MEASURING FOOD LOSSES

Session 2:
Measuring grain losses on a farm
Objectives of the presentation

• Provide guidance on the measurement of grain losses on a farm

• Present the different data collection and measurement techniques or methods to estimate grain losses
Outline

• Introduction

• Overview of measurement approaches

• Measuring losses based on farmer’s declarations

• Measuring losses based on objective measurements

• Measuring losses based on visual scales

• Overview of off-farm loss measurement approaches
Introduction

• Obtaining reliable information on losses on a farm is **challenging**
  ➢ Several approaches have been tried in different countries and contexts

• No one-fits-all **set of methods or techniques**

• Post-harvest loss assessment activities should be **coordinated** with other data collection exercises: agricultural and rural surveys (especially those involving yield measurements and crop-cutting), income and expenditure surveys, nutrition assessments, etc.

• The data collected **should adhere to international classifications, standards and definitions** used for food and agriculture and advocated by FAO and other United Nations entities
Overview of measurement approaches
1.1. Data collection: introduction

- Initial or rapid baseline surveys
- Sample surveys based on probabilistic sampling
- Experimental design (field trials)
- Other techniques, including non-probabilistic surveys
1.1. Data collection: survey approaches

- **Initial or rapid baseline surveys (pilot):**
  - Preliminary examination of specific problem points, conducted first to expose the most serious grain loss points
  - The first steps makes it possible to understand better the post-harvest system, and identify the causes of losses
  - Relevant data from other sources, such as rainfall and temperature, should be collected at the same time
1.1. Data collection: survey approaches

- **Probability sample surveys:**
  - Used for the main loss assessment, with the aim to obtain statistically reliable data for different administrative and agroecological units, including villages, regional units and national units.
  - Samples are selected using **probabilistic procedures.** Several procedures exist:
    - Simple, stratified or clustered random sampling
    - With equal probabilities of selection or proportional to size (in case units vary significantly in size)
  - These surveys are best suited to situations in which the target population is numerous, scattered and heterogeneous, such as rural farming areas.
1.1. Data collection: non-survey approaches

• **Experimental designs (field trials):**
  - Small sample of units (farms, fields, storage facilities)
  - Different crops, conditions, farming practices, etc.
  - Small sample size allows in-depth measurements and fieldwork
  - On-farm, can be used to assess the impact of harvesting techniques or storage practices on losses
  - Off-farm, storage simulation trials can be conducted at research stations with a high degree of control over the conditions of the experiment

  - **Drawbacks:** small sample, non-probabilistic selection => lack of statistical representativity and robustness
1.2. Measurement techniques

Once the data collection method has been chosen, the measurement approach needs to be specified:

- **On-farm physical measurements**: for crop area, harvest (crop-cutting) and post-harvest operations
- **On-farm post-harvest operations**: for example, weigh-in of produce when it is being processed, such as threshed and winnowed, cleaned and dried, transported or milled, and weigh-out at the end
- **Laboratory analysis** of grains stored
- **Farmer’s own estimates or declarations**
- **Visual scales**: mix between objective and subjective methods
1.3. Modelling approaches

- Modelling can be used to fill in data collection gaps (such as between two surveys) and when the data collected needs to be improved or corrected before dissemination.

- It combines data from different sources in a modelling framework (such as econometric) to come up with reliable loss estimates: data from surveys and administrative records can be used to estimate model parameters.

- It is often used by researchers to identify and estimate the major determinants of post-harvest losses.

- The advantages are the lower cost and the ability to predict losses in advance so that decision-makers can adopt appropriate and timely measures.

- Disadvantages are related to the quality of the estimates (such as precision and coverage), based on the modelling approach and quality of the underlying data.
Measuring losses based on farmer’s declarations
2.1. Farmer’s declarations: description

• Ask farmers if they experienced losses and an estimate of the amount lost (% or kg)

• In most farm surveys, only losses during storage are considered

• Losses by type of operation (such as harvest and threshing) can be difficult to report by the farmer

• Advantage: lighter and quicker approach than objective measurement

• Inconvenient: subjectivity because sometimes the required information is not available
2.2. Farmer’s declarations - Example: approach adopted in Ghana

**LEVEL**
- **DISTRICT**

**SIZE**
- 2 districts: Kintampo North and Sawla
- Purposive, based on the availability of listings
- 20 per district
- Proportional to size (# of agri households)
- 14 per EA: 6 enquiry-only, 8 enquiry + measurement
- Equal probability of selection
- 1 field per farm and commodity

**SELECTION METHOD**
**Enumeration Area**

**Agricultural Households**

**Fields**
2.2. Farmer’s declarations - Example: approach adopted in Ghana

<table>
<thead>
<tr>
<th>4.1 Main CROP</th>
<th>Equipment used</th>
<th>Quantity handled</th>
<th>Unit</th>
<th>Weight of unit in Kg</th>
<th>Quantity lost</th>
<th>Unit</th>
<th>Weight of unit in Kg</th>
<th>Causes of Loss</th>
<th>Harvest period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2 Harvesting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.3 Threshing/Shelling/dehusking</td>
<td>57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.4 Winnowing/Sieving/Cleaning</td>
<td>73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5 Drying</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.6 Transport (threshing to store)</td>
<td>105</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.7 Storage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 2.2. Farmer’s declarations - Ghana: preliminary results

<table>
<thead>
<tr>
<th>Crops</th>
<th>All districts</th>
<th>Kintampo</th>
<th>Sawla</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millet</td>
<td>5.3</td>
<td>-</td>
<td>4.7</td>
</tr>
<tr>
<td>Maize</td>
<td>11.6</td>
<td>14.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Rice</td>
<td>9.4</td>
<td>9.9</td>
<td>4.5</td>
</tr>
<tr>
<td>Sorghum</td>
<td>3.4</td>
<td>11.1</td>
<td>2.4</td>
</tr>
</tbody>
</table>
2.2. Farmer’s declarations - Ghana: preliminary results
2.3. Farmer’s declarations: limitations and challenges

• **Under-reporting** of yields and losses

• **Complexity** of the questionnaire

• **Reference period, timing**: past, current or future harvest?
Measuring losses based on objective measurements
3.1. Objective measurements: description

- On and off-farm processes and operations

- These processes are not applicable for all crops or situations.
- Transport (on and off-farm) could be also added between each operation
3.1. Objective measurements: description

• **Harvesting:**

  - Post-production = harvest + post-harvest
  - Manual or mechanized approach
  - Losses mainly are the result of shattering and shedding of grains
  - Loss measurement should be linked with an annual production survey (crop-cutting)
  - Pick the grains or cobs you found in the field before crop-cutting
  - The crop-cutting plot selected at random within the field before harvesting
  - The crop-cutting plot is harvested according to the usual farmer practices and the yield is weighted and recorded
  - All ears, cobs or grains remaining on the field are picked up and weighed for estimating harvest loss
3.1. Objective measurements: description

• **Stacking and stooking:**

  ➢ The produce may be stacked or stooked in the field to make it dry

  ➢ Losses are mainly the result of shedding and scattering

  ➢ Stacks and stooks are built on a plastic sheet or tarpaulin to collect all scattered grains (do not change the usual situation for the farmer)

  ➢ Standard techniques for estimating losses because of insects during stacking when this process takes many months
3.1. Objective measurements: description

• Threshing and shelling:
  - Grains are beaten to separate them from the husk (rice), cob or ear
  - Losses occur because of damage to the grain, spillage or scattering
  - The produce from the crop-cutting plot is threshed based on the farmer’s practices
  - A sample of discarded grain-straw mixture is taken (e.g. 250 g)
  - The loss is estimated from the grain remaining in the grain-straw mixture
3.1. Objective measurements: description

• Cleaning and winnowing:
  ➢ Blowing away the chaff, bran and other material from the grain obtained after threshing
  ➢ Loss occurs as edible grain passes into the chaff
  ➢ A sample of the threshed grain is selected and cleaned and winnowed, according to the farmer’s practices
  ➢ The grain remaining in a sample of unclean mixture or chaff is collected and weighed to measure losses
3.1. Objective measurements: description

- Machinery can be used for some or all of the operations => measurement approach needs to be adapted
- Example 1: combined harvester-thresher
3.1. Objective measurements: Description

• **Machinery can be used for some or all of the operations**
  => measurement approach needs to be adapted

• **Example 1: Combined harvester-thresher**

  ➢ Estimate the **pre-harvest** losses for any given field by setting up at least two randomly selected “crop-cutting plots” and gathering inside the delimited plots grains already that has already fallen on the ground prior to the start of harvesting

  ➢ Let the combine harvest the whole field; when the combine finishes harvesting, set up again two randomly selected crop-cutting plots and gather all grain fallen and on stalks

  ➢ The amounts gathered during the two steps are then used to estimate the losses because of the combine in the field
3.1. Objective measurements: description

- Example 2: mechanical maize shellers

Same measurement approach as the one for manual threshing can be adopted
3.1. Objective measurements: description

• Drying:

- Losses from birds, rodents, insect and other pests

- **Data required**: quantity of grain initially spread out for drying; moisture content and the quantity of dried grain collected by the farmer after drying

- Measurement usually done on a sample of dried grain
3.1. Objective measurements: description

• **Storage:**
  - Greatest post-harvest loss usually occurs during storage
  - Easier to estimate, to prevent and reduce
  - At farm level, trader, processor, retailer, wholesaler, government and private warehouses, etc.
  - Losses caused by insects, mites, pests, moulds, fungi, etc.
  - To estimate losses, samples must be taken at regular intervals over a sufficiently long time period, such as monthly during a six-month period for a farm
  - Assessment methods: **Visual scale**, **Standard Volume and Weight Methods (SVM)**, **Count and weigh or gravimetric method**, Converted Percentage Damage method, **Thousand Grain Mass Method (TGM)**
3.1. Objective measurements: description

• **Transport:**

  - **On-farm:** from field to the threshing floor, threshing floor to the storage
  - **Off-farm:** from storage to the market, with different modes of transport being used at different stages
  - Losses are normally estimated as the difference of weights between the quantity loaded and the quantity unloaded (**weigh-in and weigh-out**)
  - **For long transport operations** (such as to reach ports and other export points), moisture content and qualitative damage during transit should also be assessed
3.1. Objective measurements: description

• **Processing:**

  ➢ Traditional hand processing or mechanical processing is used to process grain through dehusking, milling and grinding of grains

  ➢ Grain loss is normally expressed as a reduction in the quality of the finished product

  ➢ At the farm level, it should be possible to weigh the grain before processing, and after, to obtain a measure of physical loss

  ➢ A comparison between the products of the process with that of a sample of grain carefully processed in the laboratory will provide an indication of the loss of quality
3.1. Objective measurements: description

- **Packaging:**
  - Losses occur as a result of defects in the methods of packaging and handling of grains, leading to shedding, scattering or damage.
  - Data on different types of packaging could be collected for a selected sample of value chain actors to study the efficiency of alternative methods of packaging.
  - Within the context of the post-harvest value chain, the losses at this stage do not seem important.
3.1. Objective measurements: description

<table>
<thead>
<tr>
<th>Variables</th>
<th>Absolute (kg)</th>
<th>Relative (%)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantities:</strong></td>
<td></td>
<td></td>
<td>All the variables refer to a single unit (agricultural holding, trader, etc.)</td>
</tr>
<tr>
<td>Harvested</td>
<td>$H$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Brought to:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Threshing/shelling</td>
<td>$T$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleaning/winnowing</td>
<td>$C$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drying</td>
<td>$D$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation</td>
<td>$T$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>$S$</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Losses during:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvesting</td>
<td>$L_H$</td>
<td>$l_H = \frac{L_H}{H + L_H}$</td>
<td>$H + L_H$ is a measure of potential harvested quantities</td>
</tr>
<tr>
<td>Threshing/shelling</td>
<td>$L_T$</td>
<td>$l_T = \frac{L_T}{T}$</td>
<td></td>
</tr>
<tr>
<td>Cleaning/winnowing</td>
<td>$L_C$</td>
<td>$l_C = \frac{L_C}{C}$</td>
<td></td>
</tr>
<tr>
<td>Drying</td>
<td>$L_D$</td>
<td>$l_D = \frac{L_D}{D}$</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>$L_{TR}$</td>
<td>$l_{TR} = \frac{L_{TR}}{T_{TR}}$</td>
<td></td>
</tr>
<tr>
<td>Storage (farmers’ declarations)</td>
<td>$L_S$</td>
<td>$l_S = \frac{L_S}{S}$</td>
<td></td>
</tr>
<tr>
<td>Storage (physical measurements)</td>
<td></td>
<td>$l_S^{(t)}$</td>
<td>$t = n$ visits; $l_S^{(t)}$ is the percentage storage loss at visit $t$ calculated using appropriate physical measurements (e.g. count and weigh method).</td>
</tr>
<tr>
<td><strong>Aggregates:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-harvest losses</td>
<td>$L_{PH} = L_T + L_C + L_S$</td>
<td>$l_{PH} = \frac{L_{PH}}{H}$</td>
<td></td>
</tr>
<tr>
<td>Harvest and post-harvest loss</td>
<td>$L_{HPH}$</td>
<td>$l_{HPH} = \frac{L_{PH} + L_H}{H + L_H}$</td>
<td></td>
</tr>
</tbody>
</table>
3.2. Objective measurements - Example: approach adopted in Ghana

- **Quantity harvested from the sub-plot**
- **Shelling**
- **Residual quantities (Qr)**
  - **Weight of grain remaining (loss)**
  - **250g sample**

**覚え方**

- **Plot S**
- **Sub-plot (s)**

**Expansion to the sub-plot**

- **L(S) = L(s) \cdot \frac{\text{area(S)}}{\text{area(s)}}**

**Expansion to the plot**

- **L(s) = \text{loss} \cdot \frac{\text{Qr}}{250}**
3.2. Objective measurements - Ghana: preliminary results

<table>
<thead>
<tr>
<th>Crops</th>
<th>Harvest</th>
<th>Threshing and shelling</th>
<th>Cleaning</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>10.7</td>
<td>5.4</td>
<td>4.9</td>
<td>4.1</td>
</tr>
<tr>
<td>Rice</td>
<td>11.9</td>
<td>3.1</td>
<td>6.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Sorghum</td>
<td>3.6</td>
<td>6.5</td>
<td>5.9</td>
<td>1.8</td>
</tr>
</tbody>
</table>
3.2. Objective measurements - Ghana: preliminary results

- **Harvest**: Farmer reporting: 4%, Objective measurements: 11%
- **Threshing/Shelling**: Farmer reporting: 5%, Objective measurements: 6%
- **Cleaning**: Farmer reporting: 2%, Objective measurements: 3%
- **Storage**: Farmer reporting: 3%, Objective measurements: 4%
3.3. Objective measurements: limitations and challenges

• Measurements not conforming with farmers practices

• **Complexity and length** of the measurement operations: grain sample selection, counting, weighing, several visits to storage facility

• **Reference period, timing**: harvesting and storage time

• **Measurement equipment** in sufficient quantity and quality: sampling spears, moisture meters, precise and portable weighing scales, sealable plastic bags, etc.
Measuring losses based on visual scales
Measurement methods for on-farm post-harvest food loss assessment: visual scales

• Most often used to measure losses during storage: grain weight losses because of, for example, insects, pest attacks and diseases. Also useful to assess grain quality

• Easy to use, provides results on the spot and reduces delays by bringing the grain to the lab

• Done in Malawi with satisfactory results

• Visual scales = mix of objective and subjective methods; a loss rate is associated to different grain quality levels

• Visual scales need to be well calibrated before use => necessitates laboratory work
Measurement methods for on-farm post-harvest food loss assessment: visual scales

**Step 1:**

- Different classes of pest infestation are defined, generally by a group of field workers, to reflect farmer use category

<table>
<thead>
<tr>
<th>Class</th>
<th>Damage level</th>
<th>Description and use</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Undamaged.</td>
<td>For food or seed.</td>
</tr>
<tr>
<td>2</td>
<td>Slight damage.</td>
<td>A few infested grains. Always acceptable for food and usually mixed with Class 1. Sells at top price. May be used for seed after hand-cleaning.</td>
</tr>
<tr>
<td>3</td>
<td>Slight-moderate damage.</td>
<td>Less than about half the cob infested. Acceptable to farmers and traders for mixing with Class 1 and 2, if in small proportion. Otherwise may be shelled selectively by hand, separating good from bad grains, or occasionally mixed with Class 4.</td>
</tr>
<tr>
<td>4</td>
<td>Moderate damage.</td>
<td>More than about half the cob infested, but still with some areas of good grains on cob. Acceptable for human food by poorer groups and in lean seasons. Rarely mixed with good maize and only for immediate consumption. May be shelled selectively or mixed with Class 5.</td>
</tr>
<tr>
<td>5</td>
<td>Severe damage.</td>
<td>Over about 90% of the cob infested. Normally animal feed; used for human food only in time of scarcity, when it is mixed with higher grades. Still saleable in certain conditions, at low price.</td>
</tr>
<tr>
<td>6</td>
<td>Very severe damage.</td>
<td>Cobs thrown away by farmer and unsaleable. Very little food value, even for animal feed.</td>
</tr>
</tbody>
</table>
Measurement methods for on-farm post-harvest food loss assessment: visual scales

Step 2:

• A weight loss parameter is defined by a specialized laboratory using loss assessment techniques and associated with each class of pest infestation

Step 3:

• A visual scale print of the different classes and associated loss parameters is prepared and given to the field teams
Measurement methods for post-harvest food loss assessment: visual scales
Measurement methods for on-farm post-harvest food loss assessment: visual scales

Step 4:

• On each farm and storage facility selected, the enumerator takes a sample of cobs and grains and matches them with the various classes of infested cobs or grains portrayed in the pictures

Step 5:

• The weight loss for any given unit is calculated by taking the average of the weight loss parameters recorded weighted by the share of the cobs in each class
5 Off-farm loss measurement (introductory considerations)
Loss measurements off-farm

• **Intermediate level:**
  - Government distribution agencies, mills, marketing cooperatives, wholesale and retail traders
  - Have to be estimated at the stage of transport, storage, processing, packing and distribution
  - Sample of handlers is to be selected and the required information collected for transport, storage and handling
  - A random sample of mills and processing factories may be chosen and the data are collected
Loss measurements off-farm

• **Government warehouses:**
  
  ➢ Data usually collected periodically by the agencies (food technology specialists)
  
  ➢ Moisture content, insect and pest infestation, etc.
  
  ➢ Many studies in India on maize, rice, sorghum and wheat
  
  ➢ APHLIS for Southern and Eastern Africa on maize crop
Conclusion

• This presentation presented standard methods to estimate grain losses on a farm

• The methods will be further detailed in the forthcoming guidelines and in other reports

• Three main types of measurement methods: purely subjective (farmer’s declarations), purely objective (physical measurements and laboratory analysis) and hybrid (visual scales)

• Modelling can help in improving measurement and close data gaps

• Statistically representative data are collected from sample surveys using random sample designs
Thank You