Food and Agriculture Organization of the United Nations

ETHIOPIAN STATISTICS SERVICE

REPORT ON PRE- AND POST-HARVEST CROP LOSSES PILOT SURVEY (2021–2022)

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Abbreviations and acronyms

APHLIS	African post-harvest losses information system
CAPI	computer-assisted personal interviewing
CSPro	Census and Surveys Processing System
CV	coefficient of variation
ESS	Ethiopian Statistics Service
GPS	Global Positioning System
GSARS	Global strategy to improve agriculture and rural statistics (GSARS)
PHL	post-harvest losses
PPS sampling	probability proportional to size sampling
PSU	primary sampling unit
SSU	secondary sampling unit
UNEP	United Nations Environment Programme

PART 1. INTRODUCTION AND OBJECTIVES OF THE SURVEY

1.1 Introduction

The attempt to ensure food security was mainly focused on increasing crop productivity and production in the field. However, increasing food production is being constrained by limited land and water resources and increased weather variability due to climate change (Aulakh and Regmi, 2013). On the other hand, a huge amount of losses occurs at different stages after crops are harvested and before consumption, after a large investment of time, labour, and money in the production process. Hence, developing adequate policies on reducing food losses at different stages of the supply chain based on timely and reliable statistical data has a paramount role to play in addressing food security in developing countries like Ethiopia.

Moreover, reducing food losses and waste is among the top priorities of the Sustainable Development Goal (SDG) framework, which has assigned a specific target to food losses and waste: "*by 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses".*

Despite the importance of measuring food losses, data on losses at different stages of the supply chain after harvest are limited in Ethiopia. Therefore, researchers have to rely on some studies by regional and international organization regarding food losses in Ethiopia. For instance, the African post-harvest loss information system (APHLIS) in its report 2021 indicate that the post-harvest loss for maize and wheat in Ethiopia accounts for about 17.6 percent and 14.1 percent of the production quantity respectively. On the other hand, in 2016, FAO estimated post-harvest loss of maize, wheat and haricot bean to be approximately 21.4 percent, 18.4 percent and 25.2 percent, respectively. In low-income countries, like Ethiopia, food is lost mostly during the early and middle stages of the food supply chain that is at crop production and handling stage and much less food is wasted at the consumer level. According to the 2011 study by FAO, annually about one-third of the food produced for human consumption is lost or wasted at the global level. A recent publication by FAO put the percentage of food lost from harvest up to but excluding the retail level at approximately 14 percent (FAO, 2019) and a study done by the United Nations Environment Programme (UNEP) put the percentage of food wasted at the retail and consumer levels at 17 percent (UNEP, 2021). However, this data has to be verified and also regularly updated through national level surveys and accordingly, the Ethiopian Statistical Service, in close collaboration with FAO has attempted to conduct a pilot survey on the on-farm and off-farm food losses for the first time.

This survey has been conducted as part of the 2021–2022 Agricultural Sample Survey, which the Ethiopian Statistical Service has been conducting since 1980–1981 to alert policy interventionists in the agricultural sector.

In general, post-harvest food loss (PHL) refers to a decrease in quantity and/or quality of food mass produced. In other words, it is defined as a "measurable qualitative and quantitative food loss along the supply chain" (De Lucia and Assennato, 1994; Hodges, Buzby and Bennett, 2011, as quoted by Aulakh and Regmi, 2013) including the production, harvesting, primary handling, aggregation, storage, transport, processing, distribution, and consumption segments (FAO, 2014).

As stated above, this on-farm survey is a pilot survey covering the three largest regions of the country and focusing on four major grain crops namely, maize, wheat, haricot bean and faba bean. The rationale for selecting these four crops is described below.

- In addition to serving as sources of income at household level and contributing to the country's foreign currency earnings, grain crops (cereals and pulses) are the major food crops for the majority of the Ethiopian population.
- Within the category of grain crops, cereals are the major food crops, both in terms of the area planted and volume of production obtained. According to a 2021–2022 Ethiopian Statistics Service (ESS) report, grain crops covered more than 12 million hectares of land and more than a million quintals of grains were produced (excluding the Tigray region) from the private peasant holdings.
- In 2021–2022, the percentage of land area under cereals, pulses, and oil seeds were 81.72, 13.94, and 4.34 percent, respectively; and the percentage production were 88.49, 9.83, and 1.68 percent, in that order. From the 81.72 percent of land covered by cereals, maize and wheat contributed 43.35 percent. Regarding production, of the 88.49 percent contributed by cereals, the share of maize and wheat was 56.43 percent. Similarly, from the 13.94 percent of land area and 9.83 percent production of pulses, the proportion of land covered by faba bean and haricot bean was 51.28 percent. In terms of production, the proportions of faba bean and haricot bean was 52.9 percent.

1.2 Objective of the survey

1.1.1 General objective

The general objective of this pilot survey was to produce data on the magnitude of pre-harvest damages and post-harvest losses of maize, wheat, faba beans, and haricot bean crops across the post-harvest value chain.

1.2.2 Specific objectives

The specific objectives of this pilot survey lies on the production of data on the following specific topics:

- magnitude of pre-harvest damages and the main factors contributing to the losses during the harvesting of the crop;
- magnitude of harvest losses and the main factors contributing to the losses;
- magnitude of crop losses during stacking or field drying;
- magnitude of the losses during threshing and the main contributing factors;
- magnitude of losses during winnowing/cleaning of the grains;
- magnitude of storage losses and their main contributing factors; and
- magnitude of transport losses: losses that occur during transportation of the product from farm to storage.

PART 2. SURVEY METHODOLOGY, DATA COLLECTION AND PROCESSING

2.1 Scope and coverage of the survey

The scope of the pilot survey focused on four crops. These were: maize and wheat from the cereals category and faba bean and haricot bean from pulses crop category. Households growing at least one or more of these four crops were enumerated and data on pre-harvest damage as well as harvest and post-harvest losses regarding each crop planted is collected. In addition, general information regarding the prices for last year production and data on prevention of post-harvest losses by households were collected.

The 2021–2022 (2014 Ethiopian calendar) pre- and post-harvest loss pilot survey covered the three regions of the country namely Amhara, Oromia and the Southern Nations and Nationalities regions.

A total of 180 enumeration areas were selected to be covered in the survey. However, due to security and eligibility reasons, 25 enumeration areas were not covered. Thus, the survey succeeded to cover 155 enumeration areas (86.11 percent) throughout the three regions. From each selected enumeration area, 20 agricultural households that cultivate at least one of these stated four crops were selected using systematic random sampling approach. Regarding the ultimate sampling units, it was intended to cover 3 600 eligible agricultural households, however, 3 049 (84.69 percent) were actually covered during the survey.

2.2 Sampling frame

The list containing the enumeration areas of all regions and their respective households obtained from the fourth round population and housing census cartographic frame was used as the sampling frame in order to select the primary sampling units (enumeration areas) for the annual agricultural survey. For this pilot survey, a sub sample was drawn from enumeration areas selected for the annual agricultural sample survey based on the eligibility criteria, i.e enumeration areas in which the stated four crop types are cultivated taking the previous year's data of agricultural sample survey as a reference. The second stage sampling units, households, were selected from a fresh list of households growing the required crop types that were prepared for each enumeration area at the beginning of the survey.

2.3 Sample design

In order to select the sample, a stratified two-stage cluster sample design was implemented. Census enumeration areas were taken to be the primary sampling units (PSUs) and the secondary sampling units (SSUs) were agricultural households having planted the survey required crop types. The sample size was determined by taking into account both the required level of precision for the national level estimates and

the amount of resources allocated to the survey. In order to reduce non-sampling errors, manageability of the survey in terms of quality and operational control was also considered.

2.4 Selection scheme

Enumeration areas from each stratum were selected systematically using probability proportional to size (PPS) sampling technique; size being number of agricultural households. The sizes for enumeration areas were obtainedfrom the fourth round of population and housing census cartographic frame in Ethiopia. From the fresh listof households prepared at the beginning of the survey, 20 agricultural households growing the survey crops within each sampled enumeration area were selected by systematic random sampling technique. The selection was made by giving priority for the households growing all the four crops, then households growing three of the four crops, then households growing two of the four crops, and finally households growing only one of the four crops.

2.5 Organization of field work

The organization of fieldwork operation has been coordinated by the head office and the 11 branch statistical offices located in the three regions. However, the Dessie branch office had to terminate its activities due to the conflict that erupted in that area after the launch of the survey.

Branch offices took part in the survey execution especially in recruiting the enumerators, organizing the second stage training, assigning the field staff to their sites of enumeration, supervising the data collection, electronic data transfer and retrieving completed questionnaires and submitting them to the head office for data processing.

The branch offices were also responsible for administering the financial and logistic aspects of the survey within their areas of operation. A total of 174 enumerators, 113 field supervisors and 10 branch office statisticians were directly involved in the data collection. After the completion of the training, all the enumerators were supplied with the necessary survey equipment (Global Positioning System [GPS] - equipped tablets, solar battery chargers, kitchen balance scales, etc.) to ensure the smooth operation of the survey.

2.6 Training of field staff

The execution of a survey and the quality of data acquired from the survey highly depend on the type of training given to the enumerators and supervisors and the consequent understanding of the tasks to be performed and the standard procedures to be followed by the enumerators and supervisors in the survey undertaking.

The quality and completeness of data are ensured when the training meets its objective of producing responsible and fervent enumerators and supervisors.

In light of this point, the training was given to the field staff in two stages. The first stage training of trainers, which took place at the head office for senior experts (Training of trainers). The experts that took part in the first stage training was then assigned in five (5) organized training centres to conduct similar training for the enumerators and other field supervisors that are from 11 branch statistical offices, even though one branch office (Dessie) couldn't conduct the survey due to the reason explained above.

In the training, the field staff was given detailed classroom instruction on how to collect data, method of area measurement, method of loss measurement, crop sample taking, crop cutting exercise, interviewing procedures, quality checking methods, manipulation of GPS-equipped tablets, usage of data collection applications loaded on tablets, online data transfer, etc.

2.7 Method of data collection

The data on pre- and post-harvest loss was collected from the selected 20 agricultural holders growing one or more of the four crops types stated above in the selected enumeration areas. The data collection involves both subjective and objective methods. The objective data collection includes measuring their land plots/parcels and crop cut experiments and also measuring the losses at different stages of post-harvest operations for the survey crops. The data collection was undertaken using computer-assisted personal interviewing (CAPI) method, using the Census and Surveys Processing System (CSPro) software.

2.8 Data processing

The data collection process was using GPS enabled tablets; the data editing and consistency checks were performed on the spot during data collection by a CSPro program loaded on the tablets. The collected data was then transferred to the supervisors' tablets through the Bluetooth. After checking the quality of the data collected by the enumerator, the supervisor transferred the collected data to the server located at the head office using a VPN network connection. At the head office, further validity checks were done on each question as well as on the consistencies between questions. When an error was observed during the validity checks, the data were sent back to the field with an error report so that errors could be corrected. Afterwards, the corrected data are sent back to the head office for further processing of the completed survey data. The final stage of data processing was to summarize the data and produce statistical tables. The production of the statistical tables was done using CSPro, SPSS and STATA software.

2.9 Concepts and definitions

Agricultural data items have to be distinctly defined and identified, so that the information about the items becomes useful. The correct way of stating data items and related terms is a pre-requisite for making standards and definitions for the collection and compilation of agricultural data. The purpose of using standard concepts and definitions is not only to foster quality data but also to ensure that the right items are enumerated and measured accurately to reflect the agricultural situation.

Standard concepts and definitions used in the survey help to maintain consistent enumeration and measurement of variables of interest. To achieve this, ESS communicated concepts and definitions to the field staff through training and instruction manuals. The concepts and definitions used in the survey included the following:

1. ***Agriculture:*** The growing of crops and/or raising of animals for own consumption and/or sale.

2. ***Agricultural household:*** A household is considered an agricultural household when at least one memberof the household is engaged in growing crops and/or raising livestock in private or in combination withothers.

3. ***Crop:*** includes cereals, pulses, oilseeds, vegetables, root crops, fruits, coffee, hops, sugarcane, cotton, tobacco, products for food, beverage manufacturing, fabric or clothing manufacturing, etc.

4. ***Crop production:*** the process of growing and harvesting of the above crops for own consumption and/orsale.

5. ***Direct (or quantitative) loss:*** The disappearance of food by spillage or consumption by rodents, birds, insects and other pests. It is measured as the loss in weight of commodities that would have been eatenif they had remained in the food chain. Losses can be the result of grain damage, which is characterizedby superficial evidence of deterioration (for example, holed or broken grains). Weight losses are generally presented in two ways: (i) the actual weight of grain lost (an absolute loss, in kg or any otherrelevant physical unit); or (ii) as a percentage or proportion of a reference quantity, such as harvested quantities (relative loss). Finally, losses should be expressed for a given moisture content, which may vary depending on the crops. Indeed, weight reduction due to a decrease in moisture content, for exampleduring drying, should not be accounted for as weight loss. These surveys focus on direct losses.

6. ***Economic losses:*** The monetary equivalent of direct or qualitative losses. For direct losses, the economic loss can be estimated by multiplying the lost quantities by the market price for the commodity.For qualitative losses, such as a stock of grain that contains a higher proportion of broken kernels, the loss corresponds to the difference between the market price of first-quality grain (or the quality level that can usually be expected by the farmer) and the price corresponding to the actual quality level, multiplied by the quantities produced.

7. ***Enumeration area:*** a census enumeration area in the rural parts of the country is a unit of land delineatedfor the purpose of population census with clear identified boundary, in some case equal to a locality or a part of a locality or a combination of small localities and usually consists of 100–150 households.

8. ***Field:*** a field is defined as any plot of land, which is a parcel or part of a parcel under the same crop ormixed crops or any other form of land use (private holding).
9. ***Food loss*****:** The measurable decrease in the quantity or quality of food produce. It is the result of any reduction in the availability of food or in the edibility, wholesomeness, or quality of food that reduces its value to humans. Food loss is considered as the unintended result of an agricultural process or technical limitation in storage, infrastructure, packaging or marketing (World Resource Institute, 2013). Food losses are often classified as direct or indirect.

10. ***Food waste:*** Term referring to food that is fit for human consumption but that is discarded either before or after it spoils. Hence, food waste is the result of negligence or a conscious decision to throw food away.

11. ***Harvest:*** The deliberate act of separating the food material from the site of immediate growth or production, for instance the reaping of cereals, the picking of fruits, the lifting of fish from water, etc.

12. ***Harvest losses***: These occur during the harvesting process and may be due to shattering, mechanical damage and shedding of the grain from the ears to the ground.

13. ***Holder:*** a holder is a person who exercises management control over the operation of the agricultural holding and makes the major decision regarding the utilization of the available resources. He/she has primary technical and economic responsibility for the holding. He/she may operate the holding directly as an owner or a manager. Under conditions of traditional agricultural holding the holder may be regarded as the person, who with or without the help of others, operates land and/or raises livestock in his/her own right, i.e. the person who decides on which, where, when, and how to grow crops or raise livestock or both and has the right to determine the utilization of the products.

14. ***Holding:*** a holding is all the land and/or livestock kept, which is used wholly or partly for agricultural production and is operated as one legal entity by one person alone, or with others without regard to management, organization, size or location.

15. ***Household:*** a household may be either:

    a) a one-person household, meaning a person who makes provisions for his own living without combining with any other person to form part of a multi-person household; or

    b) a multi-person household, that is, a group of two or more persons who live together and make common provisions for food and other essentials of living. The persons in the group may pooltheir incomes and have a common budget to a greater or lesser extent. They may be related or unrelated persons or a combination of both. These persons are taken as members of the household.

16. ***Indirect (or qualitative or nutritional) losses*****:** The loss caused by a lowering of quality leading toits rejection as food, of its nutritional value or of its economic value, these three aspects being interrelated. The quality of a food commodity can be assessed against criteria such as appearance, shape, size, and sometimes, smell and flavor. The assessment of nutritional losses (a type of qualitative loss) generally requires in-depth laboratory analysis. Nutrient losses may be due to selective feeding by pests, which targets the most nutritious parts of grains. Qualitative losses, although relevant, will not be treated in these surveys.

17. ***Meher (main) season crop:*** any temporary crop harvested between the months of Meskerm (September) and Yekatit (February) is considered as Meher season crop, in most cases crops thoseplanted during the major rainy season.

18. ***Parcel:*** a parcel of holding is any piece of land entirely surrounded by land and/or water and/or road and/or forest etc., which is not part of the holding. It may consist of one or more cadastralunits, plots or fields adjacent to each other.

19. ***Pre-harvest:*** The period between the planting and the harvest of the crop.

20. ***Post-harvest***: The period beginning after separation from the site of immediate growth or production and ending when the food reaches its final use.

21. ***Post-harvest losses (PHL):*** Any losses occurring after the separation of the product from the site of immediate growth (harvest) to the moment it reaches the consumer. For this survey, we dealt only with quantitative losses.

    - **Stacking or stooking:** Grain losses that occur during the crops are harvested and remained stacked in the field or somewhere appropriate in order to bring the harvested crop to its appropriate moisture content for threshing.

    - **Threshing losses:** Losses that occur during mechanical and/or manual threshing system**.**

    - **Winnowing/cleaning losses**: Losses that occur during the threshed grain product iscleaned in order to separate the cleaned grains from the chaff, husk or any other waste materials.

    - **Storage losses:** Losses that occurred during the crop product is at a storage facility.

    - **Transport losses:** Losses that occurs during transporting the product from farm to storage

    - **Post-production losses**: The combination of harvest losses and PHL.

22. ***Pre-harvest losses***: Losses that occur before the beginning of the harvesting process and that maybe due to attacks by insects, mites, rodents, birds, weeds, or diseases afflicting and damaging crops.

PART 3. SUMMARY OF THE SURVEY RESULTS

3.1 Socio-demographic characteristics of the agricultural households

As shown in Table 1 below, the pilot survey totally covered 3 034 households which includes 2 637 (87 percent) male-headed households and the remaining 397 (13 percent) are female-headed households. Most of the households are from Oromia region, 1 287 (42.4 percent), followed by Southern Nations and Nationalities region, 1 000 (33 percent) and Amhara region 747 (26.6 percent).

Table 1: Number and percentage distribution of households by sex of household head and region

Region	Sex of household head					
	Male		**Female**		**Total**	
	Number of households	Male-headed household %	Number of households	Female-headed households %	Number of households	Regional coverage %
Amhara	656	87.8	91	12.2	**747**	**24.6**
Oromia	1 146	89.0	141	11.0	**1 287**	**42.4**
Southern Nations, Nationalities and Peoples Region	835	83.5	165	16.5	**1 000**	**33.0**
Total	**2 637**	**86.9**	**397**	**13.1**	**3 034**	**100.0**

Source: Authors' own elaboration, 2023.

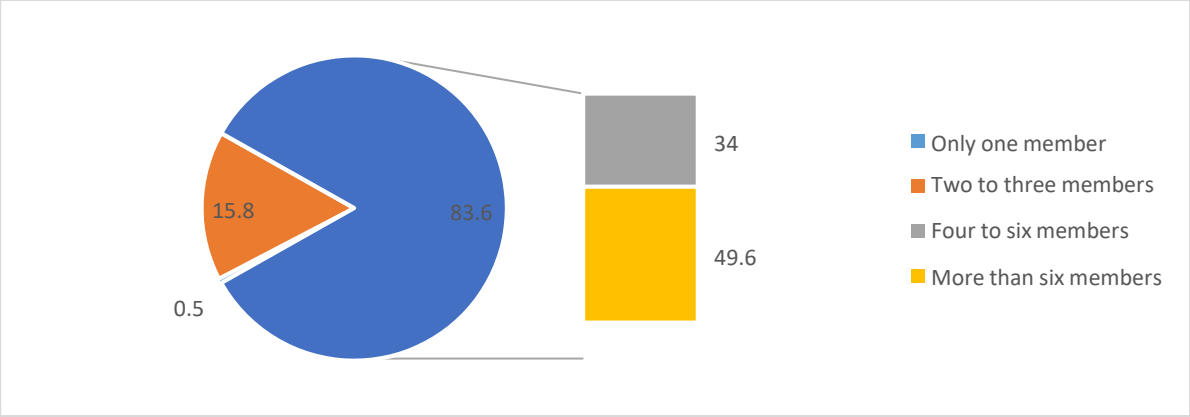
As indicated in Table 2 below, among the total households, only 0.5 percent of the households are single member households while in contrary most of the households (49.6 percent) have more than six household members, while 34 percent and 15.8 percent of the households have 4 to 6 household members and two to three household members respectively. Splitting this by the sex of the household heads, 26.7 percent of female- headed households and 53 percent of male-headed households have more than six household members, while 2.5 percent female-headed households and 0.2 percent of male-headed households have only one household member. This indicates that, in general, most of male-headed households have the larger number of household members, while female-headed households have fewer household members.

Table 2: Percentage distribution of households by household size group and sex of household head

Household size group	Sex of the household head			Number of households
	Male %	Female %	Total %	
Only one member	2.0	2.5	5.0	16
Two to three members	13.1	34.0	15.8	480
Four to six members	33.6	36.8	34.0	1 032
More than six members	53.0	26.7	49.6	1 503

Source: Authors' own elaboration, 2023.

Figure 1: Percentage distribution of households by household size group



Source: Authors' own elaboration, 2023.

As we can notice from Figure 1, households having four and more household members account for about 83.6 percent the total households, while the remaining 16.4 percent households have less than four household members.

When we look at the household size with regard to the age of the household heads, we can see from Table 3, most of the households (54 percent), with the lowest age group of the head of the household, which is 18 to 24 have two to three household members. On the other hand, most of the households (40 percent) with the age group between 25 and 34 have household members 4 to 6 while 57.6 percent, 64.8 percent, and 50.6 percent of households with the age group 34 to 44, 45 to 54 and 55 to 64 years respectively have more than six household members. We can also notice from the table that most of the households (64.8 percent) with the age of the head between 45 to 54 years have the larger number of household size, while 57.6 percent of the households with the age of the households between 35 to 44 years have the larger household size, which is more than six members.

Table 3: Percentage distribution of households by household size group and age group of household head

Age group of the head the household	Household size group				
	Only one member (%)	Two to three members (%)	Four to six members (%)	More than six members (%)	Number of households
18 to 24 years	1.3	53.9	31.6	13.2	76
25 to 34 years	2.0	27.0	40.2	32.6	537
35 to 44 years	4.0	7.5	34.5	57.6	839
45 to 54 years	0.0	8.3	27.0	64.8	727
55 to 64 years	1.3	14.3	33.8	50.6	463
65 years and over	1.3	26.9	38.7	33.1	391
Total	**5.0**	**15.8**	**34.1**	**49.6**	**3 033**

Source: Authors' own elaboration, 2023.

Table 4: Percentage distribution of education level of the heads of household by sex of the household head

Heads highest grade completed	Sex of the household head			Number of households
	Male (%)	Female (%)	Total	
Non educated	42.5	79.3	47.3	1 435
Educated, non-formal education	11.5	4.8	10.7	323
First grade completed	2.5	1.8	2.4	72
Second grade completed	4.9	3.0	4.6	140
Third grade completed	5.7	2.3	5.3	160
Fourth grade completed	6.3	2.0	5.7	173
Fifth grade completed	5.7	1.3	5.1	154
Sixth grade completed	5.5	1.5	5.0	152
Seventh grade completed	3.4	0.5	3.0	92
Eighth grade completed	4.1	1.0	3.7	113
Ninth grade completed	2.2	0.8	2.0	60
Tenth grade completed	2.8	1.3	2.6	79
Eleventh grade completed	3.0	0.0	3.0	8
Twelfth grade completed	9.0	0.0	8.0	25
Above twelfth grade	7.0	0.0	6.0	18
Completed tenth grade and attending diploma	1.0	5.0	9.0	28
Total	**100.0**	**100.0**	**100.0**	**3 032**

Source: Authors' own elaboration, 2023.

Table 4 shows that about 47.3 percent of the household heads fall in the non-educated category; but the percentage is almost double for female-headed households (79.3 percent); while uneducated male-headed households represent 42.5 percent. The opposite gender pattern applies to households in the "Educated non-formal education" category, which account for 10.7 percent the total. Generally, we can also see that male-headed households have better school attendance.

Referring to Table 5, households with the household head age 18 to 24 years group, account for only 2.5 percent of the total households. Heads of households within the middle age category; that is between 35 and 44 years and 45 to 54 years, account for about 27.7 percent and 24 percent of total households respectively.

Regarding the sale of crop products, Table 6 shows that most of the households (42.5 percent) sell their crops to wholesale traders; the next type of traders the households sell the most are retail traders (38.1 percent) and consumers (17 percent).

From Table 7 we can see that in general most of the households (64.4 percent) use animals to transport their crop products to the market; transport by foot is the second most common mode of transport, with 27.2 percent of the total number of households. The sex of the household head does not seem to influencethe mode of transport to the buyers.

Table 5: Percentage distribution of households by age group of household head and sex of household head

Age group of the head the house hold	Sex of the household head			
	Male (%)	Female (%)	Total (%)	Number of households
18 to 24 years	2.7	1.0	**2.5**	**76**
25 to 34 years	18.6	11.6	**17.7**	**537**
35 to 44 years	28.3	23.7	**27.7**	**839**
45 to 54 years	23.2	29.2	**24.0**	**727**
55 to 64 years	14.8	18.6	**15.3**	**463**
65 years and over	12.4	15.9	**12.9**	**391**

Source: Authors' own elaboration, 2023.

Table 6: Percentage distribution of households by buyer type and sex of household head

Main buyers of survey crops	Sex of the household head			Number of households
	Male (%)	Female (%)	**Total** (%)	
Wholesaler	42.3	44.8	**42.5**	860
Retailer	38.5	33.9	**38.1**	770
Cooperative/union	1.6	2.6	**1.7**	35
Consumer	17.0	17.2	**17.0**	344
Processors	0.4	0.0	**0.3**	7
Other	0.2	1.6	**0.3**	7

Source: Authors' own elaboration, 2023.

Table 7: Percentage distribution of households by mode of transport to the crop buyer and sex of

household head

Main mode of transport to market/buyer	Sex of the household head			Number of households
	Male (%)	Female (%)	**Total (%)**	
Foot	26.5	33.3	**27.2**	571
Motorcycle	2.2	0.5	**2.0**	43
Bus	1.6	1.5	**1.6**	34
Animal transport	64.9	59.7	**64.4**	1 354
Bajaj	1.2	2.0	**1.3**	27
Other	3.5	3.0	**3.4**	72

Source: Authors' own elaboration, 2023.

Table 8: Percentage distribution of households by mode of packaging and sex of household head

Main mode of packaging for market/buyer	Sex of the household head			Number of households
	Male (%)	Female (%)	**Total** (%)	
Sack/jonya/madabariya	95.8	90.1	**95.3**	**1 927**
Baskets/zembil	3.2	7.3	**3.6**	**72**
Plastic bags	0.5	1.6	**0.6**	**13**
Bag made of leather	0.1	0.0	**0.1**	**2**
Other	0.4	1.0	**0.4**	**9**

Source: Authors' own elaboration, 2023.

From Table 8, we can recognize that about 95.3 percent of the total households use sack/jonya/madabariya as the main mode of packaging for their crops when transporting them to the market. It was reported that only about 3.6 percent of the households use baskets/zembil. The trend looks the same across male and female-headed households. That is about 90 percent and 7.3 percent of female-headed households use sack/jonya/madabariya and baskets/zembil in that order, while 95.8 percent and 3.2 percent of male- headed households use the same method of packaging in the same order.

The survey collected data on amount of last year crop production sold by the households. As it is indicated in Table 9 below, among the households who produced and sold these four crops last year, about 34.2 percent, 42.95 percent, 44 percent and 55.6 percent of the households sold maize, wheat, faba beans and haricot beans respectively. With regard to the gender of the head of the households, female-headed households sold an average of 36.78 percent of maize, 45.85 percent wheat, 40.24 percent faba bean and 44 percent of haricot bean that they have produced. Male-headed households sold on average 33.98 percent of maize production, 42.6 percent of wheat, 44.34 percent of faba bean and 56.38 percent of haricot bean.

When we look at the distance from the market where households sold their products, in general households

travelled an average of 6.6 kilometres to sell their products. With regard to gender, on average male-headed households travelled 6.5 kilometres and female-headed households travelled an average of 7.8 kilometres to take their crop products to the markets.

Table 9: Percentage of quantities sold from the quantity produced by crop type and sex of household head

Crop name	Sex of household head		
	Male (%)	Female (%)	Total (%)
Maize	33.98	36.78	**34.24**
Wheat	42.60	45.85	**42.95**
Faba bean	44.34	40.24	**44.00**
Haricot bean (Red or White)	56.38	44.04	**55.36**

Source: Authors' own elaboration, 2023.

Table 10: Average distance in kilometre (km) to the selling market by crop type and sex of household head

Crop type	Sex of the household head		
	Male **(km)**	Female **(km)**	Total
Maize	6.2	5.9	**6.2**
Wheat	6.8	10.2	**7.2**
Faba bean	6.8	7.1	**6.8**
Haricot bean (red or white)	5.6	5.5	**5.6**
Total	6.5	7.8	6.6

Source: Authors' own elaboration, 2023.

3.2 Agricultural practices of the households

These are referring to the activities conducted by a farmer on a farm to produce agricultural products and the farming practices of the farmer.

The results in Table 11 below shows that 89.7 percent of the total fields are pure stand, while 10.3 percent of the fields are mixed crop stand. Looking this crop wise, wheat crops are mostly (96.9 percent) cultivated in a pure stand form compared to the other crops, followed by faba bean (90.6 percent), maize (85.5 percent), and haricot bean (82.6 percent).

Table 11: Percentage distribution of fields by crop and planting type

	Planting type

Crop types	Pure stand plots (%)	Mixed crop plots (%)	Total number of plots
Maize	85.5	14.5	3 424
Wheat	96.9	3.1	2 554
Faba bean	90.6	9.4	2 124
Haricot bean	82.6	17.4	849
Total	**89.7**	**10.3**	**8 951**

Source: Authors' own elaboration, 2023.

3.3 Harvest and post-harvest operation techniques

The quantity of crop production lost at the post-harvest stage mainly depends on the tools and agricultural practices of the farmer. In this pilot study, farmers were asked to report on techniques they use when performing some farm operations.

The pilot survey result shows that about 60 percent of the crop fields are mainly harvested using sickle, followed by digging/picking/cutting by hand (25.7 percent). When we look at this practice by crop, 88 percent of the wheat fields are mainly harvested by sickle, whereas in only 3.2 percent of the fields a combiner machine was used to harvest the crop.

Regarding faba bean cultivation, sickle was used in 63.7 percent of the fields to harvest the crop, while in 31.6 percent of the fields digging/picking/cutting by hand took place. On the other hand, for most of the haricot bean fields (91.8 percent), the harvest has been performed through digging or cutting by hand and about 6.3 percent of the haricot bean fields harvested using sickle.

Regarding the main techniques used to thresh the crops, the pilot survey shows that 59 percent of the households used hands to thresh or shell the crops followed by usage of animal (34.6 percent) to do the threshing activity. Only 4.7 percent of the households use modern machine for threshing. With regard to the crop types, in two cases the use of hand is higher than the total percentage with more than 90 percent of households growing haricot bean directly used hands to shell the crop, and more than 86 percent of maize crop growers threshed or shelled using hand. Modern machines where used only for two crop types out of four; mostly wheat crop households (12 percent) used modern machine for threshing followed by maize growers (3.2 percent).

Table 12: Percentage distribution of fields by harvesting tool type and crop type

The main tool of harvesting you used to harvest the crop	Crop type				**Total**
	Maize	Wheat	Faba bean	Haricot bean	

Sickle	48.4	88.1	63.7	6.3	59.9
By using pole/gejera	14.4	0.2	2.3	0.3	5.6
Mencha	2.1	0.2	0.1	0.0	0.8
Digging/cutting by hand	23.3	0.4	31.6	91.8	25.7
Combiner machine	0.0	10.9	0.0	0.0	3.2
Other	11.8	0.1	2.4	1.7	4.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Authors' own elaboration, 2023.

Table 13: Percentage distribution of households by threshing technique and crop type

Crop type	The main technique of threshing used to thresh the crop			
	Using animal	Using hand	Using modern machine	Other
Maize	7.0	86.2	3.2	3.5
Wheat	66.9	21.0	12.0	0.1
Faba bean	42.3	56.8	0.0	0.9
Haricot bean	6.8	90.4	0.0	2.7
Total	**34.6**	**59.0**	**4.7**	**1.7**

Source: Authors' own elaboration, 2023.

Based on the result presented in the Table 14 below, the threshing floor mostly used by the households was earth coated with animal dung (58.5 percent) followed by plastic sheet or canvas (27.8 percent) and this applies to all of the crop types. With regard to the crop types nearly 69 percent of wheat and faba bean crops were mainly threshed on an earth coated with animal dung. Whereas 45.1 percent and 43.6 percent of the households mainly used earth coated with animal dung to thresh maize and haricot bean crops respectively. On the other hand, 40.8 percent and 46.9 percent of the households mainly used a plastic sheet or canvas to thresh maize and haricot bean crops respectively.

From the result shown in Table 15 below, we can see that most of the households (61.7 percent) used keeping the grain in the house by putting it in local bag called *madabaria* as a storage practice followed by the other local bag called jonya/kesha (15.8 percent) and traditional granary/gotera (14.6 percent).

Table 14: Percentage distribution of households by type of threshing floor and crop type

Crop type	The type of floor used when the [crop] was threshed			
	Concrete floor	Earth coated with animal dung	In a plastic sheet or canvas	Other

Maize	1.9	45.1	40.8	12.2
Wheat	0.6	68.4	15.5	15.5
Faba bean	1.0	69.3	18.6	11.0
Haricot bean	1.5	43.6	46.9	8.0
Total	**1.2**	**58.5**	**27.8**	**12.5**

Source: Authors' own elaboration, 2023.

Table 15: Percentage distribution of households by type of storage used and crop type

The main storage type used to store the crop	Crop type				
	Maize	Wheat	Faba bean	Haricot bean	**Total**
Traditional crop granary/gotera	26.4	13.6	4.7	0.8	**14.6**
Kept in the house by sack/jonya	14.6	19.0	15.0	10.7	**15.8**
Kept in the house by sack/madaberiya	46.8	61.9	75.9	78.1	**61.7**
Modern metal or wood silos/granary	1.5	0.2	0.1	0.0	**0.6**
Pilling in the room /house	0.9	0.8	0.5	2.5	**0.9**
Storing in the equipment made of steel	0.0	0.0	0.1	0.2	**0.0**
Storing in the house without threshing/shelling	5.0	0.4	0.2	0.8	**1.9**
Pics sack made for crop storage	2.6	1.5	1.0	0.6	**1.7**
Keeping under the grounds	0.1	0.0	0.0	0.0	**0.0**
Other	2.1	2.5	2.4	6.2	**2.7**

Source: Authors' own elaboration, 2023.

Overall, about 55 percent of the households used chemicals to protect the crop from damage and 27.7 percent of the households used non-chemical method of protection while only 17.3 percent of the households used both chemical and non-chemical mechanism. When looking at this by types of crops, about 61.6 percent, 54.4 percent, 49.3 percent and 38.3 percent of households reported the use of chemicals to protect crop damages for maize, wheat, faba bean and haricot beans respectively.

Table 16: Percentage distribution of households by use of pesticide and crop type during storage

Mechanism used to protect the crop from damage during storage	Crop type				
	Maize	Wheat	Faba bean	Haricot bean	**Total**
Chemical	61.6	54.4	49.3	38.3	**54.9**

Non chemical	18.7	26.5	39.2	46.3	**27.7**
Both	19.8	19.1	11.5	15.4	**17.3**

Source: Authors' own elaboration, 2023.

3.4 Pre- and post-harvest losses by operation

This section presents results on reported magnitudes of crop loss based on the operation taken at each stage of harvesting, threshing, cleaning/winnowing, storage and transport. The survey implemented both, subjective and objective methods to collect the data on the post-harvest losses at differ stages of the operations. In this pilot survey, the main activities considered were, harvest loss, stacking loss, threshing loss, winnowing loss, storage loss and transport losses. In addition to post-harvest losses, the survey collected data on pre harvest losses or damages.

In this survey report, relative (percentage) losses of crops are reported. Relative losses are a ratio of quantity lost to the quantity handled multiplied by 100. In order for the reader to be able to compute the value of quantities lost, we presented the area and production estimates of these four crops obtained from the 2021–2022 (2014 Ethiopian calendar) annual agricultural sample survey.

Table 17: Estimate of area and production of crops for 2021–2022 (2014 Ethiopian calendar), Meher season

Crop types	Post-harvest cropland area estimates (quintal)	Post-harvest crop production estimates (quintal)
	2021–2022 (2014)	2021–2022 (2014)
Wheat	1 697 047.71	52 137 610.04
Maize	2 563 201.20	107 220 062.46
Faba beans	520 551.71	10 807 217.93
Haricot beans	339 350.35	5 780 716.91

Source: Authors' own elaboration, 2023.

3.4.1 Pre-harvest losses

Generally, crop loss is estimated as the difference between potential (attainable) yield and the actual yield. Crop losses, and by extension food losses, occur before the harvest, during the harvest and after the harvest. To compute the losses or the damages at pre-harvest stage the data on the actual yield that could be found and the damages occurred on the specific crop on the specific field has been collected by probing the farmer to estimate. And the attainable or potential production was taken as the sum of the actual production and the quantity damaged due to different reasons before harvest.

The weighted percentage damage in the Table 18 below shows that about 11.21 percent, 9.12 percent, 15.78 percent, 11.43 percent of maize, wheat, faba bean and haricot beans were damaged before harvest respectively.

As it can be seen from the Table 19 below, regardless of the crop types about 46 percent of the causes for crop damage at pre-harvest stage was attributed to shortage of rain, followed by antimicrobial diseases and anti-crop pest (12.8 percent) and (11.9 percent) respectively.

Table 18: Weighted and un-weighted percentage of pre-harvest damages by crop type

Crop types	Un-weighted percentage of quantity produce damaged	Weighted percentage of quantity produce of damage
Maize	10.78	11.21
Wheat	8.37	9.12
Faba bean	15.45	15.78
Haricot bean	10.79	11.43

Source: Authors' own elaboration, 2023.

Table 19: Percentage distribution of fields by crop and reasons for damage

The main reasons for the crop damage	Crop type				
	Maize	Wheat	Faba bean	Haricot bean	Total
Antimicrobial disease	17.4	10.4	0.0	28.6	12.8
Frost	2.3	7.5	9.8	0.0	5.2
Flood	2.5	0.0	12.4	0.0	2.9
Locusts	0.0	0.0	0.0	0.0	0.0
Anti-crop pest	20.9	0.0	15.2	13.1	11.9
Shortage of rain	28.7	76.7	25.3	26.2	46.1
Too much rain	7.6	5.3	8.4	0.0	6.5
Wild animal	4.0	0.0	0.0	17.0	2.5
Bird	3.7	0.0	13.2	0.0	3.5
Snow	1.9	0.0	7.0	0.0	1.8
Weed	1.8	0.0	0.0	0.0	0.8
Seed shortage	1.5	0.0	0.0	0.0	0.7
Reduction of farmland fertility	1.5	0.0	0.0	0.0	0.6
Instability in the environment	0.0	0.0	0.0	0.0	0.0
Sowing bad seed	2.4	0.0	0.0	0.0	1.0
Theft	0.0	0.0	0.0	0.0	0.0
Fire events	0.0	0.0	0.0	0.0	0.0
Unexpected rain	1.6	0.0	0.0	0.0	0.7
Eating by animal	2.2	0.0	8.7	0.0	2.2
Other	0.0	0.0	0.0	15.1	0.7

Source: Authors' own elaboration, 2023.

3.4.2 Post-harvest loss results from subjective measurement

Losses in food crops occur during harvesting, threshing, winnowing, storage, transportation, processing and marketing. While in the field and during storage, insects, rodents, birds and other pests damage the products, in the post-harvest phase, products can also be spoiled by the infestation of fungi, yeasts or bacteria. In addition, food grain suffer qualitative and quantitative losses while in storage. The quantitative losses are generally caused by factors such as incidence of insect infestation, rodents, birds and also due to physical changes in temperature, moisture content, etc. The qualitative loss is caused by reduction in nutritive value due to factors such as attack of insect pest, physical changes in the grain and chemical changes in the fats, carbohydrates, protein and also by contamination of myco toxins, besides, residue, etc. The storage loss/gain is a very sensitive issue as it depends upon agro climatic conditions. In order to minimize the losses during storage it is important to know the optimum environment conditions for storage of the product, as well as the conditions under which insects/pests damage the produce.

3.4.3 Overall post-harvest losses

Based on the result from the data collected through the subjective measurements, about 8.43 percent of maize, 10.51 percent wheat, 14.26 percent faba bean and 17.49 percent haricot bean production, were lost on aggregate on different post-harvest operation stages. The results show that the losses for faba bean and haricot bean were higher as compared to the other crops.

Table 20: Weighted and un-weighted percentage loss of overall stages by crop type for subjective measurements

Crop type	Weighted percentage loss	Un-weighted percentage loss
Maize	8.43	7.83
Wheat	10.51	9.89
Faba bean	14.26	13.29
Haricot bean	17.49	14.33

Source: Authors' own elaboration, 2023.

3.4.4 Losses at different post-harvest operation stages (subjective measurement)

Looking at disaggregated values of losses at different stages, losses during harvesting contributes for about 2.85 percent for maize, 3.27 percent for wheat, 4.49 percent for faba bean and 6.76 percent for haricot bean. During stacking about 4.01 percent of maize, 3.81 percent of wheat, 6.00 percent of faba bean and 4.44 percent haricot bean were lost. Similarly, about 2.05 of maize, 3.00 percent of wheat, 4.08 percent of faba bean and 3.56 percent haricot bean were lost during threshing. The loss during winnowing, which usually takes place together with threshing activity, accounts for about 2.13 percent of the overall loss for maize, 1.54 percent for wheat, 2.42 percent for faba bean and 2.27 percent for haricot bean.

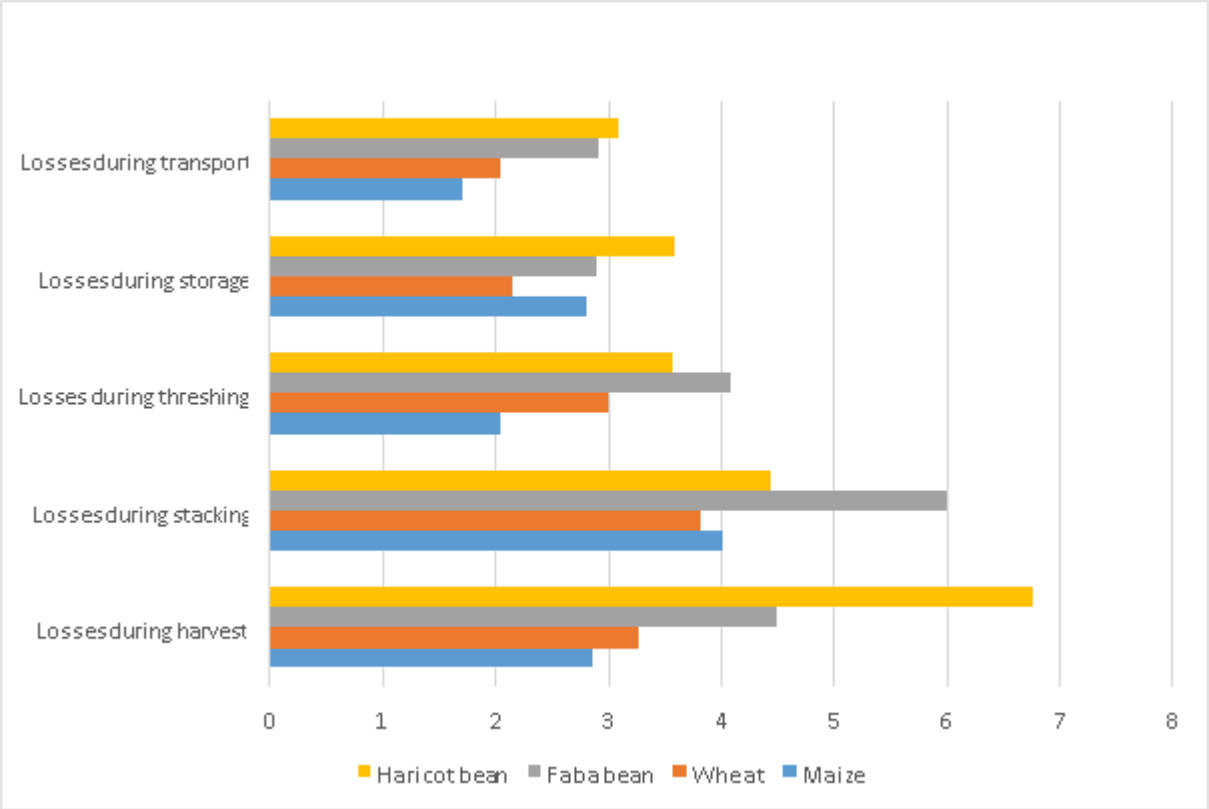
As crops are grown seasonally, farmers usually store their production for certain periods for food reserves and for seeds for next season or for sale. Small-scale farmers in Ethiopia retain 60 to 90 percent of the total grain produced for subsistence and store it for 6 to 12 months (Tadesse, 2008). However, as expected, there are some losses during storages as well. According to the results found from this pilot survey, farmers suffer losses of about 2.81 percent of maize, 2.14 percent of wheat, 2.90 percent of faba bean and 3.58 percent of haricot bean during storage. The losses during transportation of the crop within farm to storage also accounts for 1.70 percent, 2.05 percent, 2.92 percent and 3.09 percent losses for maize, wheat, faba bean and haricot bean respectively. From the above results described, the losses during harvesting took the largest share of the overall losses relative to the other loss points.

Table 21: Percentage of weighted post-harvest losses at different loss points found from subjective measurement

Crop types	Losses during harvest	Losses during stacking	Losses during threshing	Losses during storage	Losses during transport
Maize	2.85	4.01	2.05	2.81	1.70
Wheat	3.27	3.81	3.00	2.14	2.05
Faba bean	4.49	6.00	4.08	2.90	2.92
Haricot bean	6.76	4.44	3.56	3.58	3.09

Source: Authors' own elaboration, 2023.

Figure 2: Percentage loss at different loss point stages



Source: Authors' own elaboration, 2023.

The un-weighted result also shown in the table below shows almost the same but a little variation from the weighted result.

Table 22: Percentage loss at the global and point loss stages from objective measurement

Crop types	Losses during harvest	Losses during stacking	Losses during threshing	Losses during winnowing (from objective measure)	Losses during storage	Losses during transport
Maize	2.81	3.83	2.05	2.04	2.66	1.70
Wheat	3.18	3.78	3.03	1.55	1.97	1.94
Faba bean	4.64	5.79	4.00	2.29	2.75	2.79
Haricot bean	5.67	4.72	3.67	2.10	3.74	2.90

Source: Authors' own elaboration, 2023.

From the Table 23 below the reasons for losses during harvesting shows that, about 49 percent of the losses were due to the remaining of some heads or stalks of crops left un-harvested in the crop field. On the other hand, 39.6 percent of the household's responded spillage of the grains on the ground, that is the grains spill over on the ground before collection, as the main reason for the loss during harvesting. In addition, it was reported that about 9 percent harvest losses happened due to spillage of the threshed stalks with the grains on the ground. As shown in Table 23 below, the percentage distributions for the reasons of losses did not show any significant difference by crop type.

Based on the result shown in Table 24, most of the reasons (about 62.7 percent) for the production loss during stacking is contributed by scattering of the grains on the ground, followed by damage due to rain (about 16.3 percent).

Table 23: Percentage distribution of harvest loss reasons by crop type

The main reasons for the loss during harvesting	Crop name					Total number of fields
	Maize	Wheat	Faba bean	Haricot bean	**Total**	
Left un-harvested	51.4	57.6	42.2	32.6	**49.0**	**2276**
Spillage of the grain on the ground	33.3	32.2	48.8	55.7	**39.6**	**1841**
Spillage of the threshed stalks on the ground	11.8	9.0	6.8	8.2	**9.0**	**419**
Other	3.5	1.3	2.1	3.5	**2.3**	**109**

Source: Authors' own elaboration, 2023.

Table 24: Percentage distribution of stacking loss reasons by crop type

Crop name	The major reasons for the loss during stacking				
	Damage due to rain	Scattering on the ground	Eaten by animal during stacking	Eaten by pests during stacking	Other
Maize	20.2	53.0	19.3	5.5	2.0
Wheat	17.0	62.0	15.1	5.7	0.3
Faba bean	15.2	65.9	11.8	5.6	1.5
Haricot bean	8.5	79.1	8.0	2.8	1.7
Total	**16.3**	**62.7**	**14.4**	**5.3**	**1.3**

Source: Authors' own elaboration, 2023.

In general, according to the survey result presented in Table 25, more than half of the reasons for the losses happening during threshing were due to grains remaining in the stalk without threshing. While scattering or spillage of the grains was the next major reason, contributing about 39 percent of the loss.

The main reason for losses during storage was attributed to "eaten by insects" category (54.6 percent). Crop disease and insufficient drying after harvest and threshing contributed for about 13 percent of the reasons each. Compared to the other three crops under this study, maize was reported to be more attacked by insects (61 percent), followed by haricot bean and wheat (52.2 percent) and (51.6 percent) respectively.

Table 25: Percentage distribution of households by crop types and reason for threshing losses

Crop type	The main reasons for the loss during threshing				
	Left un-threshed in the stalk	Scattering or spillage during threshing	Breaking of the grains during threshing	Eaten by animals	Other
Maize	41.5	48.8	6.1	2.8	0.9
Wheat	59.7	31.2	1.8	7.1	0.3
Faba bean	55.6	37.8	2.6	3.3	0.8
Haricot bean	46.3	50.5	2.1	0.0	1.2
Total	**52.4**	**39.6**	**3.2**	**4.2**	**0.7**

Source: Authors' own elaboration, 2023.

Table 26: Percentage distribution of households by reason for storage losses and crop type

The main reasons for the loss during storage	Crop type				
	Maize	Wheat	Faba bean	Haricot bean	**Total**
Eaten by insects	61.6	51.6	48.0	52.2	**54.6**
Attacked by disease	10.2	13.9	18.8	10.8	**13.3**
Insufficient drying	10.9	11.5	16.0	22.6	**13.4**
Other	17.3	23.0	17.1	14.5	**18.7**

Source: Authors' own elaboration, 2023.

3.4.3. Results from objective measurements

Losses occur at all levels of the value chain, reflecting a variety of possible factors or causes. The methods and techniques used for measuring them will vary depending on the nature of the losses: caused by bio-deterioration linked to climatic conditions (humidity, temperature, rainfall, etc.), pest infestation, spillage, scattering or other mechanical reasons including removal by birds, rodents, etc. Physical measurements described in this section have been used to assess the relative amount lost due to these causes.

The weighted results of the data collected using objective method presented in the Table 27 below show that losses occurring during harvesting account for about 4.19 percent for maize 4.94 percent for wheat and for about 5.98 percent and 6.73 percent for faba bean and haricot bean respectively.

Similarly, the results from objective method shows that about 3.22 percent of maize, 4.38 percent of wheat, 4.37 percent of faba bean and 4.68 percent of haricot bean are lost during stacking. Stacking losses usually occur during the time when the crops are left on the field in the form of stacks after the crops are harvested in order to make them dry or to reduce the moisture content. The pilot survey results show that during threshing activities about 3.42 percent, 2.95 percent, 4.17 percent and 3.93 percent of maize, wheat, faba bean and haricot bean are lost respectively. During winnowing, which is the activity implemented in order to separate the grain from dust materials, about 2.13 percent, 1.54 percent, 2.42 percent, 2.27 percent of maize, wheat, faba bean and haricot bean are lost respectively.

The losses during storage was collected using objective measurement by taking two samples randomly from the crop that has been threshed and stored for a minimum of 1 month. According to the results of the survey obtained using objective methods, about 2.51 percent of maize, 2.11 percent of wheat, 1.89 percent of faba bean and 2.41 percent haricot bean are lost in the storage.

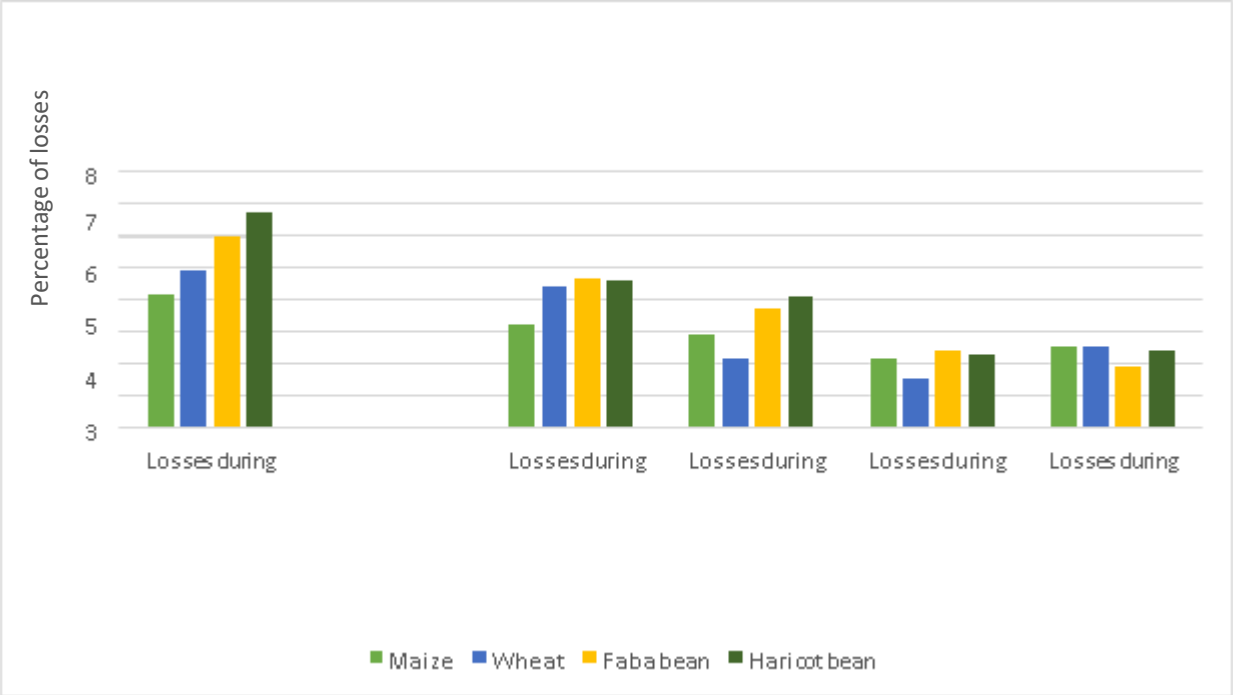
Data on losses during transportation were not collected for the objective method since it is difficult to handle with the logistic we have and the nature of the losses at this stage. However, in order to compute the total losses obtained using the objective method, the results obtained from the subjective measurements were used.

Table 27: Percentage of weighted post-harvest losses at different loss points found from objective measurement

Crop types	Losses during harvest	Losses during stacking	Losses during threshing	Losses during winnowing	Losses during storage
Maize	4.19	3.22	3.42	2.13	2.51
Wheat	4.94	4.38	2.95	1.54	2.55
Faba bean	5.98	4.68	4.17	2.42	1.89
Haricot bean	6.73	4.62	3.93	2.27	2.41

Source: Authors' own elaboration, 2023.

Figure 3: Percentage loss at overall and loss point stages from objective measurement



Source: Authors' own elaboration, 2023.

As we can see from the results from the table below, the un-weighted results also shows similar trend in termsof magnitude of the losses occurring at different stages of post-harvest operation with like that of the weighted results.

Table 28: Percentage of un-weighted post-harvest losses at different loss points found from objective

measurement

Crop types	Losses during harvest	Losses during stacking	Losses during threshing	Losses during winnowing	Losses during storage
Maize	4.01	2.84	3.35	2.04	2.48
Wheat	5.07	4.08	3.00	1.55	2.43
Faba bean	5.75	4.49	4.30	2.29	1.76
Haricot bean	6.58	4.74	4.07	2.10	2.29

Source: Authors' own elaboration, 2023.

3.5 Comparison of subjective and objective measurement of post-harvest losses

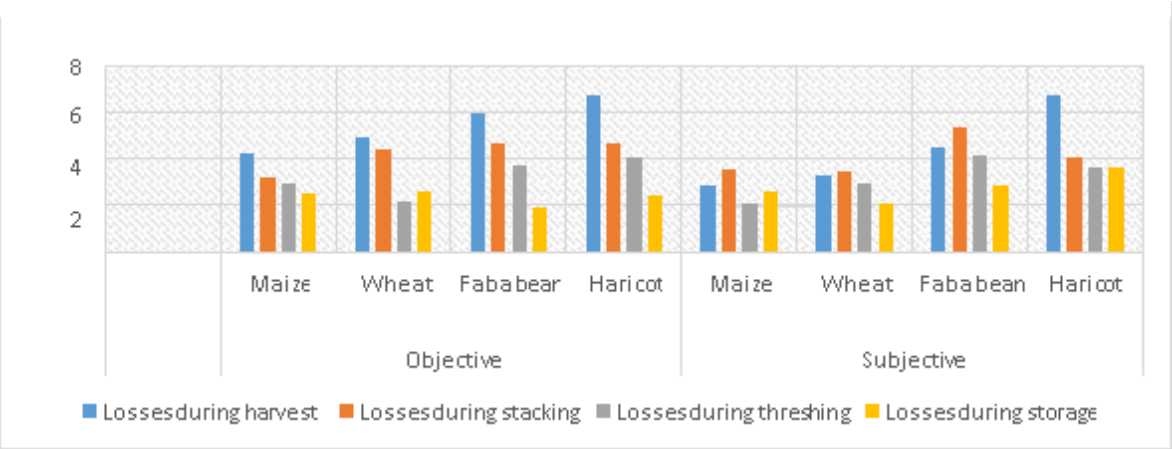
The results from data collected using both subjective and objective methods shows similar trends for each stage of post-harvest losses in most of the cases. However, slightly higher values are observed from the objective method of data collection.

Table 29: Weighted percentage losses obtained both by subjective and objective measurements by crop type

Crop types	Losses during harvest		Losses during stacking		Losses during threshing		Losses during storage	
	Objective	Subjective	Objective	Subjective	Objective	Subjective	Objective	Subjective
Maize	4.19	2.85	3.22	3.56	2.93	2.03	2.51	2.57
Wheat	4.94	3.27	4.38	3.42	2.19	2.9	2.55	2.11
Faba bean	5.98	4.49	4.68	5.37	3.74	4.16	1.89	2.89
Haricot bean	6.73	6.76	4.62	4.02	4.07	3.59	2.41	3.65

Source: Authors' own elaboration, 2023.

Figure 4: Comparison of subjective and objective measurement results (percentage of losses)



Note: *The storage loss for objective measurement was made by considering two samples of each crop from stored quantity using random method stated in the post-harvest loss measurement guanine developed by the Global strategy to improve agriculture and rural statistics (GSARS). However, it is important to note here that due to time constraints, a period of only one month after threshing and storing was considered for this pilot survey. In addition, despite the repetitive measurements recommended in the guideline, only a single measurement was taken during this pilot exercise. This might cause a lower value for storage losses (and lower CV) for results obtained by measurement compared to the subjectively reported values. In the future surveys, this should be considered to improve measuring storage losses using the objective approach.*

Source: Authors' own elaboration, 2023.

3.6 Pooled estimate of inquiry based and physical measurement results

The estimation of average percentage losses through the pooling of physical measurements and enquiry based estimates may improve the overall accuracy and precision of the final estimates. Which is calculated based on a weighted average of each type of estimator taking the standard deviations of the respective estimates as weights. This procedure needs the results of both enquiry based and physical measurement results due to this case we did not calculated for winnowing and transport losses since the data is collected in only one of the method for these two loss points.

Based on this calculation and as it can be seen from the Table 30 below, the average losses on maize is 3.78 percent, 3.72 percent, 2.45 percent and 2.53 during harvesting, stacking, threshing and storage processes respectively. For wheat crop an average of 4.26 percent, 4.05 percent, 2.64 and 2.52 percent during harvesting, stacking, threshing and storage processes respectively. Faba bean losses also account for 5.76 percent, 5.65 percent, 3.87 percent and 2.20 percent during the processes; harvesting, stacking, threshing and storage respectively. Similarly, among the total possible volume of production handled for haricot bean about 6.48 percent, 4.53 percent, 3.80 and 2.70 percent is lost (%) during the processes; harvesting, stacking, threshing and storage respectively.

Table 30: Percentage of pooled estimate of inquiry based and physical measurement results

Crop type	Harvest	Stacking	Threshing	Storage
Maize	3.78	3.72	2.45	2.53
Wheat	4.26	4.05	2.64	2.52
Faba bean	5.76	5.65	3.87	2.20
Haricot bean	6.48	4.53	3.80	2.70

Source: Authors' own elaboration, 2023.

3.7 Strategies used to prevent post-harvest crop losses

Reducing post-harvest losses (PHLs) of food crops is a critical component of sustainably increasing agricultural productivity. Post-harvest loss reduction is of high importance in an effort to combat hunger, raise income and improve food security and livelihoods for vulnerable people. In this pilot survey respondents were asked questions about the strategies they apply to prevent the post-harvest losses and the most effective methods of preventing the losses.

Based on the results from this survey, most of the farming households (78.6 percent) responded that the main technique they used to prevent post-harvest loss was harvesting on time. Very few of them also responded that they use measures like, proper stooking after harvesting (8 percent), proper shelling/threshing (3.8 percent) and usage of chemicals (2 percent) in order to prevent post-harvest losses.

Table 31: Percentage distribution of households by sex of household head and loss prevention technique

The main actions implemented by households to prevent post-harvest losses	Sex of household head		
	Male	Female	Total
Harvesting on time	78.2	81.5	78.6
Proper stooking when harvesting	8.1	7.4	8.0
Proper shelling/threshing	4.0	2.3	3.8
Proper winnowing/cleaning	1.6	0.6	1.5
Proper drying	0.6	1.6	0.8
Proper storage of a produce	1.2	1.0	1.1
Use of protected granaries/silos	0.3	0.5	0.4
Storage hygiene	0.3	0.4	0.3
Use of chemicals	2.1	1.4	2.0
Timely application of chemicals	1.8	1.1	1.7
Care when processing	0.2	0.0	0.2
Nothing	0.6	1.6	0.7
Other	1.0	0.7	0.9

Source: Authors' own elaboration, 2023.

Table 32: Percentage distribution of households by sex of household head and most effective loss prevention technique

The most effective actions to prevent post-harvest losses	Sex of household head		
	Male	Female	**Total**
Harvesting on time	54.5	56.6	**54.7**
Proper stacking when harvesting	12.6	14.5	**12.9**
Proper shelling/threshing	9.2	11.0	**9.4**
Proper winnowing/cleaning	5.7	4.6	**5.6**
Proper drying	5.3	3.6	**5.1**
Proper storage of a produce	3.5	1.8	**3.3**
Use of protected granaries/silos	1.3	2.0	**1.4**
Storage hygiene	1.2	.5	**1.1**
Use of chemicals	2.1	1.7	**2.1**
Timely application of chemicals	2.2	1.0	**2.0**
Care when processing	0.4	0.0	**0.4**
Nothing	0.5	0.1	**0.5**
Other	1.4	2.6	**1.6**

Source: Authors' own elaboration, 2023.

Despite the inability of farmers to apply the most effective prevention technique to prevent the post- harvest loss due to different reasons, the survey collected data on their knowledge of the most effective methods of post-harvest loss prevention techniques. Accordingly, about 54.7 percent of the households responded harvesting on time was the first best way to prevent post-harvest loss followed by proper stooking after harvest (12.9 percent), proper shelling/threshing (9.4 percent), proper winnowing/cleaning (5.6 percent) and proper drying (5.1 percent).

With respect to post-harvest assistance, about 62.3 percent of the total households reported that they never received any assistance regarding post-harvest activity in the last two years. The percentage is very similar when disaggregating by gender of heads of households, with 64 percent of female-headed households and 62 percent of male-headed households reported not received any assistance respectively.

Table 33 presents the main source of information used to obtain post-harvest management information. Of the total interviewed households, about 39 percent of them mainly used agricultural development agents to get information on post-harvest management systems, while about 21 percent of them reported that they obtained information mainly from other farmers, still 33 percent of the respondents reported that they have never received any information regarding the post-harvest management system.

Table 33: Percentage distribution of households who receive assistance on post-harvest management by sex of household head and main source of information

The main source of information used to obtain post-harvest management information	Sex of household head		
	Male	Female	**Total**
Agricultural development agent	39.6	38.1	**39.4**
Other farmers	20.9	22.4	**21.1**
Television/radio	4.4	2.4	**4.2**
Agro-dealers	0.7	0.1	**0.6**
Newspaper	0.0	0.0	**0.0**
Short SMS	0.3	0.0	**0.3**
Other	1.1	0.5	**1.0**
None	32.9	36.5	**33.4**

Source: Authors' own elaboration, 2023.

Table 34: Percentage of households who received assistance by sex of household head

Did the household receive any specific assistance on post-harvest losses during the last two years?	Sex of household head		
	Male	Female	**Total**
Yes	38.0	36.0	**37.7**
No	62.0	64.0	**62.3**

Source: Authors' own elaboration, 2023.

Table 35: Percentage of households by type of assistance received and sex of household heads

Type of assistance received	Sex of household head		
	Male	Female	Total
When to harvest	56.4	64.7	57.4
Proper stooking when harvesting	14.8	16.0	14.9
Proper shelling/threshing	9.4	6.3	9.0
Proper winnowing/cleaning	2.6	0.7	2.3
Proper drying	2.1	1.7	2.0
How to prepare granaries	1.1	5.7	1.6
Proper storage of a produce	3.0	0.0	2.6
To use protected granaries/silos	0.5	0.3	0.5
How to care for storage hygiene	0.7	1.0	0.8
How and when to apply chemicals	6.9	3.7	6.5
Care when processing	1.1	0.0	1.0
Other	1.4	0.0	1.2

Source: Authors' own elaboration, 2023.

Among the households who took the assistance, most of them (57.4 percent) received assistance on "When to harvest". In addition, 14.9 percent of the respondents also reported that they received assistance on "Proper stooking when harvesting" and 9 percent received assistance on how to "Proper shell/thresh".

Respondents were asked for their satisfaction level for the assistance they obtained. In general, 34.8 percent of the households who received assistance on post-harvest losses were very satisfied, 46.9 percent of them were satisfied and 15.8 percent of the households were somewhat satisfied while only 2.4 percent of the households reported not satisfied.

Table 36: Percentage of households with extent of satisfaction with the assistance received on post-harvest losses by sex of household head

Extent of satisfaction with the assistance received on post-harvest losses	Sex of household head		
	Male	Female	**Total**
Very satisfied	35.0	33.0	**34.8**
Satisfied	45.9	54.3	**46.9**
Somewhat satisfied	16.4	11.7	**15.8**
Not satisfied	2.6	1.0	**2.4**

Source: Authors' own elaboration, 2023.

APPENDIX A

ESTIMATION PROCEDURE AND COEFFICIENT OF VARIATION OF RELATIVE LOSSES

Appendix A.1. Estimation of loss indicators based on survey data

Once the loss is calculated at individual level (farm), averages or totals can be compiled for different aggregated units, (for this pilot survey purpose) at country level using the methodology that reflects the sample design adopted for the survey. The calculation procedure is presented below in general terms.

Appendix A.1.1. Quantitative (or weight) losses

Total quantity losses for a given area or administrative unit are estimated by the formula:

$$\hat{L} = \sum_{i \in S_j} w_i \, . \, L_i$$

Where:

- j is the index representing the lowest administrative level or stratum (enumeration area etc.)pertaining to the sample;
- i is the index representing the individual unit for which the data is collected, such as a farm, a household;
- S_j the sample of individual units randomly selected in j;
- w_i the sample weight of the unit i in the stratum j; and
- Li the weight loss of the given commodity measured for unit i. This variable may refer to lossat any stage (harvesting, threshing, transport, etc.) and to any measurement method, enquiry-based, physical measurements, visual-scales or other.

Appendix A.1.2 Relative (or percentage) losses

Percentage losses are estimated as a ratio of quantity losses to the quantity handled (or quantity handled plus quantity lost, in the case of harvest losses):

$$\hat{l}_j = \frac{\hat{L}_j}{\hat{Q}_j}$$

Where:

- $\hat{Q}_j$ is the estimated quantity used as the denominator: $\hat{Q}_j = \sum_{i \in S_j} w_i \, . \, Q_i$ and
- $\hat{l}_j$ is the estimated percentage loss for stratum j.

For the strata immediately above *j*, percentage losses are determined in a similar way. For example, for a given district

$$\hat{l}_d = \frac{\hat{L}_d}{\hat{Q}_d}$$

A convenient calculation procedure, derived from this ratio, is given by:

$$\hat{l}_d = \sum_{j \in S_d} \theta_j(Q).\hat{l}_j$$

Where:

- Q is the relevant denominator for the type of measured loss. For example: Q= H + L_H for harvest losses, Q= T for threshing losses and so on for the other operations
- $\theta_j(Q) = \hat{Q}_j/\hat{Q}_d$ is the weight of strata *j* in *d*

Appendix A.1.3 Estimation of variances, standard deviations and confidence intervals

One of the advantages of probability sample surveys is that they can provide an indication of the precision of the estimated indicators. This precision is generally measured by standard deviations, coefficients of variation and confidence intervals. An operational procedure to calculate variances, standard deviations and confidence intervals for percentage losses is provided below.

Standard deviations

To calculate standard deviations, variances must first be determined. As percentage losses are estimated as a ratio of two estimates, its variance cannot be obtained directly but must be approximated. Using the standard approximation of the variance of the ratio of two random variables, the variance of percentage losses at district or primary sampling level is given by:

$$\hat{\mathrm{V}}(\hat{l}) = \left(\frac{\hat{Q}}{\hat{L}}\right)^2 \left[\frac{\hat{\mathrm{V}}(\hat{L})}{\hat{L}^2} + \frac{\hat{\mathrm{V}}(\hat{Q})}{\hat{Q}^2} - 2\frac{\widehat{\mathrm{Cov}}(\hat{L},\hat{Q})}{\hat{L}.\hat{Q}}\right]$$

Where:

- $\hat{\mathrm{V}}(\hat{L}) = \frac{1}{n(1-n)}\sum_j \left(\hat{L}_j - \frac{\hat{L}}{n}\right)^2$ is the estimated sample variance of weight losses
- $\hat{\mathrm{V}}(\hat{Q}) = \frac{1}{n(1-n)}\sum_j \left(\hat{Q}_j - \frac{\hat{Q}}{n}\right)^2$ is the estimated sample variance of the denominator
- $\widehat{\mathrm{Cov}}(\hat{L},\hat{Q}) = \frac{1}{n(1-n)}\sum_j \left(\hat{L}_j - \frac{\hat{L}}{n}\right)\left(Q_j - \frac{\hat{Q}}{n}\right)$ is the estimated sample covariance between weight losses and the denominator
- n is the number of SSUs (enumeration areas, etc.).

The standard deviation is defined as the square root of the variance: $\widehat{SD}(\hat{l}) = \sqrt{\hat{\mathbb{V}}(\hat{l})}$

Confidence intervals

These provide the interval to which the true (unknown) value is likely to pertain. To construct a confidence interval, three elements are necessary: the estimate of the indicator (such as the average percentage losses), its estimated standard deviation and its estimated or assumed probability distribution. It is often assumed that the (standardized) indicator follows a normal distribution. With this assumption, the 95-percent confidence interval for percentage losses is given by the following formula:

$$CI_{95\%}(\hat{l}) = [\hat{l} \pm 1.96.\widehat{SD}(\hat{l})]$$

This means that the true and unknown percentage losses a 95-percent chance of pertaining to this interval. The assumption of normality can be relaxed: other distributions may be chosen or the empirical probability distribution determined by non-parametric methods.

APPENDIX B

COEFFICIENT OF VARIATION (CV) OF PERCENTAGE LOSS ESTIMATES

Table B1. Coefficient of variation for pre-harvest losses

Crops	Subjective measurement	
	Estimated % loss	CV
Maize	11.21	0.08
Wheat	9.12	0.13
Faba	15.78	0.1
Haricot bean	11.43	0.26

Table B2. Coefficient of variation for harvest losses

Crops	Subjective measurement		Objective measurement	
	Estimated % loss	CV	Estimated % loss	CV
Maize	3.05	2.86	4.19	1.29
Wheat	3.24	2.66	4.94	1.29
Faba	4.94	2.94	5.98	0.60
Haricot bean	6.26	1.61	6.73	1.61

Table B3. Coefficient of variation for stacking losses

Crops	Subjective measurement		Objective measurement	
	Estimated % loss	CV	Estimated % loss	CV
Maize	4.01	3.95	3.22	8.60
Wheat	3.81	1.89	4.38	2.31
Faba	6.00	0.78	4.68	2.75
Haricot bean	4.44	5.88	4.62	5.86

Table B4. Coefficient of variation for threshing losses

Crops	Subjective measurement		Objective measurement	
	Estimated % loss	CV	Estimated % loss	CV
Maize	2.1	5.3	2.8	2.6
Wheat	3.0	2.6	2.1	3.9
Faba	4.1	1.8	3.7	1.3
Haricot bean	3.6	22.9	3.9	4.2

Table B5. Coefficient of variation for storage losses

Crops	Subjective measurement		Objective measurement	
	Estimated % Loss	CV	Estimated % loss	CV
Maize	2.81	**15.60**	2.51	**1.01**
Wheat	2.14	**15.32**	2.55	**1.03**
Faba	2.90	**3.97**	1.89	**2.66**
Haricot bean	3.58	**6.34**	2.41	**3.10**

Table B6. Coefficient of variation for transport losses

Crops	Subjective measurement	
	Estimated % loss	CV
Maize	1.7	**11.91**
Wheat	2.05	**7.78**
Faba	2.92	**2.54**
Haricot bean	3.09	**17.93**

Source: Authors' own elaboration, 2023.

APPENDIX C

QUESTIONNAIRE

Section 1: Area and household identification										
1	2	3	4	5	6	7	8	9	10	
Region	Zone	wereda	kebele	Enumeration area	Household ID number	Holder's ID number	The holder name	Number of household members	Household phone 1	Household phone 2

Section 2: Marketing of produce (last year/season)

	Market	Grains											
		Maize			Wheat			Faba bean			Haricot bean		
1	Quantity produced (kilogram)												
2	Quantity sold (kilogram)												
3	List the main three buyers of your commodity												
4	Distance to market/buyer (kilometre)												
5	Mode transport to market/buyer												
6	Mode packaging for market/buyer												

Codes for buyers (Q3)	Codes
Wholesaler	1
Retailer	2
Cooperative/union	3
Consumer	4
Processors	5
Other	6

Mode of packaging (Q6)	Code
Sack/jonya/madabariya	1
Baskets	2
Plastic bags	3
Bag made of leather	4
Other	5

	Section 3: Prevention of post-harvest losses	
1	What are the three main actions that you implemented to prevent post-harvest losses?	|____||____||____|
2	According to you, what would be the three most effective actions to prevent post-harvest losses?	|____||____||____|
3	Did the household receive any specific assistance on post-harvest losses during the last two years? 1. Yes 2. No	|____|
4	Which kind of assistance did you receive (the most important one)?	|____|
5	Are you satisfied with the assistance received on post-harvest losses?	|____|
6	What is the main source of information used to obtain post-harvest management information?	|____|

Codes for Q1 and Q2		Codes for Q4		Codes for Q5		Codes for Q6	
Loss prevention methods	**Codes**	**Assistance received**	**Codes**	**Satisfaction**	**Codes**	**Source of information**	**Codes**
Harvesting on time	1	When to harvest	1	Very satisfied	1	Agricultural development	1
Proper stooking when harvesting	2	Proper stooking when harvesting	2	Satisfied	2	Other farmers	2
Proper shelling/threshing	3	Proper shelling/threshing	3	Somewhat satisfied	3	Television/radio	3
Proper winnowing/cleaning	4	Proper winnowing/cleaning	4	Not satisfied	4	Agro-dealers	4
Proper drying	5	Proper drying	5			News paper	5
Proper storage of a produce	6	How to prepare granaries	6			Short SMS	6
Use of protected granaries	7	Proper storage of a produce	7			Other	7
Storage hygiene	8	To Use protected granaries	8			None	8
Use of chemicals	9	How to care for storage hygiene	9				
Timely application of chemicals	10	How and when to apply chemicals	10				
Care when processing	11	Care when processing	11				
Nothing	12	Other	12				

Section 4: Pre-harvest losses due to crop damage

1	2	3	4	5	6	7	8		
Parcel number	Plot number	Crop name	Crop code	Area of the plot in metre square	Is this plot inter-cropped or pure stand? 1.Pure stand >>>8 2. Inter-cropped	If the plot was inter-cropped, whatis the area share in percentage of the [crop]?	How much productiondid you get from this [crop]? Use [code 9] for unit code		
							Quantity	Unit code	kg

Code 9: Quantity unit codes

Description	Code	Description	Code	Description	Code	Description	Code	Description	Code
Kg	1	Bobo	11	Gan	21	Big Madaberia	31	Bunch	41
Quintal	2	Packets	12	Ensira	22	Small Madaberia	32	Melekia	42
Chinet	3	Bags	13	Gurzign	23	Dirib	33	Guchiye	43
Dawla	4	Bundles	14	Tassa	24	Sahin	34	Bekole	44
Kunna	5	Pieces	15	Kubaya	25	Mankorkoria	35	Enkib	45
Medeb	6	Bars	16	Birchiko	26		36	Shekim	46
Kurbets	7	Boxes	17	Sini	27	Zurba	37	Number	47
Silicha	8	Leaves	18	Gembo	28	Akara	38	Gotera	48
Akmada	9	Litres	19	Bottles	29	Small plastic bag (Mika)	39	Lemba	49
Esir	10	Kil	20	Birr	30	Kerchat Kemba	40	Shirimeri	50

Description	Code	Description	Code	Description	Code
60 Egir	51	Ladan	61	Mosh	71
61 Wesla	52	Mesbesh	62	Other	72
M62 Riaesfe	53	Tireshwa	63		
63 Kurfo	54	Bichere	64		
K64 Laole	55	Kumta	65		
65 Kesha	56	Kefer	66		
C66 ethar	57	Nefki/Nefek	67		
67 Mosha	58	Kalkalo	68		
68 Aanik	59	Darota	69		
69 Abet	60	Gebeta	70		

13	14			15		16	
What is the estimated percentage of [crop] yield lost due to the damage, from the total possible production you would get?	What are the three main reasons for the crop damage?[code 10]			If it would have been no damage at all what were expected total production of [crop]? Use [code 9] for		How much is the kilogram equivalent of one local unit reported in Q15?	
	1	2	3	Quantity	Unit code	kg	g

Code 10: Codes for reasons of crop damage (Q14)

Description	Code
Antimicrobial disease	1
Frost	2
Flood	3
Locusts	4
Anti-croppest	5
Shortage of rain	6
Too much rain	7
Wild animal	8
Bird	9
Snow	10

Description	Code
Weed	11
Seed shortage	12
Reduction of farm land fertility	13
Instability in the environment	14
Sowing bad seeds	15
Theft	16
Fire event	17
Unexpected rain	18
Eating by animals	19
Other	20

Section 5: Crop losses during harvesting (farmer estimate)

1	2	3		4		5	6		7		8	9			10		11	
Crop name	Crop code	How much production did you collected from this crop?		How much is the kilogram equivalent of one local unit reported in Q3?		What is the main tool used to harvest the [crop name]? [code 8]	What is the estimated quantity of crop loss during harvesting? Use [code 5] for unit code		How much is the kilogram equivalent of one local unit reported in Q6?		What is the loss in terms of percentage from the possible quantity of production you could get?	What are the three main reasons for the loss at this stage? [Code 9]			What were the expected total production of [crop] without losses?		How much is the kilogram equivalent of one local unit reported in Q10?	
		Quantity	Unit code	kg	g		Quantity	Unit code	kg	g		1	2	3	Quan-tity	Unit code	kg	g

Code 8: Codes for harvesting tool used (Q5)	
Description	Code
Sickle	1
By using pole/gejera	2
Mencha	3
Digging by hand	4
Combiner machine	5
Other	6

Code 9: Codes for reason on harvest losses	
Description	Code
Left unharvested	1
Spillage of the grain on the ground	2
Spillage of the threshed stalks on the ground	3
Other	4
No losses	5

Section 6: Harvest and cleaning loss (physical measurement)

1	2	3	4	5	6	7		8		9		10		11		12		13
Parcel No	Plot No	Crop name	Crop code	Harvest date of [crop]	Did you used combiner harvesting system to harvest and thresh the [crop] on this field 1.Yes>>12 2. No	Fresh weight of threshed produce harvested from 4 m by 4 m subplot		Dry weight of threshed produce harvested from 4 m by 4 m plot		Fresh weight of grains shed or missed, as well as all cobs and ears remaining on the ground after threshing the 4 by 4 subplot		Dry weight of grains shed or missed, as well as all cobs and ears remaining on the ground from the 4 by 4 subplot		Weight of straw found after threshing the harvested [crop] from the 4 by 4 subplot (only form annual harvest)		Weight of all grains that have fallen and remaining on stalks in the subplot prepared after the harvest has been taken place		Total production obtained after threshing
						kg	g	kg	g	kg	g	kg	g	kg	g	kg	g	kg

Section 7: Losses during stacking and stooking									
1	2	3	4	5	6	7		8	
Parcel No	Plot No	Crop name	Crop code	Harvest date of [crop]	Does this [crop] on this plot stacked or stooked on the field prior to threshing 1. Yes 2. No>> Next crop	Weight of the grains found after threshing the sampled stacks		Weight of the grains left on the ground, at which the sample stacks are taken	
						kg	g	kg	g

Section 8: Crop losses during threshing (farmer estimate)

1	2	3	4	5		6		7		8		9	10			11		12	
Crop name	Crop code	What is the main technique of threshing you used to thresh the [crop name]? [Code 10]	What is the type of floor at which the [crop] is threshed? [Code 11]	Total cleaned production you collected from the [crop] you brought to threshing		How much is the kilogram equivalent of one local unit reported in Q5?		What is the estimated quantity of crop losses occurred during the activities after harvest up to threshing (including)?		How much is the kg equivalent of one local unit reported in Q7?		What is the loss in terms of percentage from the possible quantity of production you could get?	What are the main reasons for the loss at this stage? List the main three [Code 12]			If it would have been no losses at all during the threshing activity, what were the expected total production of [crop] you could collect?		How much is the kg equivalent of one local unit reported in Q11?	
				Quantity	Unit code	kg	g	Quantity	Unit code	kg	g		1	2	3	Quantity	Unit code	kg	g

Code 10: codes for main technique of threshing (Q3)

Description	Code
Animal	1
Using hand	2
Using modern machine	3
Other	4

Code 11: Codes for type of threshing floor (Q4)

Description	Code
Concrete floor	1
Earth coated with animal dung	2
In a plastic sheet or canvas	3
Other	4

Code 12: Codes for reason for loss during threshing (Q10)

Description	Code
Left un-threshed with the stalk	1
Scattering or spillage during threshing	2
Breaking of the grains during threshing	3
Eaten by animals	4
Other	5

Section 9: Losses during threshing (Physical measurement)

										During cleaning or winnowing of the threshed crop product in order to remove the chaff materials from the clean grains, we will ask our respondent and take enough amount of sample(15 to 20 kg) independently and then clean or winnow as a usual/farmer practice separately and collect the chaff material and the cleaned grain record appropriately.							
1	**2**	**3**	**4**	**5**		**6**		**7**		**8**		**10**		**11**		**12**	
Par-cel No	Plot No	Crop Name	Crop code	Weight of straw found after threshing the harvest [Crop] from the 4by4 sub plot [***Copy from harvest loss Section 5, Q12]***		Weight of the remaining /unthreshed grains that are found from the straw found in Q5		Number of grains that are found from quantity Q6		Quantity of sample crop production taken		Weight of residual amount of chaff (husks, plant material, stones, etc.) while we clean/winnow the sample taken		The quantity of clean grain found		Quantity of grain found from the residual amount of chaff (husks, plant material, stones, etc.) in Q10	
					g	**kg**	**g**	**kg**	**g**	**kg**	**g**	**kg**	**g**	**kg**	**g**	**kg**	**g**

Section 10: Losses at storage (Farmer estimate)

1	2	3		4		5	6	7		8		9	10	11
Crop name	Crop code	How much did you store? From your last harvest?		How much is the kg equivalent of one local unit reported in Q3?		What is the main storage type used to store the harvest from[crop] [Code16]	For how many months does this crop stored?	How much quantity lost during storage due to different reasons?		How much is the kg equivalent of one local unit reported in Q7?		What is the main reason for the loss?	Did you used any mechanism during storage to protect the crop from damage? 1. Yes 2. No if no next crop	What type of mechanism did you used? 1 Chemical 2 Non chemical 3 Both
		Quan-tity	Unit code	kg	g			Quan-tity	Unit code	kg	g			

Code 16: Mode of storage Q5

Description	Code
Traditional crop granary/gotera	1
Kept in the house by sack/jonya	2
Kept in the house by sack/madaberiya	3
Modern metal or wood silos/granary	4
Pilling in the room/house	5
Storing at as to rage made of steel	6
Storing in the house without threshing/shelling	7
Packsack made for crop storage	8
On the ground	9
Other	10

Code 17: Codes for reason for loss (Q9)

Description	Code
Eaten by insects	1
Attacked by diseases	2
Insufficient drying	3
Other	4

Section 11: Losses during storage (Physical measurement)

1	2	3	4	5		6	7		8	9		10	11		12	13		14	15	
Crop name	Crop code	At what form does the crop found now? **[Code 16]**	**Sample 1**									**Sample 2**								
			Number of total sample_1 grains	Weight of total sample_1grains		Number of un-damaged grains in sample_1	Weight of un-damaged grains from the sample_1		Number of damaged grains from the sample_1	Weight of damaged grains from the sample_1		Number of total sample_2 grains	Weight of total sample_2grains		Number of un-damaged grains in sample_2	Weight of un-damaged grains from the sample_2		Number of damaged grains from the sample_2	Weight of damaged grains from the sample_2	
				kg	**g**		**kg**	**g**		**kg**	**g**		**kg**	**g**		**kg**	**g**		**kg**	**g**

Code 16: Q3 Codes

Description	Code
Threshed/shelled and stored	1
Stored unthreshed/unshelled	2

Section 12: Losses during transport

1	2	3	4		5		6		7		8
Crop name	Crop code	What is the main mode of transport used to transport the produce from harvest to threshing to storage?	What is the total quantity of produce handled		What is the kg equivalent of one local unit reported in Q4?		What is the total quantity of the produce lost during transporting the produce from the farm up to storage?		What is the kg equivalent of one local unit reported in Q6?		What is the main causes of loss? 1. Scattering 2. Spillage 3. Other
			Quantity	Unit code	kg	g	Quantity	Unit code	kg	g	

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