Food and Agriculture Organization of the United Nations

SUSTAINABLE DEVELOPMENT GOALS

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Guidelines on the measurement of harvest and post-harvest losses

Estimation of crop harvest and post-harvest losses in Malawi

Maize, rice and groundnuts

FIELD TEST REPORT

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Abstract

A study was conducted in two Agriculture Development District (ADDs) of Malawi, Salima and Lilongwe, to pilot a new methodology for estimating on-farm harvest and post-harvest losses. The study was carried-out with technical support from the Global strategy to improve agricultural and rural statistics (GSARS) of the Food and Agricultural Organization of the United Nations (FAO). This pilot exercise principally aimed at strengthening the capacity of Malawi in generating reliable estimates on post-harvest losses. The data collection was carried out using a household questionnaire which was specifically developed for this exercise. The analysis of the results showed that a significant amount of farm produce is lost during harvesting, followed by threshing. The study also highlighted that on-time harvesting and use of chemicals are considered by farmers as the most effective strategies for preventing on-farm losses, even though farmers are not always in a position to implement these strategies. The authors recommend that a solid baseline on harvest and post-harvest losses be established by replicating on a larger scale this pilot survey for three consecutive years, to account for weather variation and other exogenous factors which may affect losses. The survey would benefit from the integration with existing country-wide data collection systems such as the Agricultural production estimates survey (APES) to ensure low operational costs and sustainability. It is also recommended that Computer assisted personal interviewing (CAPI) should be introduced for future exercises to improve on data quality and timeliness.

In collaboration with:

Global strategy to improve agricultural and rural Statistics

Government of the Republic of Malawi

National Statistical Office (NSO)

Department of Agricultural Research Services (DARS)

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Abbreviations and acronyms

ADD	Agriculture development division
APES	Agricultural production estimates survey
DARS	Department of Agriculture Research Services
EPA	Extension planning area
FAO	Food and Agriculture Organization
GDP	gross domestic product
GSARS	Global strategy to improve agricultural and rural statistics
IFPRI	International Food Policy Research Institute
MASSMP	Malawi Agricultural Statistics Strategic Master Plan
MoAIWD	Ministry of Agriculture Irrigation and Water Development
NAIP	National Agriculture Investment Plan
NSO	National Statistical Office
PHL	Post-harvest losses

1. Introduction

Malawi is one the countries that benefitted from technical support on post-harvest losses[1] from the Global strategy to improve agricultural and rural statistics (GSARS) of the Food and Agricultural Organization (FAO) of the United Nations. Malawi requested this support to address one of the priorities of its action plan for implementing the Malawi Agricultural Statistics Strategic Master Plan (MASSMP), which recommended the development of a reliable methodology for estimating post-harvest losses. The technical support largely focused on improving capacity of the country in designing, compiling and analysing on-farm post-harvest losses based on a comprehensive and statistically sound methodology.

Malawi requires reliable statistics on post-harvest losses. The estimates are useful for monitoring the outcomes of the investments aimed at reducing post-harvest losses in the country. The figures also help the Government to determine the discounting factor required to calculate net crop production, which in turn is needed to estimate the domestic food gap, gross domestic product and related official statistics.

Malawi has been conducting post-harvest losses (PHL) studies regularly since 2009. However, previous studies had several methodological limitations. For example, the reported losses of 10.7 percent and 7.1 percent in 2016 were based on farmers' perception for maize during storage only. The present methodology focused on losses for various crops and for different on-farm operations from harvesting to storage. This approach also has its limitations. For instance, the limited resources did not allow to select a sample large enough (8 districts and 20 households per district were surveyed) to produce district level estimates.

The technical assistance to Malawi was provided from August 2017 to September 2018. As part of strengthening collaboration at national level, the project was implemented jointly with the National Statistical Office (NSO), FAO-Malawi and the Department of Agricultural Research Services (DARS). A technical team was formed and tasked to oversee the effective implementation of the survey while at the same time ensuring that the results are reliable and accurate. The team validated the study tools in August 2017, prepared the enumerators' manual in September 2017, trained the enumerators in January, 2018 and supervised the enumerators during data collection, which was conducted in the first half of February, 2019. The survey used 16 enumerators (most of them extension officers from the Ministry of Agriculture) drawn from the sampled sections to administer the questionnaires to the farmers. The enumerators were supervised by 8 officers from the technical team.

In terms of sample design, a multi-stage sampling procedure was employed to draw a sub-sample from the Agricultural Production Estimates Survey (APES). First, Salima and Lilongwe ADDs were purposively sampled for their proximity and easy logistics. In each ADD, two districts were selected, namely Lilongwe East, Lilongwe West, Salima and Nkhotakota. In each district, two Extension Planning Areas (EPAs) were sampled and two sections in each sampled EPAs were selected. From the two sections, two blocks were selected and 15 farmers from each block were drawn for the sample to reach 240 farmers for the survey.

[1] In this document, the term "post-harvest losses" is used to refer to the losses encountered on the farm, during and after harvest.

2. Presentation of the data

This section of the report provides descriptive statistics on the basic demographics and socio-economic characteristics of the farmers and rural households surveyed. The section presents information on household headship and agricultural and non-agricultural activities of the households.

The results show that all farmers interviewed were involved in agricultural activities as their main economic activity (Table 1). This is supported by literature which says that agriculture remains the backbone of the economy in Malawi and vital for the livelihoods of most Malawians to ensure national food self-sufficiency and household food and nutrition security. Agriculture generated approximately 28 percent of gross domestic product (GDP), 65 percent of employment, and 63 percent of export earnings in 2015. If the broader agri-food system is considered, comprising sectors highly dependent on agriculture such as agroindustry or providers of agricultural inputs and services, the contribution to GDP and employment generation reach, respectively, 44 percent and 74 percent (Malawi National Agriculture Investment Plan, 2018).

The study further explored the type of agricultural activities farmers are mainly involved in. The results show that farming in Malawi is predominantly rainfed. Overall, 99 percent of the farmers reported rainfed farming as the major activity carried out by their households (Table 1). The National Agriculture Investment Plan (NAIP) acknowledges that in Malawi, irrigation development has always lagged behind national ambitions, largely due to a lack of financial resources required to carry-out the substantial investments needed and to limited technical capacity for system design and construction. Malawi's irrigation potential is estimated at 408 000 hectares of which only 107 000 ha (26 percent) have been developed (NAIP, 2018).

Critical examination of the results further reveals low participation of farmers in horticultural activities as their main economic activity, reported by only 0.2 percent of the farmers.

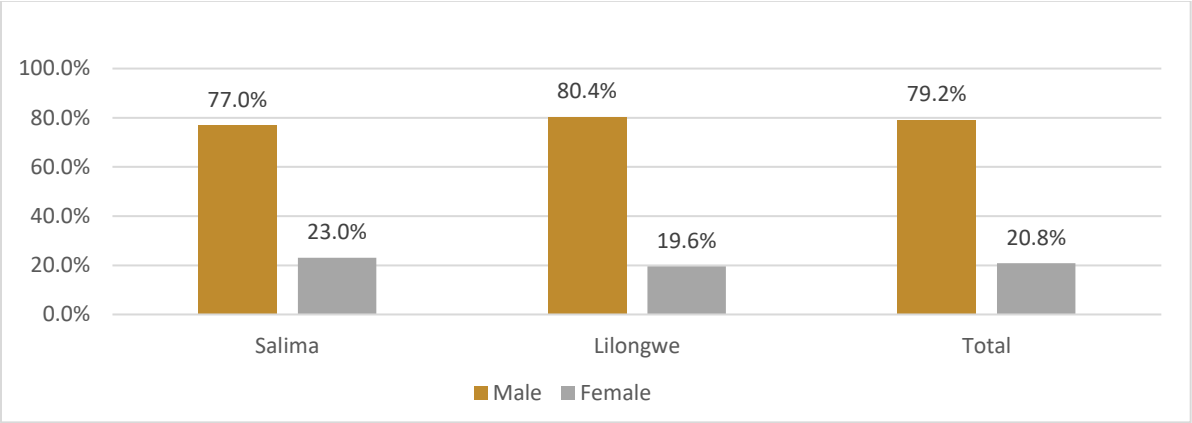
Table 1: Type of agricultural activities

	Salima		Lilongwe		Total	
	Number of holdings	% of total	Number of holdings	% of total	Number of holdings	% of total
Rain fed crops	173 237	98.70	323 677	98.90	496 914	98.80
Irrigated field crops	1 394	0.80	3 629	1.10	5 023	1.00
Horticulture	852	0.50	-	0.00	852	0.20
Livestock	-	0.00	-	0.00	-	0.00
Fishing	-	0.00	-	0.00	-	0.00
Other	-	0.00	-	0.00	-	0.00

Table 2: Education level of the household holdings members

Education level	Number	Percent
No education	117 713	23.1
Primary school	332 827	65.3
Secondary school	579 71	11.4
Tertiary education	1 395	0.3
Total	**509 907**	**100**

Figure 1: Sex of head of household by Agriculture Development District



Socio-demographic characteristics of the agricultural households

Literacy is key for farmers' capacity to absorb and apply technical information from interventions. Table 2 and Figure 1 present results on the level of education of the members of the households and percentage of female-headed and male-headed households. The results show that the majority of the household members had attended primary education (65.3 percent). Very few (0.3 percent) reported acquired tertiary education, and 11.4 percent attended secondary education. Close to a quarter (23.1 percent) of the population concerned have never received formal education.

In terms of sex of the heads of the household, overall, 79.2 percent of the farm households in both ADDs are headed by males. Salima has a slightly higher proportion of households headed by females (23.0 percent) as compared to Lilongwe (19.6 percent).

3. Agricultural practices of the households

3.1 Area planted and production of the agricultural households

Table 3 shows the number and percent distribution of households by crop grown at ADD level. Crop production is concentrated on maize, by far the dominant crop, grown by 58 percent of the farmers. In Salima, the most commonly cultivated crop amongst interviewed farmers was hybrid maize with 35.3 percent of the farmers growing the crop, compared to 26.6 percent in Lilongwe. The popularity of this variety is probably due to the high productivity of the crop which makes it more viable for commercial and subsistence use. Groundnuts and local maize were cultivated by 26.2 percent and 19.5 percent of the interviewed farming households respectively. In Lilongwe, the most commonly cultivated crop amongst the interviewed farming households was groundnuts, with 28.3 percent of the farmers cultivating the crop, followed by hybrid maize (26 percent) and local maize (18 percent). The popularity of a non-staple crop (groundnuts) in Lilongwe reflects a progressive shift from subsistence to commercially viable crops by farmers in this district.

Table 3: Number of holdings by crop and Agriculture Development District

Crop	Salima		Lilongwe		Total	
	Number of holdings	% of the total	Number of holdings	% of the total	Number of holdings	% of the total
Maize local	62 838	21.00	105 932	18.80	168 769	19.50
Maize hybrid	105 726	35.30	150 507	26.60	256 233	29.70
Maize composite	11 445	3.80	65 024	11.50	76 469	8.80
Rice	32 828	11.00	0	0.00	32 828	3.80
Groundnuts	66 550	22.20	159 721	28.30	226 271	26.20
Sorghum	2 038	0.70	2 352	0.40	4 390	0.50
Millet	0	0.00	0	0.00	0	0.00
Beans	0	0.00	1 814	0.30	1 814	0.20
Pigeon peas	3 288	1.10	0	0.00	3 288	0.40
Cow peas	7 418	2.50	3 388	0.60	10 806	1.30
Field grams	0	0.00	0	0.00	0	0.00
Soya beans	2 519	0.80	74 543	13.20	77 062	8.90
Ground beans	852	0.30	1 664	0.30	2 516	0.30
Chick peas	0	0.00	0	0.00	0	0.00
None	3 676	1.20	0	0.00	3 676	0.40
Total	**299 179**	**100.00**	**564 945**	**100.00**	**864 124**	**100.00**

Results on area planted by crop are presented in Table 4. Due to the small sample only three major crops, namely maize, rice and groundnuts, grown in the two ADDs, provided reliable results. The results show that maize is the major crop in the two ADDs, with a sown area of 256 951 ha. By variety, hybrid maize is the most widely grown, with 136 778 hectares and an average crop area of 0.5 ha. 81 351 ha of hybrid maize was planted in Lilongwe and 55 427 ha of the same variety in Salima. The table also reveals that a total of 31 949 ha of composite maize was planted in Lilongwe, with an average of 0.5 ha. The table further shows that groundnuts were planted in Lilongwe over an area of 65 642 ha, compared to 60 417 in Salima. Salima has the highest crop area for rice. This is so due to the fact that Salima boarders Lake Malawi and has lots of wetlands, while Lilongwe is upland. Overall, sown area in Lilongwe is greater than in Salima, due to the larger size of this district. Looking at the average crop area, Salima has generally higher averages than Lilongwe.

Table 4: Area planted (Ha) by crop and Agriculture Development District

Crop	Salima		Lilongwe		Total	
	Total area Planted	Average Area Planted	Total area Planted	Average Area Planted	Total area Planted	Average Area Planted
Maize local	36 979	0.6	46 421	0.4	83 400	0.5
Maize hybrid	55 427	0.5	81 351	0.5	136 778	0.5
Maize composite	4 824	0.4	31 949	0.5	36 773	0.5
Rice	205,90	0.6	.	.	20 590	0.6
Groundnuts	60 417	0.9	65 642	0.4	126 059	0.6

Table 5: Quantity harvested, average harvest per household and yields, by crop and Agriculture Development District

Crop		Maize local	Maize hybrid	Maize composite	Rice	Groundnuts
Salima	Harvest (1 000 tons)	41.9	98.9	6.7	15.7	26.4
	Average harvest per household (kg)	718	966	742	602	451
	Av. yield (kg per ha)	1 573	2 130	1 917	2 149	991
Lilongwe	Harvest (1 000 tons)	80.8	276	34	.	94.2
	Average harvest per household (kg)	774	1 847	534	.	598
	Av. yield (kg per ha)	1 953	3 387	1 434	.	1 848
Total	Harvest (1 000 tons)	123	375	40.7	15.7	121
	Average harvest per household (kg)	754	1 489	560	602	558
	Av. yield (kg per ha)	1 817	2 876	1 494	2 149	1 618

Table 5 above shows the quantity harvested and yields by crop and ADD. It shows that 375 thousand tons of hybrid maize were harvested in both ADDs, with an average yield of 2,876 kg/ha. 276 thousand tons of hybrid maize were harvested in Lilongwe, almost 3 times higher than in Salima, corresponding to an average yield of 3,387 yield kg/ha. These results indicate that both yields and production tend to be higher in Lilongwe. As expected, yields for hybrid maize are higher than for other maize varieties. The table also reveals that 121 thousand tons of groundnuts were harvested in both ADDs, with Lilongwe having the highest quantity. This corresponds to an average yield of 1,618 kg/ha.

3.2Farm Inputs

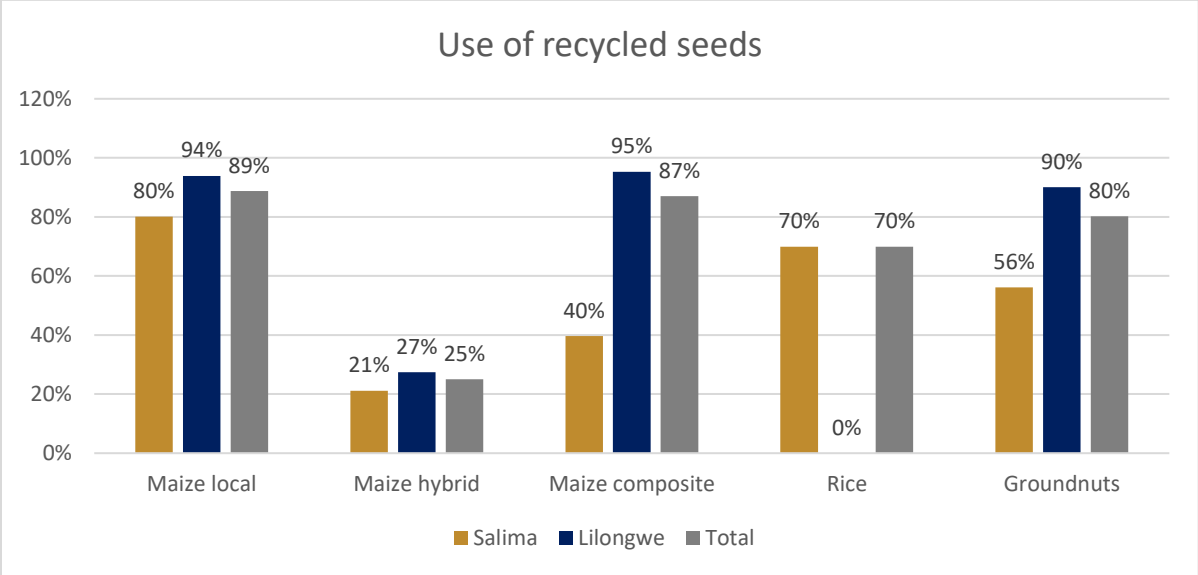
The Government of Malawi recognizes the fundamental importance of a sustainable seed industry in contributing to increased agricultural production and diversification (National Seed Policy, 2018). Through appropriate policies and programmes, the Government continues to work on establishing a conducive environment for the development of the seed industry. Furthermore, the Government recognizes the importance of both public and private investments in research, training, marketing and the provision of support services in the seed industry.

Table 6: Seeds used by crop and Agriculture Development District

Crop		Maize local	Maize hybrid	Maize composite	Rice	Groundnuts
Salima	Total quantity of seeds (kg)	767 194	1 212 219	96 098	559 619	1 512 290
	Average quantity of seeds per HH (kg)	12.3	11.5	8.4	17.7	23
	Average quantity of seeds per Ha (kg)	24.1	25.1	22.4	63.8	50.7
Lilongwe	Total quantity of seeds (kg)	1 191 346	2 040 445	774 080	.	2 657 520
	Average quantity of seeds per HH (kg)	11.3	13.6	11.9	.	16.8
	Average quantity of seeds per Ha (kg)	29.3	25.3	24.9	.	55.4
Total	Total quantity of seeds (kg)	1 958 540	3 252 664	870 178	559 619	4 169 810
	Average quantity of seeds per HH (kg)	11.6	12.7	11.4	17.7	18.6
	Average quantity of seeds per Ha (kg)	27.3	25.2	24.5	63.8	54

Table 6 summarizes the quantities of seeds by crops that were used in the 2016/2017 growing season in the two ADDs and the associated seeding rates. The table shows that on average 27.3 kg of local maize, 25.2 kg of hybrid maize and 24.5kg of composite maize seed were planted per hectare. By household, the table shows that farmers on average use more hybrid variety in Lilongwe whereas in Salima farmers' preference was on local variety. The average quantity of seed used per household ranged from 11.4 kg for composite maize to 18.6 kg for groundnuts. The results also show that seeding rates are generally higher in Lilongwe.

Figure 2: Percent of households reporting using recycled seeds by Agriculture Development District



Use of recycled seed has been cited to be one of the factors contributing to low yields. In both ADDs, it has been observed that the percentage of farmers using recycled seeds is very high. For the local variety of maize, close to 90 percent of the farmers recycle their seeds (Figure 2). The percentages are 25 percent, 87 percent, 69 percent and 80 percent for maize hybrid, maize composite, rice and groundnuts respectively.

3.3Harvest and Post-harvest practices

The quantity of produce that farmers loose greatly depends on how the farming operations are conducted, such as time and length of harvesting, harvesting methods, processing and cleaning practices used. In the study, farmers were asked to report the month they started and finished harvesting and the number of days they took to harvest the crop. The average length of harvesting was 5 days for both maize local and maize hybrid (Figure 3). The composite maize took longer to harvest in Salima (6 days) as compared to Lilongwe (4 days). Generally, maize took shorter period to harvest (4–6 days) when compared to rice and groundnuts (7–8 days).

Due to the Government of Malawi's limited capacity to foster investment in physical capital and farm mechanization, the farming methods being used are still mostly traditional. Very few farmers have access to mechanized farming equipment such as tractor-drawn ploughs or ridges, to combine harvesters or even to mechanical shelling and threshing machinery. The National Agricultural Investment Plan (NAIP) highlights mechanisation as one of the areas requiring important investments. In Malawi, a majority of smallholder farmers continues to use rudimentary manual practices, including for harvesting and processing (NAIP, 2018). This is highly inefficient and burdens millions of households, making agriculture unattractive, particularly to the youth. NAIP aims at increasing the use of machinery in farming and agro-processing activities by 50 percent, taking into account environmental considerations and respecting the principles of conservation agriculture.

The survey results support the above literature on the low mechanisation rates in Malawi, with only 2.1 percent of the farmers surveyed that reported using mechanical harvesting for maize composite, 0.6 percent for maize hybrid and 0.6 percent for groundnuts. Mechanical harvesting is relatively more common in Lilongwe, where it is reported by 2.1 percent of the farmers for composite maize and 1 percent for hybrid, than in Salima.

Figure 3: Average length of harvest in days

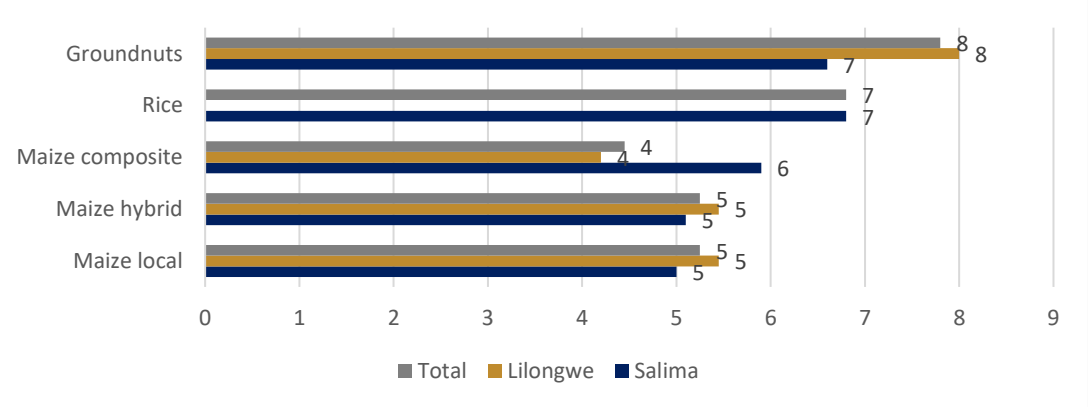


Table 7: Harvesting method by crop and Agriculture Development District

Crop	Salima		Lilongwe		Total	
	Harvesting method		Harvesting method		Harvesting method	
	Manual	Mechanical	Manual	Mechanical	Manual	Mechanical
Maize local	100	0	100	0	100	0
Maize hybrid	100	0	99	1	99.40	0.60
Maize composite	100	0	97.60	2.40	97.90	2.10
Rice	100	0	0	0	100	0
Groundnuts	99.10	0.90	100	0	99.70	0.30

Table 8: Threshing and shelling methods (%)

Crop	Salima		Lilongwe		Total	
	Manual	Mechanical	Manual	Mechanical	Manual	Mechanical
Maize local	98.6	1.4	98.8	1.2	98.7	1.3
Maize hybrid	99	1	99	1	99	1
Maize composite	100	0	100	0	100	0
Rice	100	0	0	0	100	0
Groundnuts	100	0	100	0	100	0

A vast majority of the farmers also used manual method for threshing and shelling their crops. Mechanical methods were reported by only 1.3 percent of the farmers for local maize and 1 percent for hybrid maize (Table 8), with similar percentages in Salima and Lilongwe.

3.4 Grain storage

Figures 4 and 5 provide information on households that stored their crops for at least one month. More quantities of the local variety of maize were in storage in Salima (34 660 769 kg) than in Lilongwe (Figure 4). Survey results also indicate that more quantities of harvested groundnuts were under storage in Lilongwe (51 257 780 kg) than in Salima (14 401 552 kg).

Figure 4: Quantity stored from previous harvest (in kg)

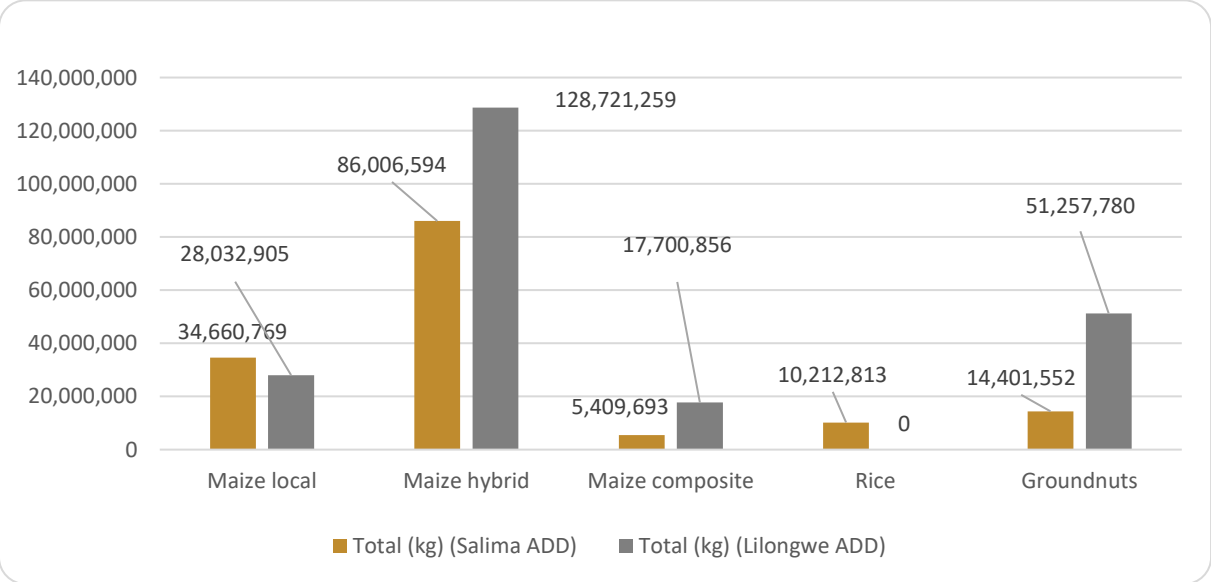


Figure 5: Average quantities stored from previous harvest by households (in kg)

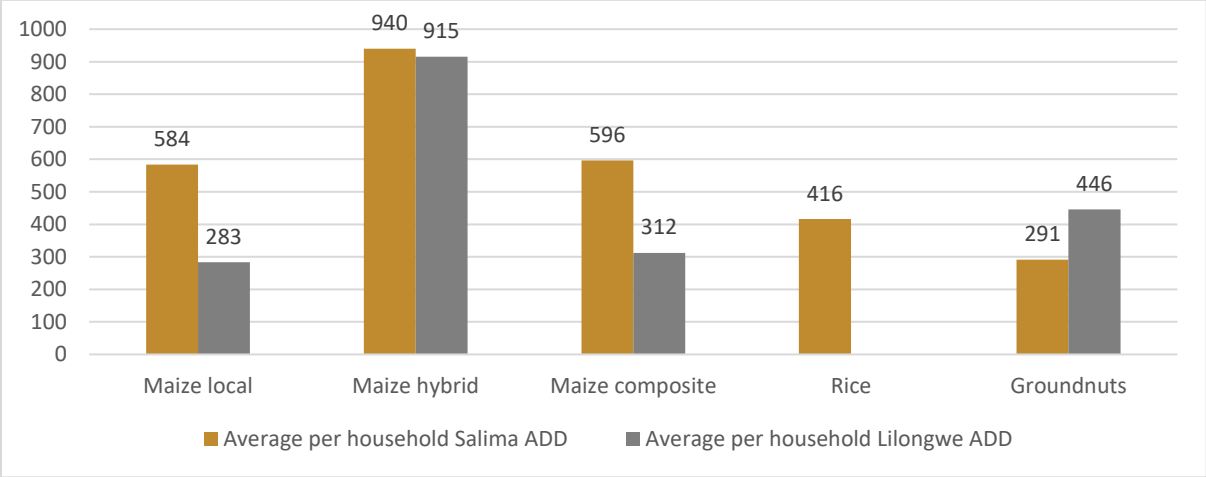


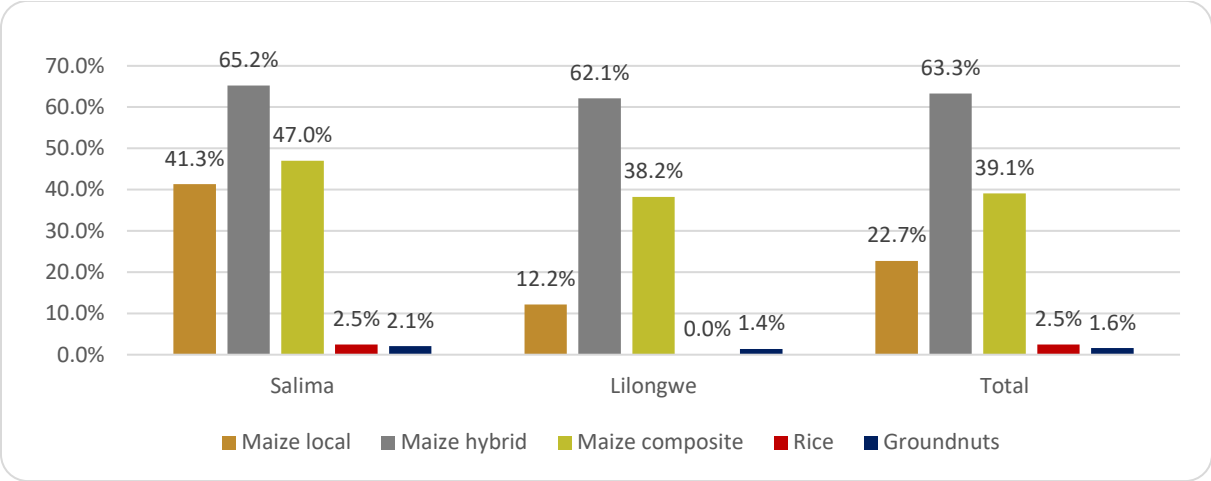
Figure 5 indicates that on average each household stored about 940 kg of hybrid maize in Salima and about 915 kg of the same variety in Lilongwe, while the average quantities stored per household varied from 283 kg to 596 kg for the other crops.

Table 9 provides information on the storage practices and facilities used by the farmers surveyed. Different crops are harvested and stored differently depending on the end utilization, for example if the crop is stored to build up the food stock of the household, as seeds for the following season or for selling. Among the interviewed households, polypropylene bags are the common type of storage facility, with nearly 77 percent of the households using them. More households in Lilongwe (80.3 percent) use polythene bags than in Salima (70.4 percent). Purdue improved crop storage bags were reported to be the second most common storage facility, with 16.6 percent of the farmers reporting using it. It is more common in Salima (25.6 percent) than in Lilongwe (11.9 percent). The results further show that traditional granary was used by only 4.9 percent of the farmers, more farmers in Lilongwe (5.7 percent) than in Salima (3.3 percent).

Table 9: Number and percentage of households by storage facility, by ADD

Facility type	Salima		Lilongwe		Total	
	Number of holdings	% of total	Number of holdings	% of total	Number of holdings	% of total
Metal silo	0	0.00	1 156	0.30	1 156	0.20
Traditional granary	7 669	3.30	25 391	5.70	33 060	4.90
Purdue improved crop storage bags	59 930	25.60	53 280	11.90	113 210	16.60
Polypropylene bags	164 630	70.40	358 949	80.30	523 579	76.90
Mudded granary	0	0.00	1 156	0.30	1 156	0.20
Other	1 671	0.70	7 208	1.60	8 879	1.30
Total	**233 900**	**100**	**447 141**	**100**	**681 040**	**100**

Figure 6: Use of pesticides during storage



The survey also collected information on the methods used to reduce grain loss at storage level. Among all the biotic factors, insect pests are considered the most damaging to grains during storage. The appropriate use of pesticides may therefore help reduce storage losses, through its role in controlling pest infestations. Survey results (Figure 6) indicate that the use of pesticides was higher in hybrid maize (63.3 percent), followed by composite maize (39.1 percent), local maize (22.7 percent), rice (2.5 percent) and groundnuts (1.6 percent). The use of pesticides for hybrid maize was slightly more common in Salima (65.2 percent) than in Lilongwe (62.1 percent). For local maize, the difference is more marked, with 41.3 percent in Salima and 12.2 percent in Lilongwe.

4. Analysis of Losses based on farmers' declaration

4.1 Methodology to compute losses

The study used computation methods described in the guidelines on the measurement of harvest and post-harvest losses developed by the GSARS (GSARS, 2018). The calculation approach is described in the Appendix II: Formulae for computing losses. The approach is succinctly described below.

The losses, generally expressed in kgs, were reported by the farmers. Quantities harvested and lost were extrapolated to ADD level using the sampling weights. Relative losses for all crops under study were calculated for harvest and post-harvest operations to measure the intensity of losses at each stage. The relative losses were calculated by dividing the estimated quantities lost at each stage by the estimated quantities handled at that stage, and expressed as a percentage. For instance, percentage storage losses were calculated by dividing the quantities of grain lost during storage by the quantities brought to storage. Using quantities brought to that particular stage as the denominator ensures that percentage losses are comprised between 0 percent and 100 percent. This measure of relative losses indicates the relative amount lost at each stage of the process. Relative losses at harvesting were calculated by dividing the quantities lost at harvesting by the sum of losses and quantities harvested, to ensure that the indicator is comprised between 0 and 100 percent[2].

[2] Harvested quantities being expressed net of losses, the losses at that stage may in principle be greater than the harvest, and may therefore lead to loss percentages greater than 100 if harvested quantities are used as the denominator.

4.2 Losses by operation

This section presents results on reported quantities of crop losses by operation: harvesting, threshing, cleaning/winnowing, drying and storage. The results indicate that for all crops, losses are greater at harvesting, followed by threshing (Table 10). Though the study did not investigate the causes of losses for each of these operations, it is likely that the use of manual methods contributes to these losses. Composite maize and groundnuts tend to experience higher losses in all stages, except for cleaning, where rice losses are the highest. Examination of results by ADD shows a similar pattern. A greater portion of harvest loss was experienced in Salima, the highest for composite maize (8.4 percent). In Lilongwe, a similar percentage loss of composite maize and groundnuts was experienced during harvesting period (7.7 percent).

The results of the study concur with findings of the previous studies conducted in Malawi. A study by the International Food Policy Research Institute (IFPRI) in 2017 found that groundnuts had slightly higher losses when compared with soya and maize. The present study concluded that losses at harvest were the highest for groundnuts and maize while IFPRI (2017) found that for soya they were highest during processing.

Table 10: Losses at each stage by Agriculture Development District

Salima						
Crop		Maize local	Maize hybrid	Maize composite	Rice	Groundnuts
Harvest	Quantity loss (Kg)	2 685 734	4 583 296	397 160	862 070	1 153 705
	Relative loss (%)	6.4	6.1	8.4	4.9	6
Threshing/ Shelling	Quantity loss (Kg)	731 927	1 664 718	48 238	292 030	313 560
	Relative loss (%)	2.8	2.2	1.2	3.6	4.7
Cleaning/ winnowing	Quantity loss (Kg)	169 852	565 046	24 861	273 581	72 765
	Relative loss (%)	1.4	1.3	0.5	3.9	2.2
Drying	Quantity loss (Kg)	264 138	550 333	34 661	208 259	321 076
	Relative loss (%)	1.4	1.8	0.9	4.1	3.5
Storage	Quantity loss (Kg)	568 408	1 088 825	82 740	85 725	332 643
	Relative loss (%)	2.2	1.9	1.9	1.2	5.5

Lilongwe					
Crop		Maize local	Maize hybrid	Maize composite	Groundnuts
Harvest	Quantity loss (Kg)	1 968 437	5 897 807	1 944 379	5 605 881
	Relative loss (%)	3.3	2.8	7.7	7.7
Threshing/ Shelling	Quantity loss (Kg)	1 338 319	2 041 329	1 216 944	404 001
	Relative loss (%)	2.9	2.6	6.3	2.7
Cleaning/ winnowing	Quantity loss (Kg)	586 743	1 112 213	617 659	143 206
	Relative loss (%)	1.8	3	3.7	3.4
Drying	Quantity loss (Kg)	528 077	1 060 349	167 776	1 054 788
	Relative loss (%)	1.8	3.1	6.4	3.7
Storage	Quantity loss (Kg)	638 995	1 434 605	303 304	740 040
	Relative loss (%)	4.4	4.1	3.3	4.6

Total						
Crop		Maize local	Maize hybrid	Maize composite	Rice	Groundnuts
Harvest	Quantity loss (Kg)	4 654 171	10 481 103	2 341 539	862 070	6 759 586
	Relative loss (%)	4.4	4.1	7.8	4.9	7.2
Threshing/ Shelling	Quantity loss (Kg)	2 070 246	3 706 047	1 265 182	292 030	717 561
	Relative loss (%)	2.9	2.4	5.7	3.6	3.2
Cleaning/ Winnowing	Quantity loss (Kg)	756 596	1 677 259	642 520	273 581	215 971
	Relative loss (%)	1.7	2.4	3.4	3.9	2.9
Drying	Quantity loss (Kg)	792 214	1 610 682	202 437	208 259	1 375 864
	Relative loss (%)	1.6	2.5	4.7	4.1	3.6
Storage	Quantity loss (Kg)	1 207 403	2 523 430	386 044	85 725	1 072 683
	Relative loss (%)	3.5	3.3	3.2	1.2	4.9

4.3 Strategies used to prevent post-harvest crop losses

Famers use different strategies to prevent post-harvest losses. These strategies are either based on previous experiences or adopted from technical recommendations provided by extension services, input or service providers. Overall, harvesting on time and proper drying were the most common practices used to prevent losses along the farmers surveyed (Table 11). The results show that 24 percent of the households from Lilongwe properly dried their crops to prevent post-harvest losses, the most common loss prevention strategy in this ADD. Households from Salima mainly focused on harvesting on time to limit post-harvest loss. The table further shows that 7.7 percent of the farmers reported applying chemicals to reduce losses. A negligible percentage of farmers declared not being aware of the strategies used to prevent post-harvest losses (0.3 percent).

Table 11: Strategies used to prevent crop loss by district

Strategy used	Salima		Lilongwe		Total	
	Number	% of total	Number	% of total	Total	% of total
Harvesting on time	109 928	23.10	209 532	21.60	319 461	22.10
Proper shelling	94 494	19.90	114 608	11.80	209 102	14.50
Proper drying	94 300	19.80	227 677	23.50	321 977	22.30
Winnowing	18 202	3.80	26 367	2.70	44 570	3.10
Re-drying	12 744	2.70	63 105	6.50	75 849	5.20
Storage hygiene	30 064	6.30	60 389	6.20	90 454	6.30
Stooking when harvesting	41 342	8.70	34 088	3.50	75 430	5.20
Use of chemicals	20 008	4.20	91 306	9.40	111 314	7.70
Timely application chemicals	24 138	5.10	69 949	7.20	94087	6.50
Use of protected granaries	5 280	1.10	21 096	2.20	26 376	1.80
Repair granary	542	0.10	5 052	0.50	5 594	0.40
Care when processing	11 458	2.40	42 620	4.40	54 077	3.70
Use of Ashes	4 338	0.90	0	0.00	4 338	0.30
Don't know	2 711	0.60	1 017	0.10	3 728	0.30
Nothing	3 254	0.70	0	0.00	3 254	0.20
Other	3 139	0.70	2 464	0.30	5 603	0.40
Total	475 942	100	969 270	100	1 445 214	100

Table 12 Percent of reported households with most effective post-harvest losses prevention actions

Strategy	Salima		Lilongwe		Total	
	Number of holdings	% of total	Number of holdings	% of total	Number of holdings	% of total
Harvesting on time	12 154	3	223 275	23	332 464	23
Proper shelling	53 491	15	76 372	8	129 864	9
Proper drying	66 642	18	95 786	10	162 428	11
Winnowing	19 057	5	10 163	1	29 221	2
Re-drying	13 269	4	64 282	7	77 550	5
Storage hygiene	40 226	11	97 630	10	137 858	10
Stooking when harvesting	28 858	8	37 337	4	66 196	5
Use of chemicals	34 042	9	138 546	14	172 588	12
Timely application chemicals	56 022	16	107 963	11	163 985	12
Use of protected granaries	12 799	4	56 145	6	68 944	5
Repair granary	0	0	1 664	0	1 664	0
Care when processing	16 063	4	49 895	5	65 957	5
Use of Ashes	1 464	0	0	0	1 464	0
Don't know	0	0	3 509	0	3 509	0
Nothing	0	0	2 681	0	2 681	0
Other	6 230	0	3 267	0	9 497	1
Total	**360 317**	**100**	**968 515**	**100**	**1 425 870**	**100**

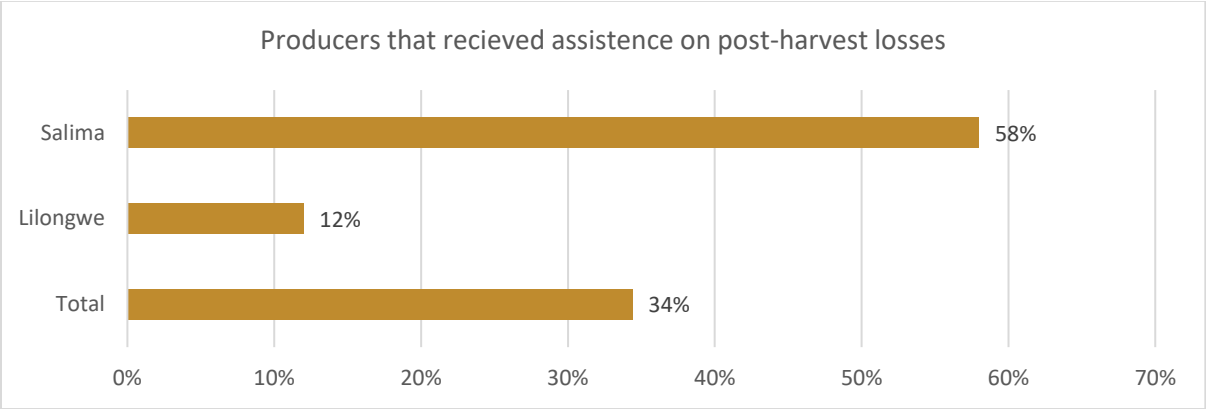
There may be some differences between what farmers consider as effective strategies to prevent losses and the practices that they effectively use, in part because of the cost of these practices and the difficulty to access the required inputs or equipment. In Salima, for example, while harvesting on time has been used by 23.1 percent of the farmers, only 3 percent of them consider this practice as effective in preventing losses (Table 12). For the other practices, overall there is a consistency between the practices used and those considered as most effective by the farmers.

The technical assistance on farm management received by farmers may explain why some fare better than others at reducing losses, even if the assistance received is not specific to losses. This study investigated the type of support provided: Table 13 shows that 50.4 percent of the households received assistance from either government or non-governmental organizations (40.1 percent in Lilongwe 40.1 percent and 69.8 percent in Salima). In terms of the type of assistance received, 44 percent of households received advices or information and 43 percent benefited from trainings. Direct assistance in the field is the least common type of technical assistance, with 11 percent of the farmers having reported it.

Table 13: Type of assistance received by households

Type of assistance	Salima	Lilongwe	Total
Received assistance (of which)	69.80	40.10	50.40
Trainings	39.90	51.60	42.80
Advices/Information	48.9%	28.90	44.0
Direct assistance in the field	8.4%	19.50	11.2
Other	2.70	0.00	2.10

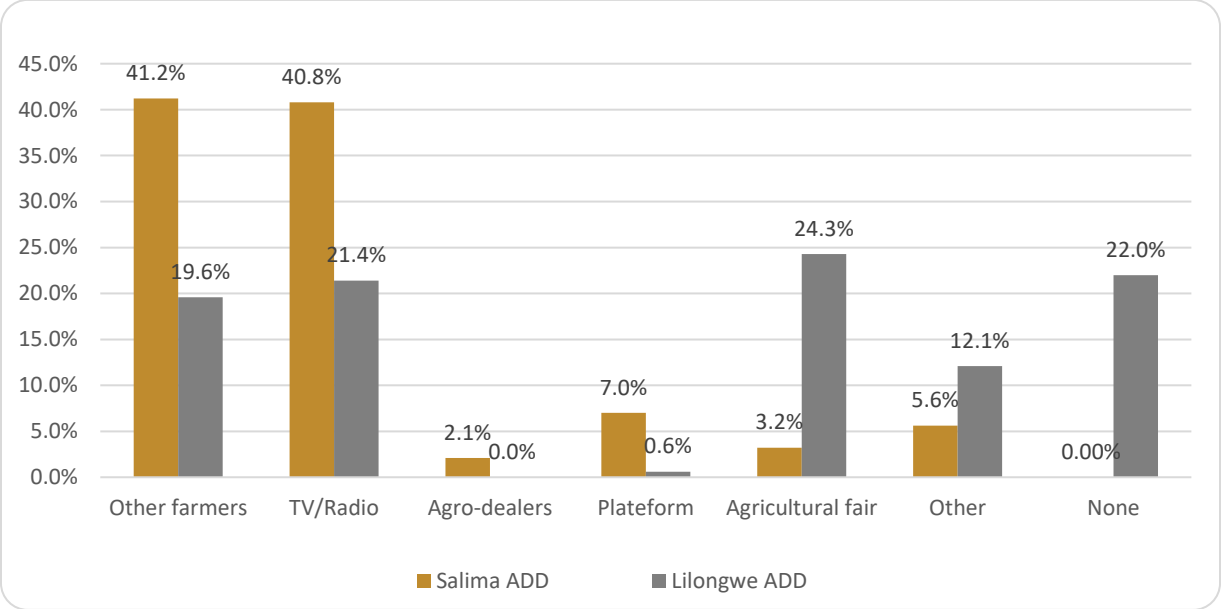
Figure 7: Assistance on post-harvest losses



In terms of the specific assistance on post-harvest losses (Figure 7), 34.4 percent of the households reported having received information on post-harvest losses management (58 percent in Salima and 12 percent in Lilongwe).

Regarding the main source of information used by the households to access post-harvest management information (Figure 8), 27.4 percent relied on TV/Radio (40.8 percent in Salima and 21.4 percent in Lilongwe). 24 percent of households from Lilongwe used agricultural fairs as their main source of information to obtain post-harvest management information, while this is only reported by 3.2 percent of the farmers in Salima. In this district, households mostly rely on other farmers to obtain information on loss management (41.2 percent). Information from agro-dealers was accessed by only 0.7 percent of households (2.1 percent in Salima and none in Lilongwe).

Figure 8: Main source of information



5. Conclusion and recommendations

The main findings of the study were that:

- Most losses occur at harvesting;
- For maize, the variety has an impact on the levels of losses for all the on-farm operations, except storage;
- On-time harvesting and the use of chemicals are considered by farmers as the most effective strategies for preventing post-harvest losses. The strategies effectively implemented by farmers show that the use of chemicals is less common than expected, probably because most farmers in the districts surveyed do not have enough financial resources to purchase enough of these products.

Overall, the findings of the present study are in line with other studies, such as IFPRI (2017). The improved methodology for estimating post-harvest losses presented in this document and tested in Malawi provides the methodological basis for improving the quality of the estimation of on-farm losses. The implementation of this pilot methodology on a larger-scale, for example through regular farm surveys conducted in the countries, would generate findings of direct relevance for policy interventions aimed at reducing losses.

For better results of future surveys, the following recommendations may be given to the organizations in charge of producing agricultural statistics:

- There is need to replicate the study with wider coverage to produce national and infra-national estimates. The survey needs to be integrated to existing national-wide surveys such as APES to lower operational costs and ensure sustainability.
- Since post-harvest losses are induced by several factors such as weather and climatic variations, the survey needs to be conducted consecutively for three years to establish the baseline data.
- There is need to introduce Computer assisted personal interview (CAPI) to improve the efficiency of data collection procedures and increase the quality of the data. Since 2012, the Global Strategy has been working closely with the World Bank Computational Tools team on the development and improvement of Survey Solutions (SuSo), an open-access software to design electronic questionnaires and manage surveys. The use of tablets aims at doing data collection and entry simultaneously: the data is collected using tablets and transmitted automatically to a server. The data collection program should be designed in such a way that errors are detected immediately during data entry hence reducing period for data cleaning.

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Appendices

Appendix I: Household questionnaire

SECTION A: Identification

Hello, my name is …… I am working with the Ministry of Agriculture, Irrigation and Water Development. We are carrying out a study on post-harvest losses. The main objective of the study is to measure losses that farmers are experiencing for the different operations within the holding.

The information you will provide will be strictly kept confidential. The interview will not take more than one hour.

A1) Name of ADD ……	ADD code |_____|
A2) Name of district ……	District code |_____|
A3) Name of EPA ……	EPA code |_____|
A4) Name of section ……	Section code |_____|
A5) Name of block ……	Block code |_____|

A6) Name of enumerator……..

A7) Identification number of the enumerator |_____|

A8) Date of the interview (day/month/year): ……../……../2018

A9) Name of field supervisor ……..

A10) Identification number of the field supervisor |_____|

A11) Questionnaire approved by field supervisor on (day/month/year): ……/……/2018

A12) Serial N° of the household |_____|

A13) Name of main respondent to this questionnaire ……..

A14) Serial N° of the main respondent of the questionnaire |_____|

A15) What is the main economic activity of the household? *(if 2, go to section B)* |_____|

A16) What type of agricultural activity is mainly carried out by the household |_____|

CODES

Codes for A15: 1= Agriculture; 2= Non-Agriculture

Codes for A16: 1= Rainfed field crops; 2= Irrigated field crops; 3= Horticulture; 4= Livestock; 5= Fishing; 6= Other

SECTION B: Socio-demographic characteristics of the agricultural household members								
						Only for household members above 5 years old		
Household member serial N°	Name of the household member (NAME)	What is the Sex of (NAME)?	What is the age of (NAME)? *For children below 1, put 00; for members over 98 years, put 99*	What is the relationship of (NAME) to the HH?	What is the marital status of (NAME)? *For children below 12, put 7*	Does (NAME) know how to read and write in any language?	What is the highest education level reached by (NAME)?	Does (NAME) participate in the farming activities of the holding during the current season?
Please start with the head of household (HH)		1=Male 2=Female	In completed years	1=HH 2=Spouse/Partner 3=Child 4=Brother/Sister 5=Spouse of child 6=Grandchild 7=Parent/Parent of spouse 8=Other relative 9=Other unrelated person	1=Married 2=Single 3=Divorced 4= Separated 5=Widower 6=Other 7=Not applicable	1=Yes 2=No	1= No education 2=Primary school 3= Secondary school 4=Tertiary education	1=Yes 2=No
B1	B2	B3	B4	B5	B6	B7	B8	B9
01		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
02		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
03		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|

04		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
05		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
06		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
07		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
08		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
09		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
10		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
11		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
12		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
13		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
14		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|
15		|___|	|___|___|	|___|	|___|	|___|	|___|	|___|

SECTION C: Agricultural practices: seeds, fertilizers, pesticides

Crop code	What is the area planted for this crop *(in ha)*?	Were the seeds recycled?	How were most of the seeds obtained?	How much seeds were used during the last season? *(in Kg)*	Did you use organic fertilizer for this crop?	Did you use inorganic fertilizer for this crop?	Did you use any pesticide for this crop? *If No, go to next crop*	Which type of pesticide did you mainly use?	Which other type of pesticide did you use? (second main)
C01	C02	C03	C04	C05	C06	C07	C08	C09	C10
|__||__|	|__|.|__|	|____|	|____|	|__|.|__|	|____|	|____|	|____|	|____|	|____|
|__||__|	|__|.|__|	|____|	|____|	|__|.|__|	|____|	|____|	|____|	|____|	|____|
|__||__|	|__|.|__|	|____|	|____|	|__|.|__|	|____|	|____|	|____|	|____|	|____|
CODES									

Codes for C01: 01=Maize local; 02=Maize hybrid; 03=Maize composite; 04: Rice; 05= Groundnuts; 06= Sorghum; 07= Millet; 08=Beans; 09= Pigeon peas; 10= Cow peas; 11= Field grams; 12= Soya beans; 13= Ground beans; 14= Chick peas

Codes for C03/C06/C07/C08: 1: Yes; 2= No

Codes for C04: 1=Own stock; 2= Purchase without subsides; 3= Purchase with subsidies; 4= Donations; 5= Other

Codes for C09: 1= Herbicides; 2= Insecticides; 3= Fungicides; 4=Other; 5=None

SECTION D: Losses by inquiry

D1) Harvesting				
D1-1) When did you start harvesting (month/year)?				|____||_____|
D1-2) When did you finish harvesting (month/year)				|____||_____|
D1-3) How many days did the harvest last?				|_____|
D1-4) What harvesting method was used?				|_____|
				Number of units Unit type
D1-5) What was the quantity harvested (in term of ears or cobs)?				|____||____|
D1-6) What is the weight of this unit in Kg?				|_____|
D1-7) What were the total quantities lost during harvest (in Kgs)? (You might need to convert in Kgs) *if 0 losses, go to next operation*				|_____|
D1-8) What are the three main causes of losses during harvest?				|___||___||___|
D2) Threshing/Shelling				
D2-1) Did you thresh/shell your harvest? (if No -> go to next operation)				|____|
If yes:				
D2-1-b) Is threshing/shelling and cleaning/winnowing done in one step?				|____|
D2-2) What was the threshing/shelling method used ?				|____|
				Number of units Unit type
D2-3) What was the quantity brought to threshing/shelling?				|____||____|
D2-4) What is the equivalent in Kg of the unit?				|_____|
D2-5) What were the total quantities lost during threshing (in Kgs)? (You might need to convert in Kgs)				|_____|

D2-6) What are the three main causes of losses during threshing/shelling?
|___||___||___|

D3) Cleaning/Winnowing

D3-1) Did you clean/winnow your harvest? (if No -> go to next operation) |_____|

If yes:

D3-2) What cleaning/winnowing method was used? |_____|

Number of units Unit type

D3-3) What was the quantity brought to cleaning/winnowing? |_____| |_____|

D3-4) What is the weight of this unit in Kg? |_____|

D3-5) What were the total quantities lost during cleaning/winnowing (in Kgs)?
(You might need to convert in Kgs) |_____|

D3-6) What are the three main causes of losses during cleaning/winnowing?
|___||___||___|

D4) Drying (Homestead)

D4-1) Did you dry your harvest? (if No -> go to next operation) |____|

If yes:

D4-2) What was the drying method used? |_____|

Number of units Unit type

D4-3) What was the quantity brought to drying? |_____||_____|

D4-4) What is the weight of this unit in Kg? |_____|

D4-5) What were the total quantities lost during drying (in Kgs)?
(You might need to convert in Kgs) |_____|

D4-6) What are the three main causes of losses during drying?
|___||___||___|

Crop: 01=Maize local; 02=Maize hybrid; 03=Maize composite; 04: Rice; 05= Groundnuts; 06= Sorghum; 07= Millet; 08=Beans; 09= Pigeon peas; 10= Cow peas; 11= Field grams; 12= Soya beans; 13= Ground beans; 14= Chick peas; 15= Not applicable Codes for D2-1, D3-1, D4-1: 1= Yes; 2= No Codes for D1-1/D1-2: 3=March; 4=April; 5=May; 6=June; 7=July; 8=August; 9=September; 10= October; 11= November Codes for D1-4/D2-2/D3-2: 1=Manual; 2=Mechanical Codes for D1-5/D2-3/D3-3/D4-3: 1=No unit; 2= Bags; 3= Baskets; 4= Bucket; 5=Drums; 6=Tins; 7=Pieces; 8=Kg; 9= Other local unit Code for D1-8/D2-6/D3-6/D4-6: 1=Spillage ; 2= Moulds; 3= Rotting; 4=Rodents/birds; 5= LGB; 6= Other pest infestation; 7= Weather/climate; 8= Other; 9= Not applicable Codes for D4-2: 1= Drying crib; 2= On the ground; 3= On the roof; 4= Other

SECTION E: Storage	
The questions in this form refer to the two main crops of the household	
E1) First crop |____|	
E1-1) Did you store your harvest at least for 1 month? *(Yes=1; No=2) if No, skip to E2*	|_____|
E1-2) How much did you store from the past harvest (in Kg)?	|_____|.|__|
E1-3) What is the storage type for this crop?	|_____|
E1-4) From this quantity (E1-2), how much did you consume/use by the household (in Kg)?	|_____|.|__|
E1-5) From this quantity (E1-2), how much did you sell (in Kg)?	|_____|.|__|
E1-6) From this quantity (E1-2), how much did you give away or payment in kind (in Kg)?	|_____|.|__|
E1-7) From this quantity (E1-2), how much is currently remaining in storage (in Kg)?	|_____|.|__|
E1-8) How much do you estimate losses at storage (in Kg)?	|_____|.|__|
E1-9) Did you use pesticides during the storage period to protect your crop? *(if no, go to E2)*	|_____|
E1-10) What is the main type of pesticide used?	|_____|

E1-11) Where did you get most of the pesticides from?	|_____|
E1-12) According to you, how effective are the pesticides used?	|_____|
E2) Second crop |_____|	
E2-1) Did you store your harvest at least for 1 month? *(Yes=1; No=2)if No, skip to F1*	|_____|
E2-2) How much did you store from the past harvest (in Kg)?	|_____|.|__|
E2-3) What is the storage type for this crop?	|_____|
E2-4) From this quantity (E2-2), how much did you consume/use by the household (in Kg)?	|_____|.|__|
E2-5) From this quantity (E2-2), how much did you sell (in Kg)?	|_____|.|__|
E2-6) From this quantity (E2-2), how much did you give away or payment in kind (in Kg)?	|_____|.|__|
E2-7) From this quantity (E2-2), how much is currently remaining in storage (in Kg)?	|_____|.|__|
E2-8) How much do you estimate losses at storage (in Kg)?	|_____|.|__|
E2-9) Did you use pesticides during the storage period to protect your crop? *(if no, go to E2)*	|_____|
E2-10) What is the main type of pesticide used?	|_____|
E2-11) Where did you get most of the pesticides from?	|_____|
E2-12) According to you, how effective are the pesticides used?	|_____|
CODES	
Codes for E1/E2: 01=Maize local; 02=Maize hybrid; 03=Maize composite; 04: Rice; 05= Groundnuts; 06= Sorghum; 07= Millet; 08=Beans; 09= Pigeon peas; 10= Cow peas; 11= Field grams; 12= Soya beans; 13= Ground beans; 14= Chick peas; 15= Not applicable Codes for E1-3/E2-3: 1= Metal silo; 2= Traditional granary; 3= Purdue improved crop storage bags; 4= Polypropylene bags; 5= Mudded granary; 6= Other Codes for E1-8/E2-8: Yes=1; No=2; Codes for E1-9/E2-9: 1= Dust ; 2= Liquid pesticides; 3= Granules; 4= Fumigants; 5= Other Codes for E1-10/E2-10: Agro dealers=1; Local vendors=2; Public/NGOs=3 Codes for E1-11/E2-11: Very effective=1; Effective=2; Little effective=3; No effective at all=4	

SECTION F: Prevention of post-harvest losses	
F1) What are the three main actions that you implemented to prevent Post-harvest Losses?	|____||____||____|
F2) According to you, what would be the three most effective actions to prevent Post-harvest Losses?	|____||____||____|
F3) Did the household receive any assistance from government or non-governmental organizations? *(if no, go to F8)*	|____|
F4) Did the household receive any specific assistance on Post-harvest Losses? *(If No, End of the section)*	|____|
F5) Which kind of assistance on PHL did you receive (the most important one)?	|____|
F6) Are you satisfied with the assistance received on Post-harvest Losses?	|____|
F7) What would you propose to improve the assistance received and services on Post-harvest Losses?	
F8) A part from the assistance received, what is the main source of information used to obtain post-harvest management information?	|____|
CODES	

Codes for F1/F2: 1= Harvesting on time; 2= Proper shelling; 3= Proper drying; 4= Winnowing; 5= Re-drying; 06= Storage hygiene; 07= Stocking when harvesting; 08= Use of chemicals; 09= Timely application chemicals; 10= Use of protected granaries; 11= Repair granary; 12= Care when processing; 13= Use of Ashes; 14= Don't know; 15= Nothing; 16= Other

Codes for F3/F4: 1=Yes; 2= No

Codes for F5: 1= Trainings; 2= Advices/Information; 3= Direct assistance in the field; 4= Other

Codes for F6: Very satisfied=1; Satisfied=2; Little satisfied=3; Not satisfied=4; No assistance=5

Codes for F8: 1= Other farmers; 2= TV/Radio; 3= Agro-dealers; 4= Platform; 5= Agricultural fair; 6= Other; 7= None

Appendix II: Formulae for computing losses by operations

Variables	Absolute (Kg)	Relative percentage
Harvested	H	
Brought to:		
Threshing/shelling	T	

Cleaning/winnowing	C	
Drying	D	
Transportation	Tr	
Storage	S	
Losses during:		
Harvesting	L_H	L_H / (H+L_H)
Threshing/shelling	L_T	L_T / T
Cleaning/winnowing	L_C	L_C / C
Drying	L_D	L_D / D
Transport	L_{Tr}	L_{Tr} / Tr
Storage	L_S	L_S / S
Aggregates:		
Post-harvest losses	L_{PH}= L_T + L_C + L_D + L_{Tr}+ L_S	$\frac{L_{PH}}{H}$
Harvest and post-harvest losses	L_{HPH}= L_H + L_{PH}	$\frac{L_{PH} + L_H}{H + L_H}$

Guidelines on the measurement of harvest and post-harvest losses

Estimation of crop harvest and post-harvest losses in Malawi

Maize, rice and groundnuts

FIELD TEST REPORT

A study was conducted in two Agriculture Development District (ADDs) of Malawi, Salima and Lilongwe, to pilot a new methodology for estimating on-farm harvest and post-harvest losses. The study was carried-out with technical support from the Global strategy to improve agricultural and rural statistics (GSARS) of the Food and Agricultural Organization of the United Nations (FAO). This pilot exercise principally aimed at strengthening the capacity of Malawi in generating reliable estimates on post-harvest losses. The data collection was carried out using a household questionnaire which was specifically developed for this exercise. The analysis of the results showed that a significant amount of farm produce is lost during harvesting, followed by threshing. The study also highlighted that on-time harvesting and use of chemicals are considered by farmers as the most effective strategies for preventing on-farm losses, even though farmers are not always in a position to implement these strategies. The authors recommend that a solid baseline on harvest and post-harvest losses be established by replicating on a larger scale this pilot survey for three consecutive years, to account for weather variation and other exogenous factors which may affect losses. The survey would benefit from the integration with existing country-wide data collection systems such as the Agricultural production estimates survey (APES) to ensure low operational costs and sustainability. It is also recommended that Computer assisted personal interviewing (CAPI) should be introduced for future exercises to improve on data quality and timeliness.

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