



**POST-HARVEST LOSS AND FOOD SECURITY: A CASE STUDY OF MAJOR FOOD CROPS IN KATSINA STATE, NIGERIA**

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**ABSTRACT**

Post-harvest loss (PHL) is the reduction in the quantity and quality of crops produced after harvest. This can lead to serious consequences for household food security in Nigeria. This study was conducted to improve our understanding of the effect of Post-harvest loss in food crops in Katsina State, Nigeria. Primary data were collected from a survey of 240 farming households that were randomly selected across 16 Local Government areas in the State. The results shows that majority of the respondents are within 41-50 years of age and married with household sizes of between 9-16 persons. Sorghum, millet, maize and cowpea are the major food crops that suffer high levels of PHL in Katsina State. Cowpea PHL were higher during storage, Sorghum PHL were higher during threshing and storage while maize PHL were higher during drying and at storage. Millet losses were also higher during threshing and storage respectively. The PHL in cowpea are mainly due to insect pest attack and spillage during post-harvest handling operations. Poor storage conditions and spillage are also responsible for the losses observed in sorghum. Maize PHL are mainly due to theft and spillage while millet losses are due to spillage and poor storage facilities. The study concludes that post-harvest losses significantly influenced household food security in Katsina State. It is therefore recommended that farmers should be trained on Post-harvest management and be provided with modern storage facilities in order to reduce PHL.

**Key words:** Food crops, Food security, Post-harvest loss, Katsina

**INTRODUCTION**

Post-harvest loss (PHL) is the degradation in both quantity and quality of food produced from harvest to consumption. The quality of losses includes those that affect nutrients or caloric compositions (Kiaya, 2014). The post-harvest management of crops in most developing countries is far from satisfactory and the incidence of huge Post-harvest losses and the challenges of liberalization and globalization calls for serious need to reduce the trend (Asian Productivity Organization, APO, 2006). It is disheartening to note that while many resources are being devoted to planting crops, irrigation, fertilizer application and crop protection measures for increased productivity, little is being done to minimize post-harvest loss by implication, productive agricultural resources such as land, water, labour, managerial skills and other inputs that could have been channelled to more viable ends are being wasted (Adepoju, 2014). In developing countries, an estimated 32% of farm produce is lost and only 5% of research funding has been allocated to activities on post-harvest handling (Mitcham, 2014). This shows that very little is being done to reduce post-harvest losses and there is no way food security can be achieved if wastage is not curbed; not even by increase in production of food crops.

One of the most challenging issues in the world today is how to provide sufficient food to more than seven billion people. Food insecurity problem is thus a global phenomenon that all hands have being on deck to solve

(Ayinde *et al.*, 2020). PHL is a major challenge in food production and supply chains in developing countries like Nigeria (Balana *et al.*, 2022). Nigeria faces a crisis of access to food and general food availability (Owoo, 2021). The PHL limit the potential income of the respondents, threaten food security and exacerbate conditions of poverty among rural households, whose income stream depends on the ability to store excess farm produce for a later date (Thamaga -Chitja *et al.*, 2004 cited by Okoruwa *et al.*, 2009). Ayandiji *et al.* (2011) and Luo *et al.* (2022), stated that food security can be reduced by increase in production and or reduction of losses. Major efforts have always been concentrated on the former to the neglect of the later. About 5-25% of fruits and vegetables leaving the farm gates are never consumed Watkins and Anubha, (2007) as cited in Mbuk *et al.* (2011), Post-harvest losses in food crops can reach 50% of total food production. It is discouraging and counter-productive for respondents, after channelling so much of their limited resources to lose the harvested produce before it gets to the market or consumers due to factors beyond their control (Adepoju, 2014). This of course has kept the hydra-headed problem of food insecurity alive because according to Adepoju (2014), Post-harvest losses have negative impact on the per-capita income and consequently, on the welfare of the respondents. As far as food insecurity problem is concerned, post-harvest handling is one important area requiring attention in an effort to combat hunger, raise income and food security

(Kaiya, 2014). A better understanding of PHL in Katsina State is thus imperative as there are no recent studies that have describe the magnitude of the menace in the state. The objectives of the study are to describe the causes and stages of PHL as well as estimate the magnitude of PHL in physical and monetary terms. It is expected that the findings from the study will help in providing empirical information that can serve as basis for the design of technologies that will help in reducing the plague of PHL in the Guinea Savannah of Nigeria.

**METHODOLOGY**

The study was conducted in Katsina state, north western Nigeria. Katsina State is lies between latitude 11° 08"N - 13° 22"N and longitude 6° 52"E - 9° 21"E. The area has an estimated population of 5.081 million people and a total land area of 23,938 square Kilometres (NPC, 2006). Katsina is a mono-ethnic and monolingual state and the people are generally Hausa/Fulani (Wikipedia, 2017). It borders Kaduna State to the south, Jigawa and Kano States to the East, Zamfara State to the west and shares an international border with Republic of Niger to the North The state

extends from the tropical grassland known as Sudan Savannah to Arid Zone in the North (Wikipedia, 2017). The rainy season which lasts for five months covers the period between May and September while the dry season covers about seven months of the year between October and April. The dry season is usually accompanied by the dry Harmattan winds with lower temperatures (Wikipedia, 2017). The state has an average temperature of between 21 °C and 30 °C. Primary data was utilized for the study and was collected with the aid of structured questionnaire which was administered on the respondents by trained enumerators. A multi-stage sampling approach was adopted for the study. In the first stage, 16 Local Government Areas (LGAs) were randomly selected from each of the three agro-ecological zones in Katsina State. In the second stage, 3 villages were randomly selected from the 16 LGAs to give a total of 48 villages. In the last stage, five households were selected proportionately from each of the selected villages to give a total of 240 respondents for the study. The sampling size selection is presented in Table 1.

**Table 1: Sample Size Selection**

| ADP Zone | No. of LGAs selected | Name of LGA   | Number of Villages Selected | No. of Respondents |
|----------|----------------------|---|-----------------------------|--------------------|
| Ajiwa    | 7                    | Batagarawa, Dutsinma, Kurfi, Safana, Kankia, Charanchi, kaita | 21                          | 105                |
| Funtua   | 4                    | Malumfashi, Danja, Kankara, Bakori                            | 12                          | 60                 |
| Daura    | 5                    | Mani, Sandamu, Daura, Dutsi, Mashi                            | 15                          | 75                 |
| Total    | 16                   |   | 48                          | 240                |

**Source:** Authors computation from Field Survey, 2020

Data was collected on Village and household socioeconomic characteristics, incidence of PHL such as major crops affected, cause of post-harvest loss, stage(s) of post-harvest loss, quantity and cost of post-harvest losses, food consumption and expenditure. Data was analysed using descriptive statistics, contingency valuation method, and ordered Probit model was used to establish the nexus between the household food security and PHL, the ordered Probit model was utilised. The model is presented below;

$$RCCSI = \beta_0 + \beta_1Z_1 + \beta_2Z_2 + \beta_3Z_3 + \beta_4Z_4 + \beta_5Z_5 + \beta_6Z_6 + \dots + \beta_{15}Z_{15} + U \dots \dots \dots 2$$

Where: RCCSI = Reduced Consumption Coping Strategy Index or household food security status measured as food secure, less food insecure, moderately food insecure and severely food insecure, and ordered as 0, 1, 2 and 3 respectively;  $\beta_0$ = Constant;  $\beta_1$ - $\beta_{15}$  = Coefficients, U= error term.

The explanatory variables that were used in the two models include:

- $X_1$  = Age of household head (years)
- $X_2$  = gender of household head (D=1 if male; 0=otherwise)
- $X_3$ =Marital status of household head (Single=0; Married=1; Widowed=3; Divorced/Separated=4
- $X_4$  = Household size (number)
- $X_5$ = educational status of household head (years)
- $X_6$ = farming experience of household head (years)
- $X_7$ = farm size (hectares)
- $X_8$ = farm income (naira)
- $X_9$ = off-farm income (naira)
- $X_{10}$ = membership of a social group (D=1 if member; 0=otherwise)
- $X_{11}$  = access to agricultural credit (D=1 if yes; 0= otherwise)
- $X_{12}$ = Livestock ownership (D=1 if owned; 0=otherwise)

X<sub>13</sub>= Land ownership (D=1 if owned; 0= otherwise)  
 X<sub>14</sub>= Dependency ratio  
 X<sub>15</sub>= Postharvest loss of household (Kg)

The Reduced Consumption Coping Strategy Index (RCCSI) is a variant of the coping strategy index calculated based on the five standard consumption coping strategies: Eating less preferred food, borrowing food/money from friends and relatives, limiting portions at meal times, limiting adult intake and reducing the number of meals per day with their universal severity weighting. This index facilitates the comparison of food insecurity across various strata by normalising the behaviours and severity scores that are used to create the index. The RCCSI score denotes that the higher the values of the RCCSI score, the higher the level of food insecurity and vice-versa. (Edeh and Gyimah-Brempong, 2015).

**RESULTS AND DISCUSSION**

**Socioeconomic Characteristics of respondents**

To better understand the background of the respondents, a detailed socioeconomic characteristics is presented in Table 2 below. The results shows that majority (34%) of the respondents interviewed are within the age of 41-50 years, this group is closely followed by those that fall within the age category of 51-60 years (29.5%). About 54% are within the age range of 31-50 years which is referred to as the active years during which people are believed to put their best into agricultural activities. All the respondents are males showing that in the study area, major food crops are grown exclusively by male respondents.

Majority of the respondents (55%) have household sizes ranging between 1-16. Majority of the respondents (41%) have farming experience of between 25 and 36 years. About 53% of the food crop respondents are educated only in Quranic education (meaning that they are capable of reading Arabic language) while 2% are without formal education. These implies that there is a high literacy level among the food crop respondents studied and as such, they should not have problems reading leaflets that are supplied by extension agents. On access to credit, only 13% of the respondents in the area had access. The major sources outlined by those who were able to access credit are family members, Bank of Agriculture and state government as indicated by 38%, 31% and 9% of the respondents respectively. The implication of this result is that only 43% (of those who got credit for food crop farming) got it through formal institutions. Only 19% of the respondents are members of a cooperative with about 39% having been members for at least 10 years. The respondents' contact with extension agents is low as only about 19% had any contact with an extension agent at least once in the last farming season. Most of the respondents had to transport through a distance of 1-5 Km to get to their farms and about 15% will go through a distance not less than 6-10 Km to get to their farms. This implies that many of the respondents' farms are not located within trek able distances from their homes.

**Table 2: Socio-economic characteristics of respondents**

| S/N | VARIABLES           | FREQUENCY | PERCENTAGE |
|-----|---------------------|-----------|------------|
| A   | Age                 |           |            |
|     | 21-30 years         | 6         | 2.5        |
|     | 31-40 years         | 48        | 20         |
|     | 41-50 years         | 82        | 34         |
|     | 51-60 years         | 71        | 29.5       |
|     | 61-70 years         | 26        | 11         |
|     | 71-80 years         | 7         | 3          |
| B   | Gender              |           |            |
|     | Male                | 240       | 100        |
|     | Female              | 0         | 0          |
| C   | Marital Status      |           |            |
|     | Single              | 2         | 1          |
|     | Married             | 238       | 99         |
| D   | Level of Education  |           |            |
|     | No formal education | 4         | 2          |
|     | Adult education     | 6         | 2.5        |
|     | Quranic education   | 127       | 53         |
|     | Primary education   | 34        | 14         |
|     | Secondary education | 46        | 19         |

|                     |                                    |                    |                             |                  |
|---------------------|------------------------------------|--------------------|-----------------------------|------------------|
| E                   | Tertiary                           |                    | 23                          | 9.5              |
|                     | Household Size                     | 1-8                | 46                          | 19               |
|                     |                                    | 9-16               | 132                         | 55               |
|                     |                                    | 17-24              | 40                          | 17               |
|                     |                                    | 25-32              | 18                          | 7                |
|                     |                                    | 33-40              | 3                           | 1.25             |
| 41-48               |                                    | 1                  | 0.75                        |                  |
| F                   | Main Occupation                    | Crop farming       | 179                         | 74.5             |
|                     |                                    | Livestock farming  | 21                          | 9                |
|                     |                                    | Fish farming       | 2                           | 1                |
|                     |                                    | Commercial driving | 3                           | 1.25             |
|                     |                                    | Tailoring          | 3                           | 1.25             |
|                     |                                    | Petty trading      | 4                           | 1.6              |
|                     |                                    | Mechanic           | 1                           | 0.4              |
|                     |                                    | Carpentry          | 5                           | 2                |
|                     |                                    | Others             | 22                          | 9                |
|                     |                                    | G                  | Years of Farming Experience | 1-12             |
| 13-24               | 65                                 |                    |                             | 27               |
| 25-36               | 98                                 |                    |                             | 41               |
| 37-48               | 40                                 |                    |                             | 17               |
| 49-60               | 13                                 |                    |                             | 5                |
| H                   | Access to Credit                   |                    |                             | Yes              |
|                     |                                    | No                 | 208                         | 87               |
|                     |                                    | I                  | Source of Credit            | State Government |
| NGOs                | 1                                  |                    |                             | 3                |
| Agric Bank          | 10                                 |                    |                             | 31               |
| Local money lenders | 4                                  |                    |                             | 13               |
| Family              | 12                                 |                    |                             | 38               |
| Friends             | 2                                  |                    |                             | 6                |
| n = 32              |                                    |                    |                             |                  |
| J                   | Membership of Cooperatives         | Yes                | 46                          | 19               |
|                     |                                    | No                 | 194                         | 81               |
| K                   | Years of Membership of Cooperative | <1                 | 3                           | 7                |
|                     |                                    | 1-5                | 17                          | 37               |
|                     |                                    | 6-10               | 8                           | 17               |
|                     |                                    | 11-15              | 8                           | 17               |
|                     |                                    | 16-20              | 4                           | 9                |
|                     |                                    | >20                | 6                           | 13               |
|                     |                                    | n= 46              |                             |                  |
| L                   | Contacts with Extension Agents     | Yes                | 46                          | 19               |
|                     |                                    | No                 | 194                         | 81               |
| M                   | PHL Training                       | Yes                | 45                          | 19               |
|                     |                                    | No                 | 195                         | 81               |
| N                   | Source of Training                 | ADP                | 9                           | 20               |
|                     |                                    | NGOs               | 5                           | 11               |

|                         |                                 |    |
|-------------------------|---------------------------------|----|
| Private consultants     | 1                               | 2  |
| LGA Dept of Agriculture | 16                              | 36 |
| Extension agents        | 14                              | 31 |
|                         | n = 45                          |    |
| O                       | Distance (Km) from home to farm |    |
| <1                      | 9                               | 4  |
| 1-5                     | 182                             | 76 |
| 6-10                    | 36                              | 15 |
| 11-15                   | 4                               | 2  |
| 15-20                   | 3                               | 1  |
| >20                     | 6                               | 2  |

Source: Authors computation from Field Survey, 2020

The result on Table 3 presents the distribution of respondents based on their farm holdings. Most of the respondents have farm holdings of between 0.5-5ha.

**Table 3: Farm Holdings of Respondents**

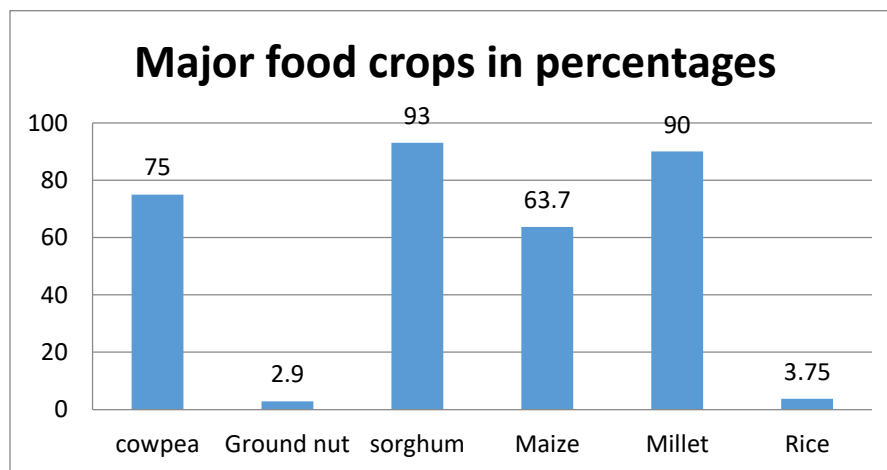
| Range   | FARM SIZE (Hectares) |   |        |   |       |   |        |   |
|---------|----------------------|---|--------|---|-------|---|--------|---|
|         | SORGHUM              |   | MILLET |   | MAIZE |   | COWPEA |   |
|         | F                    | % | F      | % | F     | % | F      | % |
| 0.5-5   | 230                  |   | 231    |   | 191   |   | 108    |   |
| 5.1-10  | 8                    |   | 6      |   | 5     |   | 2      |   |
| 10.1-15 | 1                    |   | 0      |   | 0     |   | 0      |   |
| 15.1-20 | 0                    |   | 1      |   | 0     |   | 0      |   |
| 21.1-25 | 1                    |   | 0      |   | 0     |   | 0      |   |

Source: Authors computation from Field Survey, 2020

**Major Food Crops prone to Post-harvest loss in Katsina State**

The major food crops that are prone to post-harvest loss in the study area are presented in Figure 1 below. The results revealed that sorghum, millet, maize and cowpea are the major food crops that suffer high levels of post-harvest loss in Katsina state. Focus group discussions with the female household

members revealed that all four crops are key to meeting household food security needs. This is because the crops are the major food crops consumed by the households in the form of local delicacies such as *fura, Kunu, kosai, pate, tuwo, moimoi*, white and jollof rice respectively. Inability to produce enough of these crops implies reduction in food consumption or purchase from market if the means is available.



- Multiple responses occurred.

**Figure 1: Food Crops prone to Post-harvest loss in Katsina State**

### Stages of Occurrence of PHL in Major Food Crops

The stages of occurrence of PHL for the food crops in Katsina State are presented in Table 4 below. The results revealed that losses occur at various stages for each crop. For example, cowpea PHL are higher during storage, this is due to the fact cowpea has lots of pests both on the field and in the store. Sorghum PHL are higher during threshing and storage while

maize PHL are higher during drying and at storage. Millet losses are also higher during threshing and storage respectively. The stages of PHL identified agrees with those reported by Olurunfemi and Kayode (2021). The use of rudimentary methods of post-harvest handling is not a key factor that contributes to high PHL observed for all crops. Also, absence of modern storage facilities in the state may not be unconnected with the high PHL at during storage.

**Table 4: Stages of Occurrence of PHL for major Food Crops in Katsina State**

|           | Threshing               | Winnowing | Drying    | Transportation | Packaging | Storage    |
|-----------|-------------------------|-----------|-----------|----------------|-----------|------------|
|           | Frequency of occurrence |           |           |                |           |            |
| Cowpea    | <b>57</b>               | 32        | <b>57</b> | 15             | 4         | <b>167</b> |
| Groundnut | 1                       | 1         | 1         | 1              | 0         | 3          |
| Sorghum   | <b>92</b>               | 44        | <b>59</b> | 49             | 10        | <b>115</b> |
| Maize     | 47                      | 22        | <b>49</b> | 30             | 6         | <b>73</b>  |
| Millet    | <b>98</b>               | 37        | 27        | 43             | 3         | <b>115</b> |
| Rice      | 5                       | 5         | 1         | 1              | 3         | 4          |

**Source:** Authors computation from Field Survey, 2020 (NB: Figures in bold indicate high frequencies)

### Causes of PHL in Major Food Crops

The major causes of PHL in food crops are presented in Table 5 below. The results revealed that PHL in cowpea is mainly due to insect pest attack and spillage during post-harvest handling operations. Poor storage conditions and spillage are also responsible for the

losses observed in sorghum. Maize PHL are mainly due to theft and spillage while millet losses are due to spillage and poor storage facilities. The findings agrees with those of Adeola (2020). The above implies the need to improve post-harvest handling of crops and the urgent need for provision of low cost storage facilities such as metal silos.

**Table 5: Major causes of PHL in food crops**

| Food Crops | Insect pest attack | Theft     | Spillage during post-harvest handling | Poor Transport facilities | Poor Packaging | Poor Storage facilities |
|------------|--------------------|-----------|---------------------------------------|---------------------------|----------------|-------------------------|
| Cowpea     | <b>185</b>         | 67        | <b>99</b>                             | 16                        | 8              | 4                       |
| Groundnut  | 5                  | 1         | 2                                     | 1                         | 0              | 0                       |
| Sorghum    | 4                  | 88        | <b>174</b>                            | 47                        | 11             | <b>158</b>              |
| Maize      | 9                  | <b>78</b> | <b>86</b>                             | 14                        | 56             | 6                       |
| Millet     | 5                  | <b>83</b> | <b>124</b>                            | 30                        | 11             | <b>106</b>              |
| Rice       | 4                  | 3         | 10                                    | 1                         | 1              | 0                       |

**Source:** Authors computation from Field Survey, 2020 (NB: Figures in bold indicate high frequencies)

### Estimation of Quantity of PHL in Monetary and physical terms

Data were collected on the estimated quantity of PHL of major food crops at different stages along their value chains. The results as presented in Table 6 revealed that farmers make huge losses from PHL. This confirms that PHL can lead to poverty as a result of loss of income by farming households. In other words PHL, if left unchecked can aggravate household poverty as the surplus that could have been sold to meet basic needs must now be consumed by household members instead.

**Table 6: Average estimate of PHL in physical and monetary terms**

| Crop    | PHL in Physical terms (Kg) | PHL (₦) |
|---------|----------------------------|---------|
| Sorghum | 350                        | 56,000  |
| Maize   | 300                        | 90,000  |
| Millet  | 400                        | 48,000  |
| Cowpea  | 120                        | 36,000  |

**Source:** Authors computation from Field Survey, 2020

**Nexus between PHL and Food Security**

The results of the ordered Probit model in Table 7 showed the nexus between PHL and food security. The Log likelihood of -266.40 with Prob > chi-square value of 0.0008 (28.34), which was significant at  $p < 0.01$ , is an indication that the model as a whole was statistically significant and well fitted. The Pseudo  $R^2$  was 0.051, while the estimated cut-off points ( $\mu$ ) showed that the categories were ranked in an ordered way of  $\mu_3 > \mu_2 > \mu_1 > \mu_0$ . The results also revealed that household size, access to credit, years of education and post-harvest losses were the statistically significant explanatory variables that

influenced food security among the food secure and moderately food insecure households in the study area. Access to credit, years of education were significant at  $p < 0.01$ ; while household size and post-harvest losses were significant at  $p < 0.10$ , except for years of education among the moderately food insecure group that was significant at  $p < 0.05$ . For the less food insecure group, results showed that only years of education was significant at  $p < 0.05$ . However, for the severely food insecure category, access to credit and years of education significantly influenced their food security level at  $p < 0.01$  and  $p < 0.05$  respectively.

**Table 7: Estimates of determinants of Food security among farming households**

| Variable                               | Coefficient | Food secure           |                | Less Food insecure |               | Moderately Food insecure |                 | Severely Food insecure |                 |
|--|-------------|-----------------------|----------------|--------------------|---------------|--------------------------|-----------------|------------------------|-----------------|
|  |             | SE                    | Z statistics   | SE                 | Z statistics  | SE                       | Z statistics    | SE                     | Z statistics    |
| Age of household head                  | 0.0163      | 0.0024                | 1.54           | 0.0019             | 1.49          | 0.0032                   | -1.54           | 0.0011                 | -1.49           |
| Household size                         | -0.0207     | 0.0027                | <b>-1.65*</b>  | 0.0022             | -1.58         | 0.0036                   | <b>1.65*</b>    | 0.0013                 | 1.57            |
| Farming experience                     | 0.0062      | 0.0022                | 0.60           | 0.0018             | 0.60          | 0.0030                   | -0.60           | 0.0010                 | -0.59           |
| Farm income                            | -5.57e-08   | 0.0000                | -1.06          | 0.0000             | -1.04         | 0.0000                   | 1.05            | 0.0000                 | 1.04            |
| Farm size                              | -0.0032     | 0.0034                | -0.20          | 0.0026             | -0.20         | 0.0045                   | 0.20            | 0.0015                 | 0.20            |
| Access to credit (Base=No)             | 0.8928      | 0.0841                | <b>3.07***</b> | 0.0359             | 0.85          | 0.0543                   | <b>-4.38***</b> | 0.0148                 | <b>-3.45***</b> |
| Membership of a social group (Base=No) | 0.1339      | 0.0437                | 0.69           | 0.0261             | 0.79          | 0.0541                   | -0.72           | 0.0156                 | -0.76           |
| Education in years                     | 0.0390      | 0.0033                | <b>2.56***</b> | 0.0028             | <b>2.33**</b> | 0.0044                   | <b>-2.53**</b>  | 0.0016                 | <b>-2.33**</b>  |
| Post-harvest loss                      | 0.0004      | 0.0001                | <b>-1.68*</b>  | 0.0000             | -1.62         | 0.0001                   | <b>1.68*</b>    | 0.0000                 | 1.60            |
| Cut 1                                  | -0.6981     |                       |                |                    |               |                          |                 |                        |                 |
| Cut 2                                  | 0.7056      |                       |                |                    |               |                          |                 |                        |                 |
| Cut 3                                  | 2.1067      |                       |                |                    |               |                          |                 |                        |                 |
| Number of observations                 | 240         | LR chi2               | 28.34**        |                    |               |                          |                 |                        |                 |
| Log Likelihood                         | -266.40     | Pseudo R <sup>2</sup> | = 0.051        | Prob > chi2        |               | 0.0008***                |                 |                        |                 |

**Source:** Authors computation from Field Survey, 2020 \*\*\* = 1% significant level, \*\* = 5% significant level, \* = 10% significant level



**Estimates of the Marginal Effect of the Nexus between PHL and Food Security**

The marginal effect of the nexus between PHL and Food Security among farming households in the study area is as shown in Table 8. The results revealed the increase in the probability of being in any of the four levels of food security identified for a unit increase in the value of the explanatory variables and a change from one level to the base level for categorical and dummy variables. The results revealed that a 1% increase in the household size, significantly ( $p < 0.10$ ) decreased the probability of the farming household being food secure by 0.004, but increased the probability of the household being moderately food insecure by 0.006. Access to credit increased the probability (0.258) of being in the food secure category at  $p < 0.01$ , but decreased the probability of being in the moderately food insecure and severely

food insecure categories by 0.238 and 0.051 respectively. Likewise, a 1% increase in the years of education significantly ( $p < 0.01$ ) increased the probability of a farming household being in the food secure and the less food insecure categories by 0.008 and 0.007 respectively; but decreased the probability of being in the moderately food insecure and severely food insecure categories by 0.011 and 0.004 respectively. Lastly, a 1% increase in the quantity of PHL, significantly ( $p < 0.10$ ) decreased the probability of the farming household being food secure by 0.0001, but increased the probability of the household being moderately food insecure by 0.0001. The above results clearly showed the nexus between post-harvest losses and food security; that is, the higher the PHL, the lower the probability of a farming household being food secure. This implies that high levels of PHL are detrimental to the food security status of rural households.

**Table 8: Marginal effect for the Determinants of Food security**

| Variables                              | Food secure      | Less Food insecure | Moderately Food insecure | Severely Food insecure |
|--|------------------|--------------------|--------------------------|------------------------|
| Age of household head                  | 0.0037           | 0.0029             | -0.0049                  | -0.0016                |
| Household size                         | <b>-0.0044*</b>  | -0.0035            | <b>0.0060*</b>           | 0.0020                 |
| Farming experience                     | 0.0013           | 0.0010             | -0.0018                  | -0.0006                |
| Farm income                            | -1.18e-08        | -9.28e-09          | 1.59e-08                 | 5.27e-09               |
| Farm size                              | -0.0007          | -0.0005            | 0.0009                   | 0.0003                 |
| Access to credit (Base=No)             | <b>0.2581***</b> | 0.0307             | <b>-0.2377***</b>        | <b>-0.0511***</b>      |
| Membership of a social group (Base=No) | 0.0301           | 0.0205             | -0.0387                  | -0.0119                |
| Education in years                     | <b>0.0084***</b> | <b>0.0066**</b>    | <b>-0.0112**</b>         | <b>-0.0037**</b>       |
| Post-harvest loss                      | <b>-0.0001*</b>  | -0.0001            | <b>0.0001*</b>           | 0.00004                |

**Source:** Authors computation from Field Survey, 2020

**Legend:** \*\*\* = 1% significant level, \*\* = 5% significant level, \* = 10% significant level

**CONCLUSION AND RECOMMENDATIONS**

Based on the findings of the study, we conclude that PHL occurs in major food crops in Katsina State especially sorghum, millet, maize and cowpea. The PHL in food crops occurs majorly during post-harvest handling and at storage. The major causes of PHL in food crops are improper post-harvest handling, poor storage facilities and use of poor packaging materials. The occurrence of PHL in food crops constitutes a serious threat to household food security and poverty. The determinants of PHL include age of farmer, distance to farm, experience and amount of credit obtained. Based on the findings of the study, the followings are recommended:

1. There is need to train respondents across the state on post-harvest handling techniques. This training can be carried out by extension agents during their regular visits to respondents. It is expected that such trainings will build he capacity of respondents thus reducing or totally eliminating PHL.
2. The provision of affordable and modern storage devices such as the metal silos will help to reduce losses occurring at storage
3. Proper packaging materials such as the Purdue improved crop storage system should be introduced to respondents across the State to

reduce losses experienced due to the use of poor packaging materials

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