50x2030
DATA-SMART AGRICULTURE

TECHNICAL NOTE ON POST-HARVEST LOSSES

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50x2030 TECHNICAL NOTES FOR COUNTRY TEAMS

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The 50x2030 Initiative to Close the Agricultural Data Gap is a multi-agency effort aimed at supporting 50 low- and lower-middle-income countries to produce fundamental agricultural and rural data through the use of integrated agricultural and rural surveys. For more on the Initiative, please visit https://www.50x2030.org/.

This publication is part of a series of 50x2030 Technical Notes for Country Teams that will provide digestible, implementation-focused guidance for data producers and survey practitioners. Each note offers a brief summary of the motivation for specific survey design decisions followed by detailed, practical guidance that can be directly translated into survey design or training efforts. These notes are part of the existing 50x2030 Technical Note series.

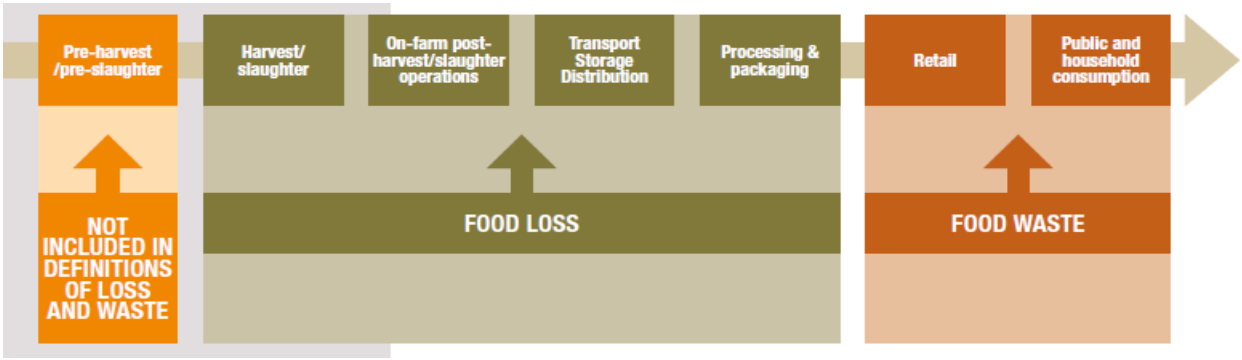
INTRODUCTION AND BACKGROUND

Measuring post-harvest losses (PHL) is essential to assess the actual food supply, as well as to detect the mechanism through which losses occur and for whom the impact may be greatest. Such information is critical to inform policies aiming at increasing food availability, improving food security, enhancing the competitiveness of agricultural producers and the efficiency of supply chains, as well as boosting the resilience of agricultural producers against economic and climate shocks. These objectives are particularly relevant in low- and middle-income countries, where agriculture often represents the main source of livelihood for large portions of the population and where losses are estimated to be particularly important.

FAO's recent global estimates[1] show that losses occurring from the farm to the retail stage (excluded) accounted for about 14 percent of food produced in 2016. Estimates also show a high variability across regions, ranging from around 5 percent in Australia and New Zealand to around 2 percent in Central and Southern Asia. The globally recognized importance of these losses is also reflected in SDG 12.3 which aims "to 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".

Food losses can occur at multiple stages of the value chain, at the production (harvest), post-harvest and processing stages in the food supply chain. International standards and definitions distinguish food losses (occurring at all stages from harvesting to processing and until the product reaches the wholesale market) from food waste (resulting from retailer and consumer behavior, while this is relatively less the case in low-income countries).[2] It is assumed that these losses are unintentional and the result of disruptions in production or in the supply chain. They typically include harvest and post-harvest losses, taking place off- or on-farm. Figure 1 shows the main operations in which food losses occur along the value chain.

Figure 1 - Operations and related losses along the value chain



Source: GSARS. 2018. *Harvest and Post-Harvest Loss Statistics. Improving the availability and quality of data for better design, monitoring and evaluation of loss reduction and prevention programs*. Statistics Division (ESS). FAO.

The wide array of causes for food losses, the various stakeholders that may be affected by losses at each stage, the differences across products, the different timing at which losses may occur, the variety of agro-ecologies and management practices, all this makes food losses extremely difficult to measure accurately. This reference note provides a guidance to survey practitioners for the collection of on-farm harvest and post-harvest losses

[1] FAO. 2019. *The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction*. Rome. Licence: CC BY-NC-SA 3.0 IGO.

[2] For more on the concepts related to food losses see GSARS. 2018. *Guidelines on the measurement of harvest and post-harvest losses.* GSARS Guidelines: Rome.

data in household and farm surveys. In particular, it lays out the approach proposed for 50x2030 surveys[3] [4], which largely builds on the experience learned in the framework of the Global Strategy to Improve Agricultural and Rural Statistics.

PRACTICAL GUIDANCE FOR CAPTURING ON-FARM PHL IN HOUSEHOLD AND FARM SURVEYS

In this technical note, PHL are defined as the losses occurring on the farm from harvest to storage and are restricted to grains, fruits and vegetables and roots and tubers.[5] More specifically, losses as defined in this note include losses during harvesting, post-harvest operations (depending on the crop, this would include threshing/shelling, cleaning/winnowing and drying, peeling, washing and slicing,). Losses also include on-farm transport, and storage at farm level[6].

Bearing in mind the objectives of obtaining reliable data under budgetary and operational constraints, declarative and physically measured data for different on-farm operations should be combined. Field tests show that the difference between physical and declarative measurements is higher for harvesting and storage losses than for other operations[7]. In addition, physical measurement for threshing, cleaning and drying operations is particularly complex and lengthy in terms of fieldwork and may be prone to measurement errors. For these reasons, measuring losses through physical measurement is recommended only for harvesting and storage, while the declarative assessment should be asked for all the on-farm operations.

Hence, the approach described in this note and proposed for collecting on-farm PHL data in 50x2030 surveys is based on a combination of declarative and physically measurements to be implemented in multiple visits over a number of agricultural seasons.

PLANNING AND PREPARATION

Given the complexity of collecting data on PHL and the need of obtaining reliable data without a detrimental increase in fatigue by farmers and enumerators and a rise in fieldwork costs, a number of preliminary considerations should be carefully taken into account.

First, it is important to combine the collection of data on PHL with existing surveys such as annual agricultural surveys, in order to maximize cost efficiency and leverage data sources. From this perspective, field visits planned for the PHL assessment should be combined with the visits planned for the 'main' survey. In addition, in

[3] For more on the 50x2030 Initiative to Close the Agricultural Data Gap visit the 50x2030 website.
[4] The 50x2030 modular survey system includes an optional module on harvest and post-harvest losses (HPHL-AG questionnaire). A detailed description of the HPHL-AG questionnaire and its integration into the 50x2030 modular survey system can be found here.
[5] In the rest of the document, for conciseness, the term post-harvest losses will refer to harvest and post-harvest losses, unless otherwise stated.
[6] For practical feasibility in data collection, the proposed approach is limited to the assessment of quantitative losses ("material rendered unfit for consumption" (GSARS, 2018)).
[7] For loss assessment results and comparisons between declarative and physical methods see GSARS. 2017. *Field Test Report on the Estimation of Crop Yields and Post-Harvest Losses in Ghana*. Technical Report no. 29. Global Strategy Technical Report: Rome; GSARS. 2018. *Field Test Report on the Estimation of Post-Harvest Losses in Malawi*; GSARS. 2018. *Field Test Report on the Estimation of Post-Harvest Losses in Zimbabwe*; GSARS. 2018. *Field Test Report on the Estimation of Post-Harvest Losses in Namibia*. Unpublished; FAO, INEGI and ICAR. 2019. *Pilot-Test of Post-Harvest Losses of Horticultural Crops in Mexico*. Unpublished.

case of an annual agricultural survey with crop-cutting components, physical assessment of harvest losses may be combined with yields estimation on the selected crop-cutting subplots. In addition, farm or household surveys usually include information that might be relevant for losses assessment and analysis (for example, information on harvested quantities and selling prices by commodities) or to understand the causes of losses.

Second, the scope of the data collection on PHL should be well defined ahead of the fieldwork activities. Analysis of existing data on agricultural production in a given country orregion must take place in order to identify the commodities on which to concentrate data collection efforts (especially for physical measurements). The selection of the commodities should be informed by their relative economic importance and their relevance in food security, as well as on country's policy priorities.

Third, since physical measurements may not be feasible at scale given the high costs of enumerators training, fieldwork and supervision, and given that international demand and the specific requirements for SDG 12.3.1 on the Food Loss Index is expected at country level only, data on PHL can be collected on a subsample of holdings, households and plots. Results should then be extrapolated to the entire population, to allow for high-quality post-harvest loss data at scale with minimal implementation burden. If there is an interest at country level to produce more disaggregated results, for example by farm types or regions, the sampling strategy and survey design should be adjusted accordingly.

Finally, as aggregate PHL parameters (for example, national averages), such as loss percentages by commodity and operation, are relatively stable from year to year, it is not recommended to carry out the HPHL-AG module on a yearly basis. A frequency of every three to five years is sufficient. However, to establish a good baseline, a first series of measurements over three consecutive years is recommended, to weed out annual fluctuations in losses caused by, for example, rain at harvest and capture the structural average level. If fieldwork implementation of the HPHL module is not feasible for three consecutive years because of technical and financial constraints, at least two consecutive measurements should be considered, meanwhile lighter measurement approaches can be carried out in between two or three survey rounds. However, in case of an agricultural survey conducted every year, the survey should include the main agricultural variables influencing losses for each crop, as well as climatic factors. This information can then be used for adjusting PHL parameters in between survey rounds.

TIMELINE OF FIELD VISITS

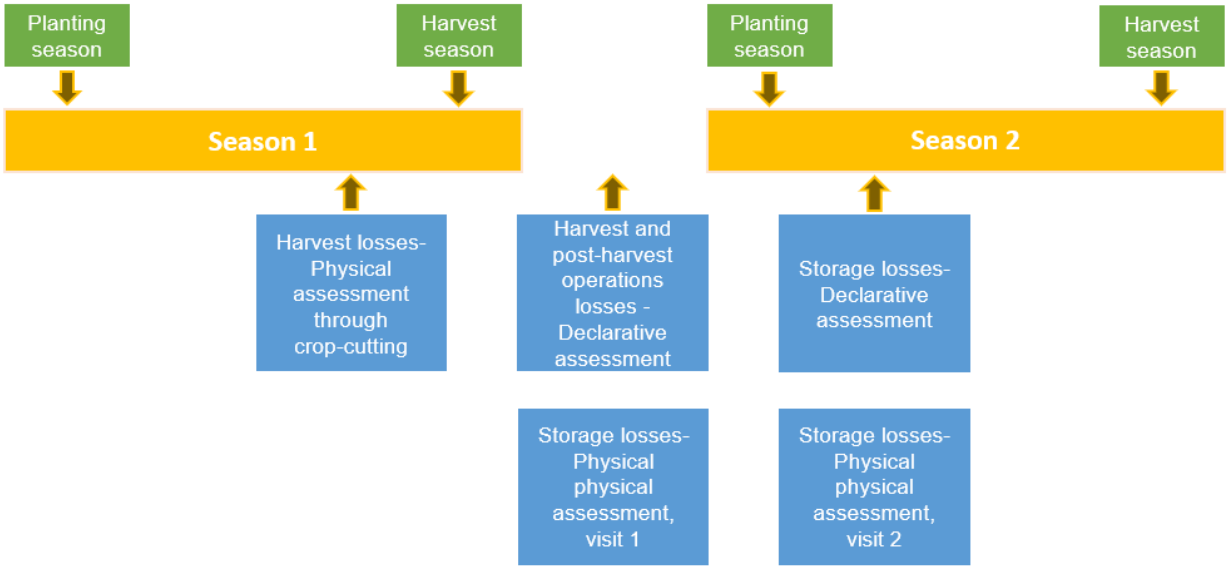
Since losses occur at different times and for different operations, ideally PHL assessment should be implemented over different visits, with the visits fielded closely to the post-production operation that is being measured. In practice, the number of field visits impacts the costs of survey operations and the overall implementation feasibility of the survey. In addition, in case of a PHL assessment integrated with an existing farm and household survey, the timing and frequency of the visits for the PHL assessment may have to follow the timing of the visits scheduled for the main survey. PHL assessments should consist of three main instruments, broadly corresponding to the main crop-specific operations that may be performed on the farm in traditional farming systems. (i) harvesting, (ii) post-harvest operations[8], including on-farm transport, and (iii) storage at farm level (storage losses are distinguished from other types of losses because of their specificity in terms of measurement).

The physical measurement of harvest losses should be fielded together with the crop-cutting harvest visit (when planned in the main survey), i.e. right before the farmers start harvesting. The declarative losses assessment for post-harvest operations (excluding storage) should be fielded as soon as the farmers finish harvesting their plots (together with the post-harvesting visit, if planned in the 'main' survey).

[8] The type of post-harvest operations depends on the crop. For grains, they typically include: threshing/shelling, cleaning/winnowing and drying. For roots, tubers, fruits and vegetables, other post-harvest operations apply, such as peeling, washing, slicing and so on.

Assessing storage losses through physical measurement requires two visits spreading over a period of three to nine months. The first visit should be fielded soon after the harvested crops are stored, i.e. at the same time of the declarative losses assessment for harvest and post-harvest operations (post-harvest visit). In order to reduce fieldwork costs, the second visit should take place at the same time as the post-planting visit of the following agricultural season, ideally after three to nine months after the previous visit (for fruits and vegetables, the second visit could take place earlier, as storage durations are lower). The declarative assessment of losses at storage level should be fielded together with the second visit for the physical measurement of storage losses.

Figure 2 - Timing of field visits over the agricultural season



MEASURING HARVEST AND STORAGE LOSSES

This section briefly describes the approach proposed in the 50x2030 surveys to collect PHL data through both physical and declarative measurements. For the implementation and costs related issues mentioned above, the measurement of losses through physical measurement is recommended only for harvesting and storage, while the declarative assessment should be asked for all the on-farm operations. Combining physical and declarative measurements methods in a given year allows to determine a proper benchmark and adjustment factors for that year, and to use such adjustment factors to correct farmers' assessments when the physical measurement methods are not implemented.

Measuring harvest losses

The physical assessment of harvest losses is based on the crop-cutting subplot selection and, in order to maximize cost efficiency, it should be combined with an existing survey implementing a crop-cutting component for production assessment. Indeed, some of the operations required for measuring harvest losses are also required for the production assessment.

The following operations are specific for crop-cutting measurement of harvest losses for grains[9], although the physical measurements of losses for fruits and vegetables follow the same logic than for grains[10].

1. crop-cutting plots (subplots) are randomly[11] placed in each selected plot before the farmer starts harvesting the plot[12]. The selection, size and placement of subplots depends on the crop density and on local cropping practices.
2. on the selected crop-cutting plot(s), before harvesting the plot, the farmer picks-up from the ground the grains, ears or cobs fallen on the ground and that the farmer would typically not include in its harvest (for example, damaged or rotten produce). This amount is weighted and can be considered as pre-harvest losses and should therefore be excluded from the PHL assessment.
3. the crop-cutting plot is harvested following the usual farmer practices and the harvested quantity corresponds to the yield of the crop-cutting plot.
4. the farmers picks-up the produce remaining on the ground or standing plants and weighs it: this corresponds to the quantities lost during the harvesting of the sub-plot.

The following equipment and materials (also required for the production assessment through crop-cutting) will be required for each field team: measuring tape; solid demarcating tool; shears, knives and sickles; bags for the harvested crops; portable weighing scales; and rolls of string.

The physical measurements must reflect as closely as possible the actual practices of the farmer, as the module intends to measure the losses effectively occurring on the field and not theoretical losses. But, even when the operations are carried out by the farmer (and this is the recommended strategy), the farmer might attempt to harvest the crop-cutting plot and handle the bundles differently from the practice usually followed, typically with more care. Conversely, in case the operations are carried out by enumerators, they may not use exactly the actual farmer's practice.

Since physical measurements of harvest losses are complex, time-consuming and expensive, it is recommended to restrict them to a subsample. The measurement of harvest losses through crop-cutting should be complemented by a declarative assessment by farmers. Farmers should be asked to report losses occurred during harvest, as well as the main causes of losses. As the plot characteristics may affect losses during harvest (for example topography, drainage, and so on), this information should be collected at the at parcel,[13]plot or crop level. Farmers could be asked to provide an estimate of losses relative to a benchmark (relative approach) or could be asked to provide the total quantities lost directly (absolute approach). In order to collect more precise estimations of losses, farmers should be allowed to report losses the way they are most comfortable. Also, if the absolute approach is chosen, it is important to allow respondents to report quantities in the units with which they are most familiar, including non-standard units. Figure 3 provides an example of a module asking farmers to provide the quantities lost during harvest for specific parcels/plots/crops.

[9] Details on the measurement techniques can be found in GSARS. 2018a. *Guidelines on the measurement of harvest and post-harvest losses*. GSARS Guidelines: Rome.

[10] For fruits and vegetables, the physical measurements follow the same logic than for grains. Sub-plots for crop-cutting experiments may be smaller for vegetables and certain fruits that tend to be grown on smaller parcels[10] (for example, lettuce, broccoli and strawberries). The measurement of yields and harvest losses for fruit trees are usually based on a random selection of trees in parcels rather than on a sub-plot.

[11] For fruit trees the random selection may not be applicable because not all trees produce ripe fruits at the same time. The farmer may have to choose which trees are ready for harvest and the selection would be purposive.

[12] Procedures and protocols are explained and discussed in FAO. 2018. *Handbook on crop statistics: improving methods for measuring crop area, production and yield*. .

[13] The term *parcel* is used to define a piece of land of one tenure type entirely surrounded by other land, water, roads, forests of a different tenure type that may or may not be used or owned by the same household. Different terms like field or garden can be used for the same concept, depending on the context where the survey is fielded.

Figure 3 – Declarative assessment of harvest losses

HARVEST LOSSES

PARCEL ID	PLOT ID	CROP ID	CNAMPE	1. Who is the respondent for this crop in this plot?	2. What harvesting method was used for [CROP]? MANUAL.....1 MECHANICAL.2	3 What were the quantities lost during harvest of [CROP]? SEE CROP CONDITION/STATE & UNIT CODES FILL IN OPTION 2 (PERCENTAGE) ONLY IF THE FARMER CANNOT PROVIDE AN APPROXIMATE QUANTITY FOR OPTION 1.								4 What was the main cause of losses during harvest? SPILLAGE.....1 PHYSICAL DAMAGE/BREAKAGE.....2 RODENTS OR BIRDS....3 OTHER PESTS.....4 DELAYED HARVESTING..5 OTHER CAUSES, SPECIFY.....6		
						OPTION 1			OPTION 2	OPTION 1			OPTION 2			
CODE	CODE	CODE	NAME	CODE ID	CODE	CONDITION/ STATE 1	QTY 1	UNIT 1	%	CONDITION/ STATE 2	QTY 2	UNIT 2	%	CODE		
1	1	1														

Measuring post-harvest operation losses

In order to minimize the implementation burden, and given that field tests show that the difference between physical and declarative measurements is higher for harvesting and storage losses, it is recommended to collect data on losses during specific post-harvest operations through the declarative farmers' assessment. Post-harvest operations are crop specific. For grains, they typically include threshing and shelling, cleaning and winnowing and drying. For roots, tubers, fruits and vegetables, other post-harvest operations apply, such as peeling, washing, slicing and so on. Losses from on-farm transport are also included in this module. The methods adopted for each of the mentioned activities, as well as the causes of losses, should also be asked. For example, as for threshing it should be asked whether the threshing method used for a specific crop was manual, mechanical or animal. This information allows to relate the level of losses with the techniques adopted by the farmers. Figure 4 provides an example of a module asking farmers to provide an estimation of losses for each post-harvest operation at crop level.

Figure 4 - Declarative assessment of losses for post-harvest operations

THRESHING/SHELLING LOSSES

CROP CODE	CROP NAME	5. Who is the respondent for this crop?	6. Did you thresh/shell your harvest of [CROP]? YES..1 NO...2 ▶12 if CROP = root or tuber go directly to Q12.	7. Was threshing and cleaning/winnowing done in one step for [CROP]? YES..1 ▶QUESTIONS 8 TO 11 SHOULD BE ASKED FOR THE COMBINED STEP NO...2	8. What was the threshing method used for [CROP]? MANUAL.....1 MECHANICAL.2 ANIMAL.....3	9. What was the quantity of [CROP] brought to threshing?		10. How much of grain do you think you lost during threshing? FILL IN OPTION 2 (PERCENTAGE) ONLY IF THE FARMER CANNOT PROVIDE AN APPROXIMATE QUANTITY FOR OPTION 1. IF NONE, RECORD ZERO AND ▶12				11 What was the main cause of losses during threshing of [CROP]? SPILLAGE.....1 PHYSICAL DAMAGE/BREAKAGE.....2 PESTS.....3 WET GRAIN.....4 IMPROPER USE OF THE THRESHER.....5 OTHER CAUSES, SPECIFY.....6 IF Q6=1 GO TO Q16
								OPTION 1			OPTION 2	
CODE	NAME	CODE ID	CODE	CODE	CODE	QTY	UNIT	QTY	CONDITION	UNIT	%	CODE
1												
2												

Measuring storage losses

The physical measurement of storage losses is implemented in two visits. The first visit should take place soon after the harvested crops are stored, ideally within one month, and the second one ideally three to nine months after the previous visit, mainly depending on the storage practices for the crop (and in particular on how long the crop is stored). The comparison between the two visits provides an estimate of the losses attributable to storage.

The main steps of the measurement of grains losses during storage are the following – and they should be repeated for each of the two visits:

1. the amount of produce stored at the time of the visit, as declared by the farmer, is recorded;
2. a sample of produce is taken, generally in two steps: first by randomly selecting a sample of packaging units (bags, boxes, drums, etc.) and second by selecting a sample of grains within these units. If the grain is stored in loose form, the selection is done in one step;

3. the moisture content in the sample of grains is recorded, damaged and undamaged grains are separated and weighed. Ideally, the analysis of the grain should be done by a specialized laboratory that would also have the skills to identify the main causes of grain damage in each sample (type of insect, fungi, rodent, etc.).

The difference in the percentage losses between the two visits provides an estimate of the relative losses during storage. Multiplying this percentage by the quantity of produce stored provides an estimate of the quantities lost during storage.

Since physical measurements of storage losses are complex, time-consuming and expensive, it is recommended to restrict them to a subsample and to complement such assessment with a farmer's declarative assessment, to be implemented in the full sample. This module should collect not only the farmers' subjective assessment of losses occurred during storage but also the storage type used, as well as the causes of losses. Figure 5 provides an example of a module asking farmers to provide an estimation of losses for storage.

Figure 5 - Declarative assessment of storage losses

2.	3.	4.	5.		6.				7.	8
Did you store any of the harvested [CROP] ? YES..1 NO...2 ▶NEXT CROP	What is the storage facility for this [CROP]? WAREHOUSE/ROOM.....1 METAL SILO.....2 TRADITIONAL GRANARY....3 IMPROVED GRANARY.....4 OUTSIDE .....5 UNDER GROUND.....6 OTHER,SPECIFY.....7	What is the storage container for this [CROP]? PLASTIC DRUMS.....1 METAL DRUMS.....2 JUTE BAGS.....3 POLYPROPYLENE BAGS.....4 BULK (E.G HEAP).....5 OTHER, SPECIFY.....6	How much [CROP] did you store from the past harvest ?		How much of [CROP] do you think you lost during storage? *FILL IN OPTION 2 (PERCENTAGE) ONLY IF THE FARMER CANNOT PROVIDE AN APPROXIMATE QUANTITY FOR OPTION 1.* *IF NONE, RECORD ZERO AND ▶ NEXT CROP*				Did you use pesticides during the storage period to protect your [CROP] ? YES..1 NO...2 ▶ NEXT CROP	What was the main cause of losses at the storage level of [CROP]? IMSECTS.....1 RODENTS OR BIRDS.....2 FUNGI.....3 OTHER PESTS.....4 CLIMATIC CONDITIONS....5 OTHER, SPECIFY.....6
					OPTION 1			OPTION 2		
CODE	CODE		QTY	UNIT	QTY	CONDITION	UNIT	%	CODE	CODE

Finally, the assessment of harvest and post-harvest losses should be complemented by asking farmers to report the main actions implemented to prevent losses (by crop) as well as the main limitation faced in the implementation of these practices. These questions could be insightful for understanding the practices used and the constraints faced by the farmers and linking this information with loss levels. Figure 6 shows an example of the questions about the practices implemented to prevent losses.

Figure 6 – Prevention of harvest and post-harvest losses

		1.	2.	3.	4.
CROP CODE	CROP NAME	What practices were implemented to prevent losses during harvest ? HARVESTING EARLY/BEFORE MATURITY...1 HARVESTING ON TIME.....2 REDUCING HARVESTING TIME.....3 APPROPRIATE HARVESTING METHOD.....4 IMMEDIATE TRANSPORT OFF-FIELD.....5 STOOKING WHEN HARVESTING.....6 NONE.....7 OTHER, SPECIFY.....8 Multiple answers allowed	What practices were implemented to prevent losses during post-harvest operations ? Multiple answers allowed USE OF ADEQUATE EQUIPMENT AND FACILITIES.....1 PROCESSING DRY GRAIN.....2 HANDLING OF GREEN OR SEMI-MATURE PRODUCE.....3 OPTIMIZING POST-HARVEST PROCESSES.....4 NONE.....5 OTHER, SPECIFY.....6 *For grains, post-harvest operations generally include threshing, cleaning and drying.* *For vegetables and fruits post-harvest operations generally include collection, cleaning, grading and packing. For roots and tubers, post-harvest operations generally include collection, drying (for certain crops), cleaning, grading and packing*	What practices were implemented to prevent losses during storage ? STORAGE OF DRY PRODUCE.....1 STORAGE OF GREEN OR SEMI-MATURE PRODUCE...2 MINIMIZING STORAGE TIME.....3 APPLYING PESTICIDES.....4 ADEQUATE PACKAGING AND CONDITIONING.....5 CONTROLING STORAGE TEMPERATURE/HUMIDITY...6 NONE.....7 OTHER, SPECIFY.....8 Multiple answers allowed	What is the main limitation faced in the implementation of practices to reduce losses during harvest, post-harvest operations and storage? LACK OF TECHNICAL KNOW-HOW.....1 UNAVAILABILITY OF ADEQUATE EQUIPMENT AND MACHINERY.....2 INSUFICIENT FINANCIAL RESOURCES.....3 REGULATION/CERTIFICATION REQUIREMENTS.....4 OTHER, SPECIFY.....5 NONE.....6
CODE	NAME	CODES	CODES	CODES	CODE
1					