme, (WFP), 2025).

According to Muñoz-Amatriaín, et al (2017), cowpea may play a major role in transforming Nigeria's agri-food system in terms of food and nutrition, livelihoods, environmental sustainability and resilience, and inclusivity. Food security and the livelihoods of millions of smallholder farmers who depend on cowpeas for their financial and nutritional well-being depend on them (Bolarinwa, 2022). Being cultivated for food, vegetables, fodder, green manure, and cover crops, cowpeas help to raise farmers' standard of living overall (Osipitan, Fields, Lo, Cuvaca, 2021). Despite Nigeria's prominence as a major cowpea producer, the country continues to experience extensive post-harvest inefficiencies that undermine both food availability and rural livelihoods.

This problem is further aggravated by socio-economic challenges such as poverty, limited market access, and insufficient policy support, which together weaken the ability of farming households to manage and mitigate these losses. Addressing postharvest losses is crucial for improving food security and enhancing the welfare of farming households in Taraba State. However, there is a lack of research that empirically examines the scale of postharvest losses, their impact on food security and farmers welfare in the state. Understanding these factors is vital for developing effective strategies and interventions to reduce losses, improve food security, and support the livelihoods of farming communities. While previous studies have examined the agronomic aspects of cowpea production, few have quantitatively established the economic linkages between post-harvest losses, income, and household food security using Structural Equation Modeling (SEM). This study addressed this research gap by exploring economic dimensions of household food security and post-harvest losses among cowpea farmers in Taraba state, providing evidence relevant to Nigeria's agricultural transformation and the Sustainable Development Goals (SDGs).

## **2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK**

### **Conceptual Review**

Different international organizations and academia's have rather different definitions of post harvest losses and household food security. United States Agency for International Development (USAID, 2024) defined food security as a state in which individuals consistently have both physical and economic access to sufficient food that meets their dietary needs for a healthy and productive life. A

household is considered food secure when its members are free from hunger and the fear of hunger. Similarly, the United Nations (2024) defines food security as the continuous availability of and access to safe, nutritious, and culturally acceptable food that satisfies individuals' dietary requirements for an active and healthy life. Four dimensions of food security have been identified according to the definition (FAO, 2013); availability of food produced locally and imported from abroad, accessibility, utilization and stability. Food and water must be safe and clean, and thus adequate water and sanitation are also involved at this level (Berry, Dernini, Burlingame, Meybeck, Conforti, 2015).

On the other hand, Kitinoja, Tokala, and Brondy (2018) defined post-harvest losses refer to the deterioration in both the quantity and quality of food products from the time of harvest to the point of consumption. A report by the Food and Agriculture Organization (FAO, 2013) highlights that, in high-income countries, the greatest volumes of food loss and waste occur in the downstream phases of the food supply chain, such as during retail and consumption. Conversely, in low-income countries, the majority of losses take place in the upstream stages, including production, post-harvest handling, and storage. Post-harvest losses (PHLs) are generally assessed through two primary dimensions: quantitative and qualitative measures (Constas, d'Errico, & Hoddinott, 2021).

### **Post-Harvest Handling and Post-Harvest Losses in Taraba State**

Cowpea harvesting in Taraba State remains largely manual and labor-intensive, with significant implications for post-harvest losses. According to the Taraba Agricultural Development Project's 2023 annual report, 92% of smallholder farmers rely exclusively on traditional tools like the curved sickle (locally called "garma") and short-handled knives ("alle") for harvesting. This dependence on manual methods stems from multiple factors: the average farm size of 1.2 hectares (NBS, 2023) makes mechanization economically unviable for most farmers, while the rugged terrain in many parts of the state limits the use of harvesting equipment. The timing of harvest presents particularly acute challenges.

The threshing process in Taraba represents a critical bottleneck in the cowpea value chain, with significant impacts on both quantity and quality. Field observations across the six LGAs conducted by the author in 2024 revealed that 78% of farming households still use the traditional "mat-and-stick" method, where dried cowpea plants are spread on bare ground and beaten with wooden sticks ("kilishi"). This approach has multiple deficiencies: first, it results in incomplete pod separation, leaving 5-8% of grains unthreshed according to controlled trials by the Crop Research Institute of Nigeria (2021). Second, the violent impact causes grain breakage rates between 8-12%, substantially reducing the proportion of premium whole grains that could fetch better prices. While improved technologies like pedal-operated threshers exist, their adoption remains limited to about 5% of farmers, constrained by the high capital cost (averaging ₦85,000 per unit) and lack of maintenance services in rural areas (NISER, 2023).

Drying practices in Taraba State significantly influence the storage stability and final quality of cowpea, yet remain largely suboptimal. The universal reliance on sun drying (practiced by 98% of farmers according to CRIN (2021) presents multiple risks to product quality. The most common approach - spreading harvested cowpea directly on bare ground - exposes grains to soil contamination, insect infestation, and sudden weather changes. A 2022 study by Abdulkadir et al

(2023) found that ground-dried samples contained 3-5 times higher aflatoxin levels compared to those dried on raised platforms. Moisture content management is particularly problematic, with TADP (2016) reporting that only 35% of farmers own moisture meters, leading to widespread guesswork in determining drying completion. Field measurements show alarming variability in final moisture content (13-18%), far exceeding the 10-12% recommended for safe storage (Ajeigbe et al., 2020). This inconsistency has direct economic consequences: the Nigerian Stored Products Research Institute (2023) estimates that improper drying contributes to 25-30% of storage losses in Taraba. While some improved technologies exist - such as tarpaulins (used by 12% of farmers) and raised drying racks (8% adoption) - their penetration remains limited by cost and accessibility factors.



Plate 1: Cowpea in pods spread out and dried under the sun  
(Demonstrating a common traditional post-harvest drying method used by farmers in Taraba State)

Storage represents the most loss-intensive phase in Taraba's cowpea value chain, with systemic challenges that undermine food security and farmer incomes. Traditional storage methods - primarily woven polypropylene sacks (used by 65% of farmers) and mud silos ("rumbu", 25% adoption) - provide inadequate protection against major storage pests (TADP, 2023). The cowpea weevil (*Callosobruchus maculatus*) is particularly destructive, capable of destroying 30-40% of stored grain within six months (Baoua et al., 2022). Field surveys conducted by the author in 2024 revealed that 82% of farmers report visible insect damage in their stores after just three months of storage. The humid tropical climate exacerbates these losses by accelerating mold growth, while rodent infestations account for an additional 5-8% loss (NSPRI, 2023). Hermetic storage technologies like PICS bags have demonstrated remarkable effectiveness in controlled trials - a 2023 study by Murdock et al. showed 95% protection against insect damage - but real-world adoption remains below 10% in Taraba. The Taraba Ministry of Agriculture (2023) identifies three key barriers: the high unit cost (₦1,500 per bag), limited distribution networks in rural areas, and lack of awareness about proper usage. These storage challenges have cascading economic impacts: farmers who cannot store their crop safely are forced to sell immediately after harvest when prices are lowest, missing out on the 100-120% price increases typical during the lean season (NBS, 2023).



Plate 2: Bags of cowpea stored in a market shop in Gidin-Dorowa, Wukari LGA (Zone 2)  
(Illustrating post-harvest handling and storage practices observed during fieldwork).

The transportation of cowpea from farms to markets in Taraba State is plagued by infrastructural deficiencies that contribute significantly to post-harvest losses. The state's rural road network remains

underdeveloped, with only 28% of farm-to-market roads rated as "good condition" by the World Bank (2022). This poor infrastructure forces farmers to rely on suboptimal transportation modes: open trucks (used for 55% of shipments), motorcycles (30%), and animal-drawn carts (15%) according to NBS (2023) data. Each of these methods contributes to product losses - the author's 2024 field measurements recorded average transit losses of 8-12%, comprising 3-5% spillage from inadequate packaging, 2-3% damage from rough handling, and 3-4% quality degradation from exposure to dust and moisture. The problem is compounded by multiple handling points along the value chain; a typical shipment undergoes 4-6 transfers between farm, assembly market, and final buyer, with each transfer incurring additional losses (FMARD, 2021). Packaging deficiencies further exacerbate these issues - 89% of farmers use second-hand fertilizer or grain sacks rather than proper food-grade packaging (ITC, 2023). These sacks often tear during transit and provide no protection against moisture or pests. The cumulative impact is substantial: the Taraba chapter of the All Farmers Association of Nigeria (2023) estimates that transportation-related losses reduce potential farmer income by 15-20% annually.



Plate 3: Bags of cowpea loaded in a truck at Maihula, Bali LGA (Zone 2)  
(Ready for transportation to market, reflecting post-harvest aggregation and distribution practices)

The marketing system for cowpea in Taraba State is characterized by inefficiencies that significantly depress farmer incomes and exacerbate post-harvest losses. The majority of smallholders (72% according to SMEDAN, 2023) sell their produce immediately after harvest through informal channels to itinerant traders, typically at prices 30-40% below market rates. This rush to sell stems from multiple factors: lack of storage options (as previously discussed), urgent cash needs (reported by 65% of farmers in a 2023 UNDP survey), and limited market information (only 12% of farmers have access to price data). The consequences are severe – as National Bureau of Statistics (2023) data shows that farmers who sell at harvest receive an average of ₦450-₦550/kg, while those who can store until the lean season (3-5 months later) command ₦900-₦1,200/kg. The absence of proper grading systems in most markets (functioning in only 15% of cases according to TADP, 2023) means farmers cannot capitalize on quality differentials. Middlemen dominate the value chain, capturing 45-50% of the final consumer price according to ITC (2023) estimates. Only about 15% of producers engage with formal markets or processors, constrained by lack of connections (58% of farmers), quality requirements (27%), and transportation costs (15%) based on a 2024 AFAN survey. These marketing inefficiencies create a vicious cycle: low prices discourage investment in quality improvement, which in turn limits access to premium markets.



Plate 4: Display of cowpea for sale in Iware market, Ardo-Kola LGA (Zone 1)  
(Showing typical market presentation and retail practices observed during fieldwork)

### Theoretical Framework

The systems theory of food security propounded by Cristina Mele, Jacqueline Pels and Francesco Polese (2010) serve as the foundation for this investigation. The systems theory of food security views food security as a complex outcome arising from the interactions within a food system, considering all elements from production to consumption, including environmental factors, social dynamics, economic conditions, and governance structures, highlighting that addressing food insecurity requires a holistic approach to manage the interconnected components of the system rather than focusing solely on individual aspects like production alone; key elements include the four pillars of food security: availability, access, utilization, and stability, where disruptions in any one area can impact the overall system and lead to food insecurity; this approach emphasizes the importance of understanding feedback loops and interdependencies within the food system to develop effective interventions for sustainable food security (Mele, Pels & Polese, 2010).

The systems theory of food security is significant to the study on postharvest, food security and cowpea farmers' welfare as it highlighted key points about food security which includes;

- i. **Holistic perspective:** It looks beyond just food production to encompass the entire food system, including processing, distribution, consumption, and the environmental impacts associated with each stage.
- ii. **Interconnectedness:** Recognizes that various factors within the food system are interconnected and influence each other, such as climate change affecting crop yields, which can impact food availability and access.
- iii. **Feedback loops:** Emphasizes the importance of considering how changes in one part of the system can have cascading effects on other parts, requiring a dynamic understanding of the system.
- iv. **Social and environmental considerations:** Integrates social factors like income inequality, poverty, and access to healthcare alongside environmental factors like water availability and land degradation into the analysis of food security.
- v. **Multi-stakeholder approach:** Acknowledges the need for collaboration among diverse actors like farmers, consumers, policymakers, and researchers to address food security challenges effectively.

### Empirical Review

Abubakar et al. (2023) analyzed the choice of postharvest management practices among rice farmers in Tolon District, Ghana, and their implications for household food security. Using a multivariate probit model, the study found that FBO membership, household size, credit access, farm size, and PHL awareness influenced postharvest practice adoption. Ordered probit results indicated that using heat control techniques, particularly in combination with chemical and sorting methods, significantly improved food consumption outcomes.

Abraham et al. (2023) investigated the impact of PICS bag usage on food security and poverty among cowpea farmers in Northwestern Nigeria. The study employed a cross-sectional survey design, collecting household-level data from both PICS adopters and non-adopters. The study found that PICS adopters demonstrated greater food security and lower poverty incidence than non-adopters, based on household food expenditure data.

Ogheneruemu and Joy (2023) assessed the relationship between PHL and food security among yam farmers using data from Nigeria's General Household Survey (GHS) 2018/2019. The research adopted a secondary data analysis approach, utilizing the Nigeria General Household Survey (GHS) 2018/2019, a comprehensive dataset with agro-economic and demographic variables. Results showed that 90.5% of yam farmers experienced low PHL (<2 ha). However, food security incidence, depth, and severity were 51.49%, 27.60%, and 18.78%, respectively. Education, household size, and cooperative membership improved food security, while postharvest losses and smaller farm sizes worsened it.

Bukar et al. (2022) evaluated the impact of tomato postharvest losses on food security across five LGAs. Using a combination of food security indices, binary logistic regression, and PHL estimation models, the study found that tomato marketers experienced high food insecurity due to small enterprise sizes, which limited income and purchasing power needed to mitigate losses. Most sampled marketing households were food insecure.

Jarsm (2022) osocio-economicwork for addressing postharvest loss in Liberia that integrates a circular economy approach, aiming to eliminate waste and retain value within the food system. The framework emphasizes sustainable, resource-efficient policies and actions to generate long-term socioeconomic and ecological benefits. Given Liberia's longstanding struggle with food insecurity, research identifies postharvest loss as a key contributor to food shortages, with negative effects on both public health and environmental quality, thereby undermining livelihoods and well-being. Jarsm emphasizes the importance of incorporating local dynamics and a systems-thinking approach, involving multiple stakeholders and strong partnerships at various levels to implement robust interventions.

Asige and Omuse (2022) examined the relationship between postharvest technology use and food security among households in Narok East sub-county, Kenya. Their descriptive study surveyed 378 household heads (from a total of 25,078) using questionnaires and interviews. Analysis via descriptive and inferential statistics including regression, ANOVA, and correlation revealed a strong, positive, and statistically significant relationship between adoption of postharvest technologies and improved food security outcomes in the region.

Robert and Ruth (2018) conducted a survey of 88 smallholder farmers in Ethiopia's Gondar region to assess postharvest challenges. Respondents reported severe losses due to rodents (46%), birds (54%), weather (55%), and pests (63%). Nearly half also cited "very serious" issues with rodents (50%) and birds (28.4%), all linked predominantly to poor storage conditions.

Adekunle, Akinbode, Shittu, and Momoh (2020) analyzed the welfare impacts of food price changes on Nigerian farm households (2010–2016), who served both as producers and consumers. Using compensating variation estimates, they found that 79% of households were net food buyers, incurring welfare losses (mean = 2.98; mean expenditure = ₦529,397.50), while 21% were net sellers who experienced welfare gains (mean = -1.66; mean expenditure = ₦513,755.70). Cereal prices emerged as the greatest source of vulnerability, though households that adapted production and consumption strategies experienced less severe welfare declines across income quintiles.

Gebreegziabher and van Kooten (2020) provided a microeconomic perspective on PHL and food security in Ethiopia using panel data from 4,000 households in the Ethiopia Socioeconomic Survey (ESS), collected under the World Bank's LSMS-ISA project. Using a random-effects probit model, the study found that PHLs were substantial and primarily due to poor storage infrastructure, rodent infestations, and inappropriate handling. Improved market access and storage practices were associated with reduced losses.

Apurba et al. (2019) analyzed determinants of postharvest losses across maize and sweet potato value chains in Uganda. Using an ordered probit model on cross-sectional survey data, the study found that education and postharvest training significantly reduced losses. Practices such as transporting with sacks or bicycles, drying on tarpaulins, and storing in brick structures were associated with lower losses.

Kumar and Kalita (2017) provides a comprehensive literature review of the grain postharvest losses in developing countries, the status and causes of storage losses and discusses the technological interventions to reduce these losses. It was discovered that, Postharvest loss is a complex problem and its scale varies for different crops, practices, climatic conditions, and country economics. Storage losses account for the maximum fraction of all postharvest losses for cereals in developing countries, and negatively affect the farmers' livelihoods. Most of the harvested grains are stored in the traditional storage structures, which are inadequate to avoid the insect infestation and mold growth during storage and lead to a high amount of losses. Technology interventions and improved storage structures can play a critical role in reducing postharvest losses and increasing farmers' revenues. Hermetic storage creates an automatic modified atmosphere of high carbon dioxide concentration using the sealed waterproof bags or structures, and significantly reduces insect infestation losses. Use of properly sealed hermetic storage structures has resulted in up to a 98% reduction in storage losses, maintained seed viability, and its quality for long storage times.

### 3. METHODOLOGY

This study adopted a survey research design which is permissible for employing a coherent research instrument for gathering information and generating data that were used in the study. The study employed Cochran's (1963) formula named after the statistician William Gemmell to determine the sample size of 384 because of the large and unknown number of the target populations which are

cowpea farmers in Taraba State, Nigeria. Multistage and purposive sampling techniques were adopted for the selection of the study area on the basis of cowpea production and marketing activities. The Taraba Agricultural Development Programme has used soil, climate, and vegetation to classify Taraba State into four agricultural zones. There are sixteen local government areas in Taraba State, which are separated into four agricultural zones: Zone I, Zone II, Zone III, and Zone IV. Zone I (the Sudan Savanna) and Zone II (the Northern Guinea Savanna) are the primary locations for cowpea production and marketing. Zones I and II were so specifically chosen. Furthermore, two Local Government Areas from Zone I and four Local Government Areas from Zone II were purposely selected making a total of six (6) LGAs. Base on the multistage purposive sampling technique, the sample size allocated in the study area is provided in Table 1 as thus;

**Table 1: Sample Size Allocation**

S/No.	Zone	LGA	Community	No. of Sample
1.	Zone I	Zing	Monkin	32
2.	Zone I	Zing	Bubong	32
3.	Zone I	Ardo-Kola	Iware	32
4.	Zone I	Ardo-Kola	Mayo-Renewu	32
5.	Zone 2	Bali	Garba-Chede	32
6.	Zone 2	Bali	Maihula	32
7.	Zone 2	Gassol	Mararaban Gassol	32
8.	Zone 2	Gassol	Sabon-Gida	32
9.	Zone 2	Wukari	Gidin-Dorowa	32
10.	Zone 2	Wukari	Bantaje	32
11.	Zone 2	Ibi	Dooshima	32
12.	Zone 2	Ibi	Dampar	32
<b>Total</b>				<b>384</b>

**Source: Field Survey (2025)**

The instrument used for this research was structured questionnaire designed by the researcher tagged “Post-harvest Losses, Food Security and Welfare” (PHLFW) in line with criteria established by FAO and World Bank in assessing post-harvest losses, food security and household welfare (FAO, 2020; World Bank, 2021). The questionnaire was divided into two sections which include; Section A: demographic and socio-economic characteristics of the respondents and B: Assessment of post-harvest handling practices of cowpea, food security and welfare of farm household. The data on post-harvest handling practices of cowpea, food security and welfare of farm household were elicited from the questions in section B. The questionnaire contains closed- ended and open-ended questions. The face and content validity of the instrument was determined through experts’ judgment, including experts in Economics Department of the Rev. Fr. Moses Orshio Adasu University Makurdi, Nigeria. Their suggestions and recommendations were affected to produce the final draft.

The data collected through the questionnaire were analyzed using descriptive statistics such as mean, standard deviation, simple percentages and frequency distribution to present and analyze socio-economic characteristics of the cowpea farmers, evaluate the extend of post-harvest losses of cowpea in the study area, determine post-harvest losses index, evaluate food security and farmers welfare in the study area. In addition, the study employed Structural Equation Modeling (SEM) to examine the

interrelationships among variables within the model of the study with aid of Statistical Package for Social Sciences (SPSS) Amos Version 23.

The study adopted Post-Harvest Losses (PHL) model, developed by Suleiman (2015) with modifications to achieve the objectives of the study. The adopted model was utilized to quantify the postharvest losses of onions. This model enabled the determination of the quantity and value of onion losses at different stages of the producer, wholesale, and retail levels of the marketing chain. The major post-harvest activities considered in the model were harvesting, sorting, packaging, storage, haulage and transportation, and marketing (selling). According to Suleiman (2015), the PHLE model is expressed as:

$$TPHL_t = \beta_0 + \sum_{i=1}^n \beta_1 S_i + \sum_{i=0}^n \beta_2 P_i + \sum_{i=0}^n \beta_3 R_i + \sum_{i=0}^n \beta_4 T_i + \sum_{i=0}^n \beta_5 M_i + \epsilon \dots \dots (1)$$

Where;

TPHL = Total post-harvest losses (kg)

Hi, Si, Pi, Ri, Ti, and Mi are losses during harvesting, sorting, packaging, storage, transportation and marketing respectively.

The study modified the model by utilizing a factorial specification design to establish if any, cause and effect relationship exist among the variables of the study. To achieve the study objectives, structural equation modeling (SEM) was applied to analyze post-harvest losses, food security and cowpea farmers welfare in Taraba State Nigeria, focusing on the influence of farmers’ socio-economic characteristics and post-harvest handlings of cowpea on post-harvest losses, the effect of post-harvest losses on food security as well as the effect of post-harvest losses on cowpea farmers income in Taraba State.

In view of the objectives of the study, the study adopted post-harvest losses index developed by Strecker, Bitzer and Kruijssen (2022) to determine the extent of post-harvest losses of cowpea in Taraba State. Hence;

$$PHL (\%) = \frac{TPHL}{TH} \times 100 \dots \dots \dots (2)$$

Where:

PHL= Post-Harvest Losses of Cowpea,

TPHL = Total post-harvest loss (kg)

TH = Total Harvest (kg)

To examine the effect of post-harvest losses on food security in the study area, the Jaspreet and Anita, (2013) model was further modified by taking foot security as endogenous variable while total post-harvest losses of food at the stages of supply chain and household income as exogenous variables. Classifying these variables as exogenous allows the model to focus on the direct impact of these critical factors on the food security system, without having to model the intricate external conditions that determine them. Hence, the functional relationship is established as thus;

$$FST = f (TPHL, CFI) \dots \dots \dots (3)$$

The model is restated in stochastic form for estimation as thus;

$$FST_t = \alpha_0 + \sum_{i=0}^n \alpha_1 TPHL + \sum_{i=0}^n \alpha_2 CFI + \epsilon \dots \dots \dots (4)$$

Where;

FST = Food Security

TPHL = Total Post-Harvest Losses

CFI = Household Income

$\alpha_0$  = The Intercept

$\alpha_1 - \alpha_2$  = Parameter estimate

$\epsilon$  = Error terms or Disturbance terms

#### 4. FINDING AND DISCUSSION

##### Assessment of Cowpea Output and Post-Harvest Losses

The summary of output and post-harvest losses at various phases of post-harvest losses handlings of cowpea in the study area is presented in Table 2

**Table 2 : Summary of Cowpea Production and Post-Harvest Losses**

	Output	Post-Harvest Losses
Cowpea Output Produced (Bag of 50kg)	2,527 and 1/2 Bags	--
Cowpea Output Produced (kg)	126,385.585 kg	-
Transportation Post-Harvest Handling (kg)	-	476.47 kg
Storage Post-Harvest Handling (kg)	-	21636.05 kg
Threshing Post-Harvest Handling (kg)	-	3864.87 kg
Packaging Post-Harvest Handling (kg)	-	1060.6 kg
Sorting Post-Harvest Handling (kg)	-	1209.335 kg
Total Post-Harvest Losses		28, 247.325kg
Total Harvest for Consumption	98138.6	

**Source: Field Survey, 2025.**

The summary of cowpea production and post-harvest losses showed that, the total bags of cowpea produced by farmers sampled within the study period were 2,527 and a half, representing 126,385.585 kilograms (kg). Post-harvest losses obtained through transportation, storage, and threshing, packaging, and sorting handlings were 476.47 kg, 21636.05kg, 3864.87 kg, 1060.6 kg and 1209.335 kg respectively. Total post harvest losses were estimated at 28,247.325kg representing 22.4% of the total cowpea produced in the study area within the study period. The total cowpea remaining for consumption is 98138.6 kg representing 77.6% of the total cowpea produced in the study area within the study period. The highest post-harvest loss was through storage handling while the lowest post-harvest losses of cowpea was through transportation handling.

Following Strecker, Bitzer and Kruijssen (2022) post-harvest losses index, the extent of post-harvest losses of cowpea in Taraba State is determined as thus;

$$PHL (\%) = \frac{TPHL}{TH} \times 100 \dots \dots \dots (5)$$

Where:

PHL= Post-Harvest Losses of Cowpea, TPHL = Total post-harvest loss (kg) while TH = Total Harvest (kg).

$$PHL (\%) = \frac{28247.325(kg)}{126385.585 \text{ kg}} \times 100$$

$$PHL (\%) = 0.2235 \times 100 = 22.4\%$$

Hence, the extent of post-harvest losses of cowpea was 22.4% of the total output of cowpea produced in Taraba State within the study period.

**Assessment of Food Security**

This sub-section presented assessment of food security among cowpea farmers in Taraba State for the study period. The responses on the evaluation of status of food security among cowpea farmers is provided in Table 3

**Table 3: Evaluation of Food Security**

S/No	Constructs	NO (%)	Rarely (%)	Sometimes (%)	Often (%)	Sum	Mean	S.D	Remark
1	Household worries of not having enough food	15 (4)	51 (13.6)	184 (48.9)	126 (33.5)	797	2.1	0.79	Food Insecure
2	Household inability to eat the kinds of foods they preferred because of a lack of resources	15 (4)	51 (13.6)	113 (30.1)	197 (52.4)	868	2.3	0.85	Food Insecure
3	Household eating a limited variety of foods due to a lack of resources	15 (4)	51 (13.6)	13 (3.5)	297 (79)	968	2.6	0.87	Food Insecure
4	Household eating some foods that they really did not want because of a lack of resources	15 (4)	24 (6.4)	88 (23.4)	249 (66.2)	947	2.5	0.79	Food Insecure
5	Household eating smaller meal than they felt they needed because there was not enough food	15 (4)	24 (6.4)	113 (30.1)	224 (59.6)	922	2.5	0.79	Food Insecure
6	Household eating fewer meals in a day because there was not enough food	15 (4)	76 (20.2)	61 (16.2)	224 (59.6)	870	2.3	0.93	Food Insecure

**Source: Field Survey, 2025.**

The result in Table 3 showed the analysis of the questionnaire items on self-evaluation of the extent of food security among cowpea farmers in the study area. The mean scale response of 2.1 revealed statistically significant value to conclude that, in the past four weeks, cowpea farmers’ household got worried about their food security in Taraba State. Similarly, the mean scale response of 2.3 revealed statistically significant value to conclude that, in the past four weeks, cowpea farmers household members were not able to eat the kinds of foods they preferred because of a lack of resources.

More so, the mean scale response of 2.6 revealed statistically significant value to conclude that, in the past four weeks, cowpea farmers’ household members had to eat a limited variety of foods due to a lack of resources, hence they are food insecure in Taraba State. In the same vein, the mean scale response of 2.5 revealed statistically significant value to conclude that, in the past four weeks cowpea farmers’ household members had to eat some foods that they really did not want to eat because of a lack of resources to obtain other types of food, hence they are food insecure in Taraba State.

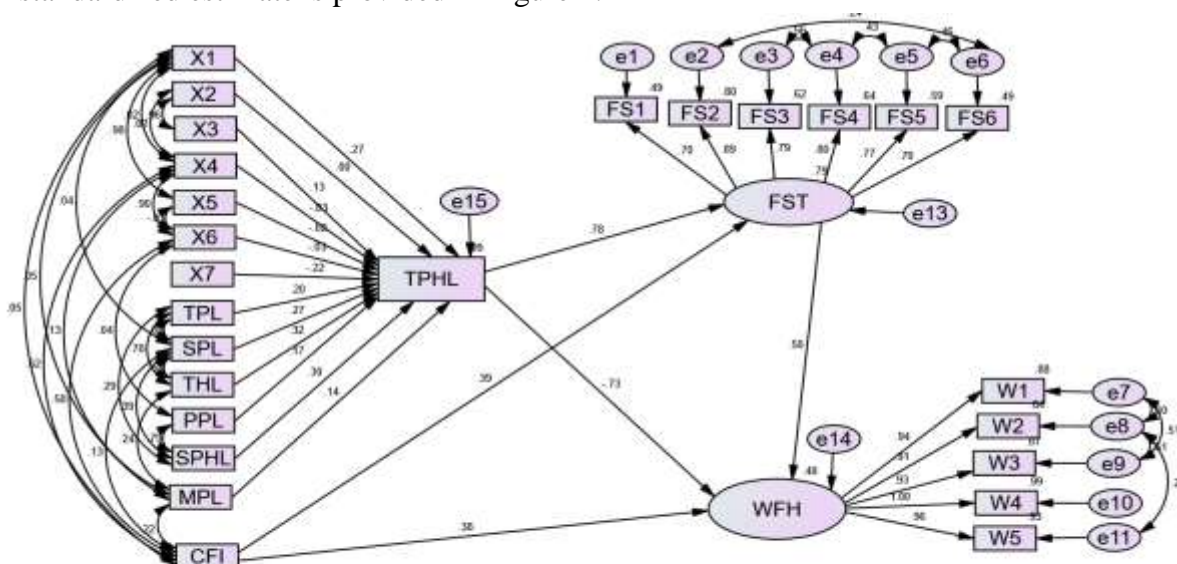
More ever, the result as indicated by the mean scale response of 2.5 revealed statistically significant value to conclude that, in the past four weeks, cowpea farmers household member has to eat a smaller meal than they felt they needed because there was not enough food, hence they are food insecure in Taraba State. in the same vein, 2.3 revealed statistically significant value to conclude that, in the past four weeks, cowpea household members have to eat fewer meals in a day because there was not enough food, hence they are food insecure in Taraba State.

### Structural Equation Model Results

Structural Equation Modeling (SEM) is a strong statistical technique that evaluates complex relationships among variables with both measured and structural components. Through the Structural Equation Model (SEM), the present study integrated the relationship among post-harvest losses (TPHL), food security (FST) and cowpea farmers’ welfare (WFH).

### Regression Result of the Structural Equation Model

The result of Structural Equation Model was based on unstandardized coefficients of the explanatory variables in model with their correspondents’ test statistic and significant values. Unlike standardized coefficients, which are normalized unit-less coefficients, an unstandardized coefficient has units and a ‘real life’ scale. Unstandardized coefficients are ‘raw’ coefficient produced by regression analysis when the analysis is performed on original, unstandardized variables. The path diagram of the unstandardized estimate is provided in Figure 1.



**Figure 1: Path Diagram of the Unstandardized Estimated SEM**

Figure 1 shows estimated relationships among the study variables. The numbers on the arrows are path coefficients (beta weights) indicating the effects of each variable on the others. The path diagram also indicated three latent or unobserved variables which are constructs that were not directly measured. These include; total post-harvest losses (TPHL), food security (FST) and cowpea farmers’ welfare (WFH) which is shown to be uncorrelated with one another but suggest a directional effect as indicated by one-headed arrows. The behavior of these variables was inferred from observed or manifest variables such as the various phases of post-harvest handlings (TPL, SPL, THL, PPL, SPHL, MPL), constructs for food security (FS1 to FS6) and constructs for farmers welfare (W1 to W6) as well as the socio-economic characteristics of the cowpea farmers (X1 to X7). These variables were obtained from actual data collected through surveys conducted in the study area. The path diagram further indicated values for disturbance terms, also called error terms which account for the unexplained variation in dependent variables (e1 to e28). These terms represent the portion of variability in an outcome that is not predicted by the independent variables in the model. All relationships shown in the model are statistically significant at  $p < 0.05$  or lower. The summary of the estimated SEM is presented in Table 6.

**Table 4: Estimated Coefficients of SEM**

Path Relationship	Unstandardized Estimate	Standardized Estimate ( $\beta$ )	C.R.	P-Value
FST <--- TPHL	0.690	0.782	17.106	<0.001
FST <--- CFI	0.292	0.392	9.149	<0.001
WFH <--- TPHL	-1.076	-0.733	-7.055	<0.001
WFH <--- FST	0.832	0.500	4.242	<0.001
WFH <--- CFI	0.466	0.376	5.397	<0.001

**Source: Author’s computation using SPSS Amos Version 23 (2025)**

The SEM further shows that post-harvest losses had a strong and positive effect on food insecurity (FST) with a standardized coefficient of 0.782 (C.R. = 17.106,  $p < 0.001$ ). This suggests that increased post-harvest losses significantly worsen food insecurity among cowpea farming households.

Cowpea farmers’ income, measured through CFI, also significantly influenced food insecurity ( $\beta = 0.392$ , C.R. = 9.149,  $p < 0.001$ ), although the direction of the relationship is unexpectedly positive. This may suggest complexities where income from cowpea farming alone does not guarantee improved food security, potentially due to post-harvest inefficiencies or household-level constraints.

Food insecurity was found to significantly influence welfare outcomes (WFH), with a standardized estimate of 0.500 (C.R. = 4.242,  $p < 0.001$ ), indicating that worsening food insecurity leads to a decline in overall welfare.

**Model Fit Assessment**

The goodness-of-fit of the Structural Equation Model (SEM) was evaluated using a range of widely accepted indices to determine the extent to which the proposed model represents the observed data.

Starting with the Chi-Square (CMIN) statistic, the model yielded a CMIN value of 6698.479 with a significance level of  $p = 0.000$ . While a significant chi-square traditionally indicates a lack of perfect fit between the observed and model-implied covariance matrices, it is well recognized that the chi-square test is highly sensitive to sample size. In large samples as is the case in this study even small differences can result in significant values. Therefore, the chi-square statistic alone does not provide a definitive assessment of model adequacy and should be interpreted in conjunction with other fit indices.

Among the incremental fit indices, the Normed Fit Index (NFI) was 0.884. Although slightly below the conventional cutoff of 0.90, it indicates a fairly reasonable level of model-data fit. The Relative Fit Index (RFI), which adjusts for degrees of freedom and model complexity, was 0.912, surpassing the recommended threshold and suggesting that the model improves meaningfully over a null model while accounting for its structure.

The Incremental Fit Index (IFI) recorded a value of 0.892, marginally under the 0.90 benchmark, but still indicative of a model that approximates a good fit. More encouragingly, the Tucker-Lewis Index (TLI), which penalizes for model complexity, was 0.921, well above the acceptable threshold of 0.90 and approaching the ideal level of 0.95. This suggests that the model strikes a balance between goodness-of-fit and parsimony.

The Comparative Fit Index (CFI) was reported at 0.901, slightly above the commonly accepted benchmark of 0.90. This confirms that the proposed model fits the data significantly better than a baseline model that assumes no relationships among variables, lending support to the theoretical structure developed in the study.

With regard to absolute fit measures, the Root Mean Square Error of Approximation (RMSEA) was 0.052, which falls well within the range considered to reflect a good fit ( $\leq 0.06$ ). This indicates that the model closely approximates the population covariance matrix, even with the complexity inherent in the post-harvest losses framework. The Standardized Root Mean Square Residual (SRMR) was 0.0482, comfortably below the acceptable threshold of 0.08 and close to the ideal of 0.05, further reinforcing the model's fit quality.

Taken together, these results demonstrate that the structural model fits the data reasonably well. While a few indices fall just short of ideal cutoffs, the majority of the values meet or exceed acceptable thresholds. The model can therefore be considered robust and empirically adequate for capturing the relationships among post-harvest losses, socio-economic characteristics, food security, and farmer welfare in Taraba State.

### **Discussion of Findings**

Findings from the field survey show that cowpea farmers in Taraba State experience notable post-harvest losses at various handling stages. The data indicates that the largest losses occurred during storage, while transportation accounted for the smallest share. In total, the estimated post-harvest loss was 28, 247.325kg, which is about 22.4% of the total cowpea output during the study period.

The SEM analysis further confirmed that all six post-harvest handling activities transportation, storage, threshing, packaging, sorting, and marketing significantly contributed to these losses. These practices had positive and significant effects, with standardized path coefficients ranging from 0.141 to 0.323. This means that inefficiencies are present throughout the entire post-harvest chain, and they play a major role in the volume of cowpea lost after harvest.

This finding aligns with global patterns; the FAO (2019) estimates that 30–40% of food produced in Sub-Saharan Africa is lost post-harvest, primarily due to inadequate storage and handling. Similar trends have been documented in Uganda, where Tibagonzeka et al. (2018) and Apurba et al. (2019) reported 20–40% losses for cereals like maize and millet, with storage accounting for the highest share. However, Taraba's losses are notably lower than the 53% caloric loss observed by Kumar and Kalita (2017) in India, likely due to differences in crop perishability or measurement methodologies. The consistency across these studies underscores the universality of storage-related challenges in agrarian economies, particularly where access to modern technologies is limited.

The SEM results showed a strong positive relationship between post-harvest losses and food insecurity among cowpea farmers. A 1% increase in post-harvest losses was associated with a 10% rise in food insecurity. This confirms that when a significant portion of harvested produce is lost, the availability of food at the household level declines. In addition, the food security indicators used such as reduced meal frequency, limited food variety, and anxiety over food availability all showed significant effects. These reflect the lived realities of many households dealing with the consequences of inadequate food supply. Similar patterns have been reported in studies across Nigeria; Bukar et al. (2022)'s research in Borno State, where tomato losses deepened household hunger, and Ogheneruemu and Joy (2023)'s analysis of Nigeria's General Household Survey, which tied losses to reduced dietary diversity. In East Africa; Asige and Omuse (2022) demonstrated in Kenya that post-harvest technologies could mitigate food insecurity despite losses, suggesting that Taraba's farmers might benefit from similar innovations.

## 5 CONCLUSION AND RECOMMENDATIONS

Based on the findings, the study concludes that, the total cowpea output from sampled farmers was 126,385.585 kg of which 28, 247.325kg (22.4%) was lost postharvest, with storage accounting for the highest losses. The study also concludes that, inefficiencies in handling practices of transportation, storage, threshing, packaging, sorting and marketing significantly contributed to these losses. The study further found that postharvest losses had a statistically significant and positive effect on food insecurity in Taraba State. SEM analysis confirmed that postharvest losses contributed to deterioration in farmers' welfare status, underscoring the economic vulnerability of cowpea producers in the state.

Drawing from the findings and conclusion made, the study makes the following recommendations:

1. To abate the extent of the post-harvest losses (PHL) in cowpea due to poor storage, cowpea farmers should priorities the use of Purdue Improved Cowpea Storage (PICS) while government or NGO-led subsidy programs should be implemented to make PICS or super grain bags affordable for smallholder farmers, as these are highly effective against bruchids without chemicals. In addition, government should support local manufacturing and distribution networks

for steel drums and metallic silos, which are highly effective alternatives to traditional, less secure storage methods.

2. Government should integrate cowpea post-harvest loss reduction directly into national agricultural and food security strategies by formalizing targets in agricultural policies to aligned with national food security and international goals (e.g., 50% reduction targets), investing in rural infrastructure, facilitating private sector financing for storage, and training extension staff in preservation technologies.

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