



# Postharvest Management: importance under climate change and best practices





## Overview

- Importance of post harvest losses under climate change
- Types of food losses and hotspots in value chains
- Causes of losses and aflatoxin
- Climate change exacerbating post harvest losses
- Post-harvest management – best practices

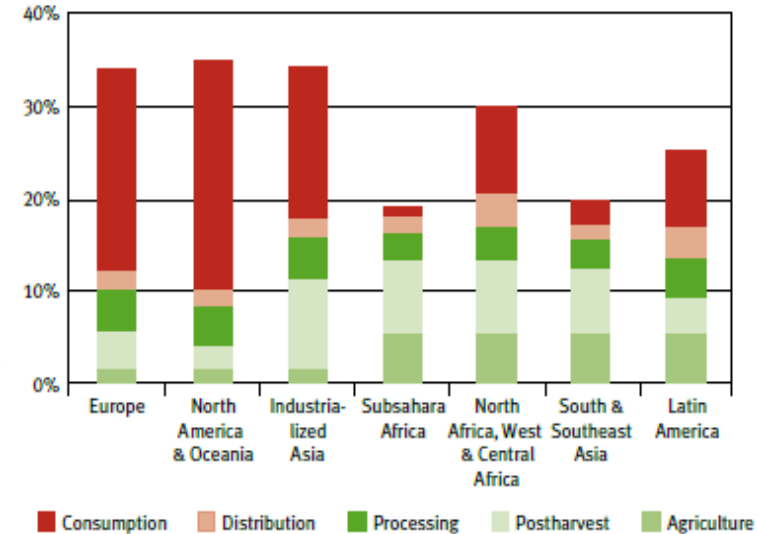


# Importance of Post Harvest Losses under Climate Change



## Importance

- Losses along value chains as major impediment to food security and sustainable growth
- Food loss is a highly important factor in efforts to combat hunger and raise incomes
- 1/3 of all food produced for human consumption is lost (can reach 50% for fruits, vegetables, root crops)
- In Sub-Saharan Africa, post-harvest losses have a value of \$4 billion per year (equivalent to value of cereal imports 2000-07 or annual calorific requirement of at least 48 million people)
- 1% reduction in post-harvest losses => \$40 million/yr economic gain - most would directly benefit smallholders
- Quantitative/qualitative losses seriously affect livelihoods; contamination with mycotoxins as severe problem for consumer health and livestock productivity





## Ecological footprint of food losses

- Not just loss of food but loss of all resources that go into creating food
- Food loss has a significant environmental impact. The later food loss occurs in the value chain, the more resources have already been wasted
- Food losses imply waste of scarce resources. Resources could have otherwise been used to produce more food, cultivate other crops or breed other animals (lost opportunities)
- However, food loss also represents **wasted production resources** such as:
  - Natural resources: land and water
  - Energy and fuels
  - Inputs like seeds / planting material, fertilizers, pesticides
  - Use (and damage) of equipment and tools
  - Unnecessary use of capacities for storage, transport, processing, marketing
  - Human capacity and working time



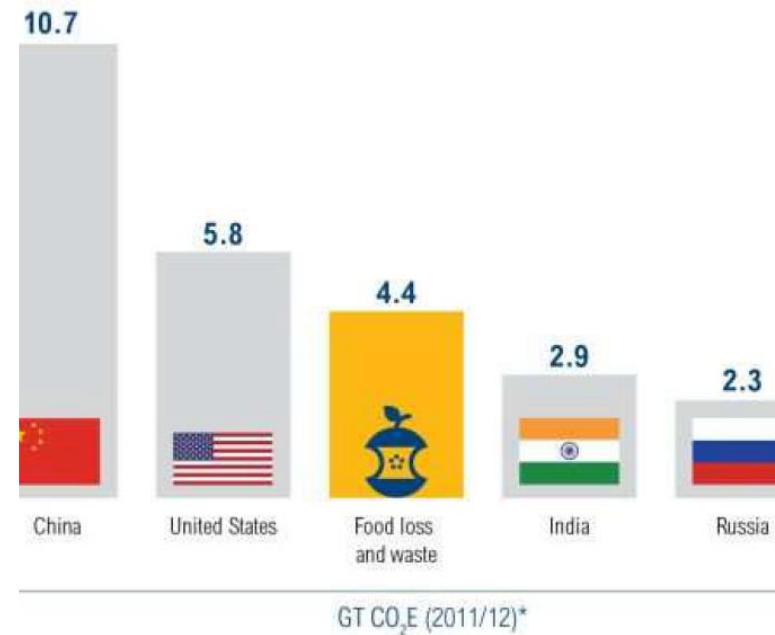
## Climate impacts

- Vulnerability of agriculture in Sub-Saharan Africa
  - Crop yields and areas suitable for growing them will decline
  - Value of harvested and traded commodities will increase
  - Costs of not reducing post-harvest losses will also increase
- Need to more than double food production to meet needs of a growing global population (SSA 70% increase needed by 2050)
- Extra food to compensate for losses is a waste of valuable resources
- Ability to store food on farm as adaptive capacity of smallholders
- Climatic fluctuations affect post-harvest losses and food safety during storage (e.g. by causing changes in populations of toxin-producing fungi).
- More frequent extreme weather events will damage infrastructure (e.g. warehouses, roads) -> impacts on food storage and distribution



## If food loss were a country, it would be third largest GHG emitter

- Food loss and waste generate 4x more GHG emissions than aviation
- Sources of emissions
  - On-farm for producing food that is ultimately lost or wasted;
  - Production of electricity and heat used to process food that is ultimately lost or wasted;
  - Energy used to transport, store, cook food that is ultimately lost or wasted;
  - Landfill emissions from decaying food;
  - Emissions from land use change and deforestation associated with producing food that is ultimately lost or wasted
- Reduce food loss and waste as win-win strategy for climate and economy





# Types of food losses and hot spots in value chains





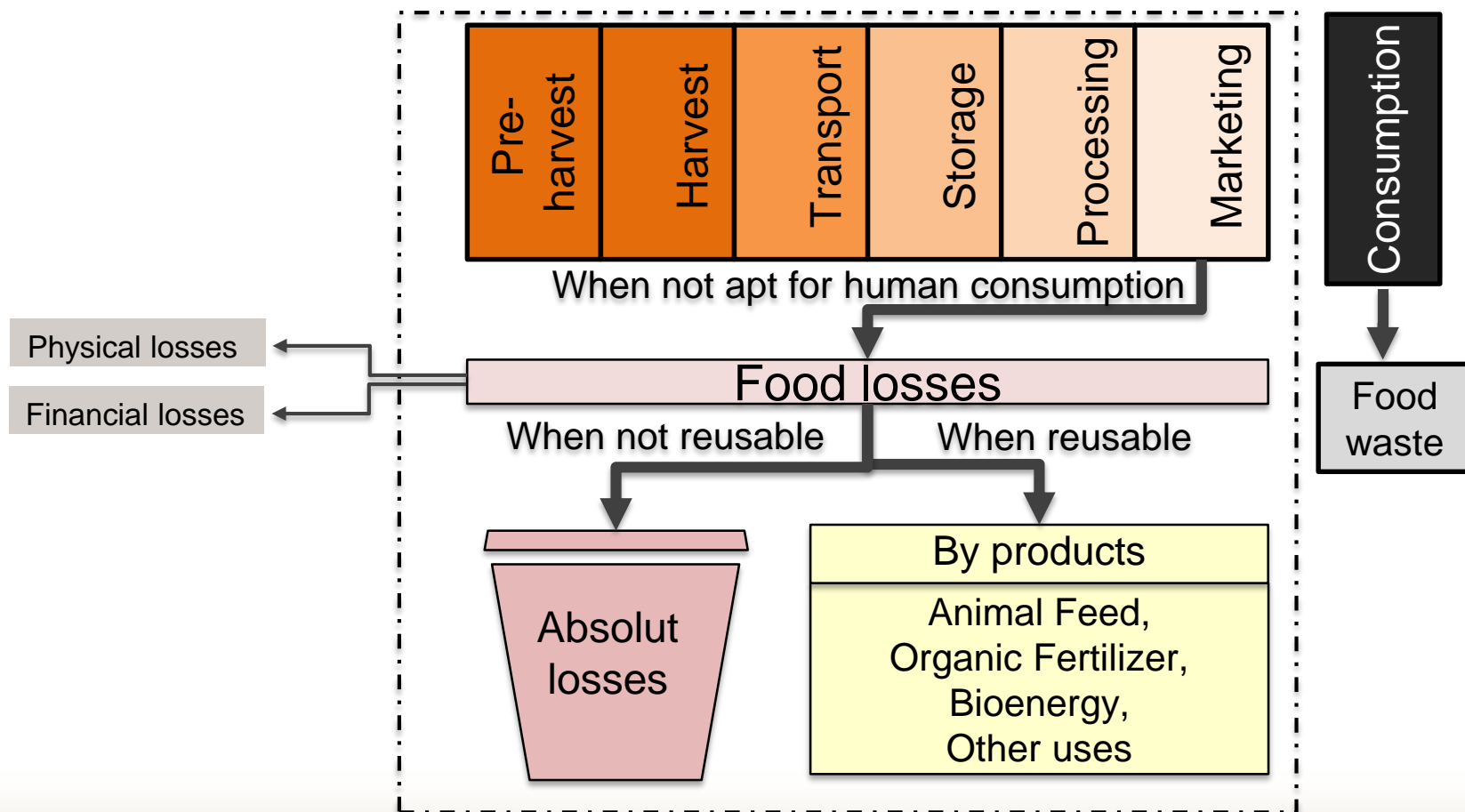
## What is food loss and food waste?

- Food loss: **decrease in edible food mass** throughout the value chain that specifically provides edible food for human consumption (FAO)
- **‘Planned’ non-food uses** versus **‘unplanned’ non-food uses**, with the latter being counted as loss
- **‘Food waste’**: food loss occurring at the end of the food chain (retail and consumption) as result of retailer and consumer behaviour
- Food quality loss or waste refers to the decrease of quality of food (nutrition aspect, financial loss, etc.) linked to degradation of the product





## Definition of losses





## Categories of critical food loss points

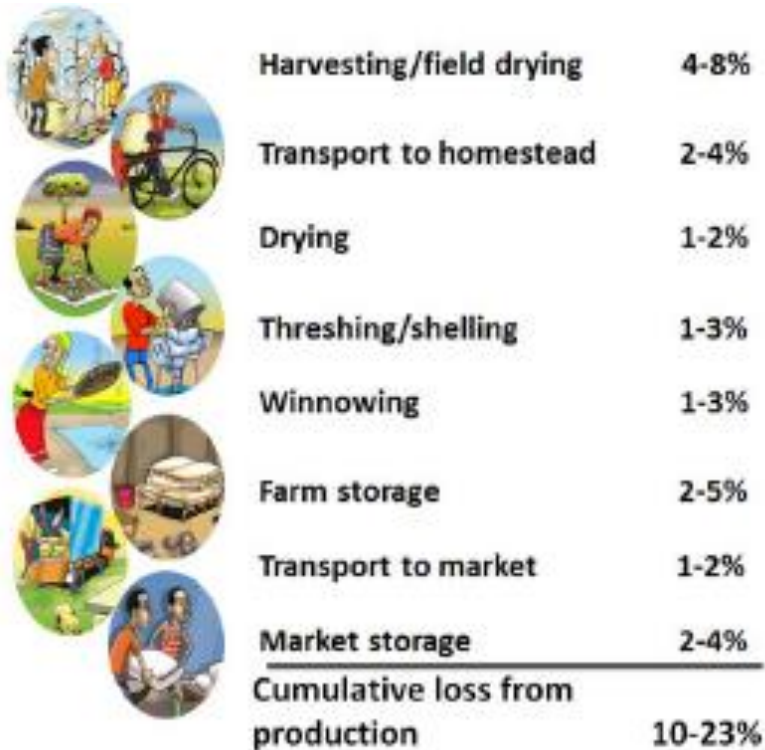
- 1. Harvest:** losses due to mechanical damage and/or spillage during harvesting, harvesting too early, etc.
- 2. Post-harvest handling and storage:** losses due to spillage and degradation during handling, storage and **transportation** between farm and distribution, contamination with foreign matter, insufficient drying.
- 3. Processing:** losses due to spillage and degradation during industrial or domestic processing, e. g. juice production, canning and bread baking. Losses may occur when crops are sorted out if not suitable to process or during washing, peeling, slicing and boiling etc.
- 4. Distribution and marketing:** including losses and waste in the market system, at e.g. wholesale markets, supermarkets, retailers, wet markets.
- 5. Consumption:** including losses and waste during consumption at the household level.



[1]



## Importance



## Causes of post-harvest losses

### Before harvest

- Poor choice of varieties
- Poor crop and livestock management
- Poor soil and seed quality
- Incorrect moisture levels during growth
- Pest infestations and diseases during growth

### During harvest

- Premature harvesting
- Physical damage during harvest

### After harvest

- Poor storage facilities after harvest
- Spillage and damage during handling, transport, packaging, marketing

### And

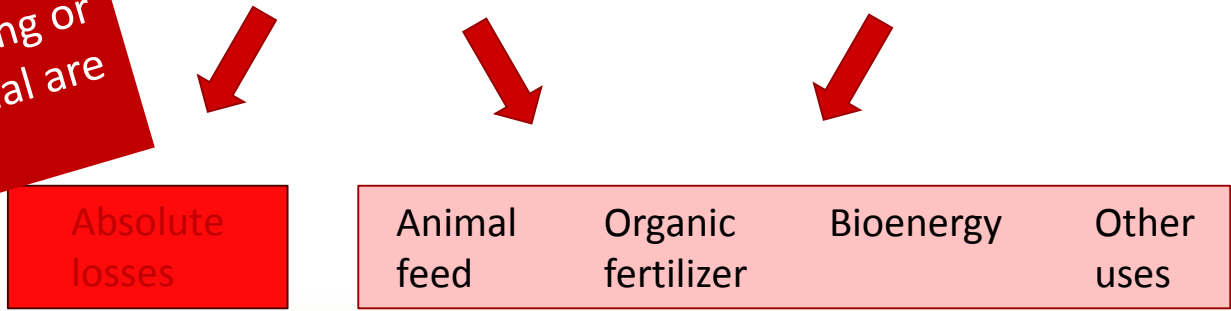
- Weak economic infrastructure
- Inappropriate practices at different stages



# RLAT: Definition of losses and scope of the GIZ tool

Plant product intended for food or feed	
Food / feed	Inedible / not used for main purpose
<ul style="list-style-type: none"> <li>Pre-harvest losses</li> <li>Harvest losses</li> <li>Transport losses</li> <li>Storage losses</li> <li>Processing losses (incl. drying)</li> <li>Marketing losses</li> </ul>	<ul style="list-style-type: none"> <li>e.g. maize stems</li> </ul> <p>Spillage, spoilage, abnormal reduction in quality such as bruising or wilting or other losses before food/ feed is used</p>
Food/feed for consumption	By-products
	<b>LOSSES</b>

**Weight losses due to drying or processing of raw material are not losses!**





## Process steps of RLAT

Phase	Preparation (up to 12 days)	Field research (up to 24 days)	Follow-up (up to 14 days)
Steps	<ol style="list-style-type: none"> <li><b>1</b> Scheduling the rapid appraisal</li> <li><b>2</b> Training of users &amp; facilitators</li> <li><b>3</b> Desktop study</li> </ol>	<ol style="list-style-type: none"> <li><b>4</b> Key expert roundtable</li> <li><b>5</b> Stakeholder workshop</li> <li><b>6</b> Focus group meetings</li> <li><b>7</b> Key informant meetings</li> </ol>	<ol style="list-style-type: none"> <li><b>8</b> Assessment of results</li> <li><b>9</b> Conclusions &amp; recommendations</li> <li><b>10</b> Reporting</li> </ol>
Relevant tools	<b>Participatory methods</b>		<b>Forms for documenting results</b> <ul style="list-style-type: none"> <li>- Cumulative loss matrix</li> <li>- Summary aflatoxin risk assessment</li> <li>- Final report structure &amp; content</li> </ul>
	<ul style="list-style-type: none"> <li>- Sampling methods</li> <li>- Loss hot spot analysis</li> <li>- Key expert roundtable</li> <li>- Stakeholder workshop</li> <li>- Focus group meetings</li> </ul>		
<b>Checklists, Data collection sheets &amp; Evaluation sheets</b>			





## Synopsis of reported damage and loss occurring within different market channels of value chains: Case of rice

### Paddy Rice 12.4 %

Harvesting  
4.43 %

Threshing &  
winnowing  
4.97 %

Paddy from  
field to home  
0.34 %

Drying & storage  
1.53 %

Paddy from storage  
to market  
0.12 %

### Parboiled Rice 5.2 %

Parboiling  
1.07 %

Drying  
3.60 %

Storage  
0.52 %

### Traditional Milling 4.4 %

Transport  
to mill  
2.37 %

Storage before  
milling  
1.16 %

Milling  
0.87 %

### Milled Rice 7.54 %

Transport from  
mill to home  
0.4 %

Storage after  
milling  
1.14 %

Milled rice from  
home to market  
0.75 %

Transport from market  
to shop  
2.27 %

Storage in store  
2.98 %



## Actors, causes and interventions for food loss reduction: Group work



- A) At which levels (family, community, government) do losses occur?
- B) At which stages of the value chain do greatest losses (hot spots and stakeholders, actors) occur?
- C) What are major causes for crop losses and damage in harvested and stored crops?
- D) Which interventions should be taken for fast and mid-term improvements?





# Causes of losses and aflatoxin



# What are stored product pests? What are urban pests?



## Insects

Beetles (approx. 60 species)

Moths (approx. 20 species)

Dustlice (approx. 10 species)



## Rodents

Rats

Mice



## Microorganisms Bacteria, Fungi



[3]

## Urban pests (vectors)

Cockroaches , rodents, birds

Flies

Ants



## Birds



[3]: [https://c1.staticflickr.com/5/4008/4684917072\\_11af04bcfd\\_b.jpg](https://c1.staticflickr.com/5/4008/4684917072_11af04bcfd_b.jpg)



## Granary weevil - *Sitophilus granarius* (Col., Curculionidae)

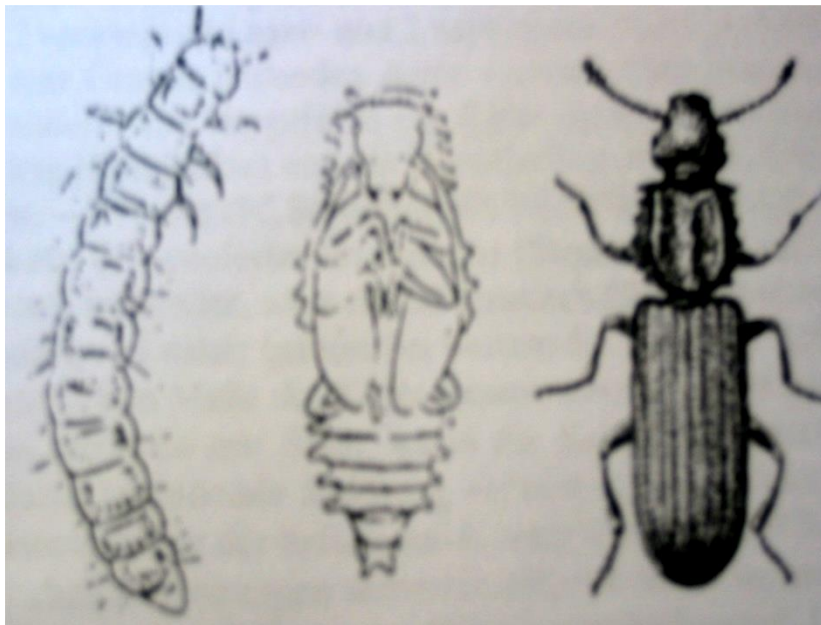


Adults 3-5 mm, larvae  
are internal feeders

Photos: Cornel Adler, JKI



## Flat grain beetle - *Oryzaephilus surinamensis* (Col., Cucujidae)



- 2,17 – 3,25 mm in size
- Long thorax with 3 ribs and 6 lateral teeth
- Elytrae with punctures and light-colored hairs in longitudinal ribs



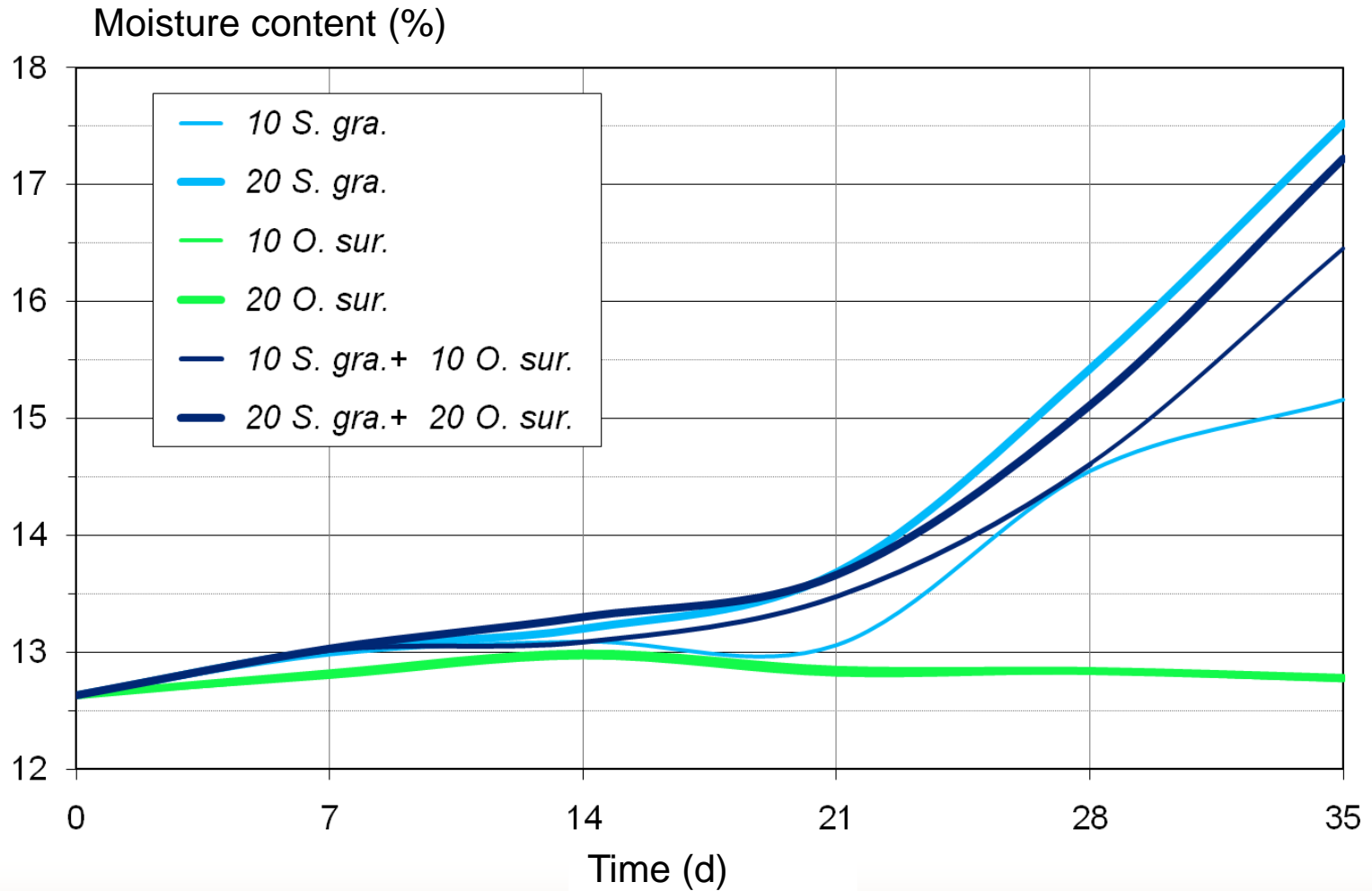


## Indian mealmoth - *Plodia interpunctella* (Pyralidae)



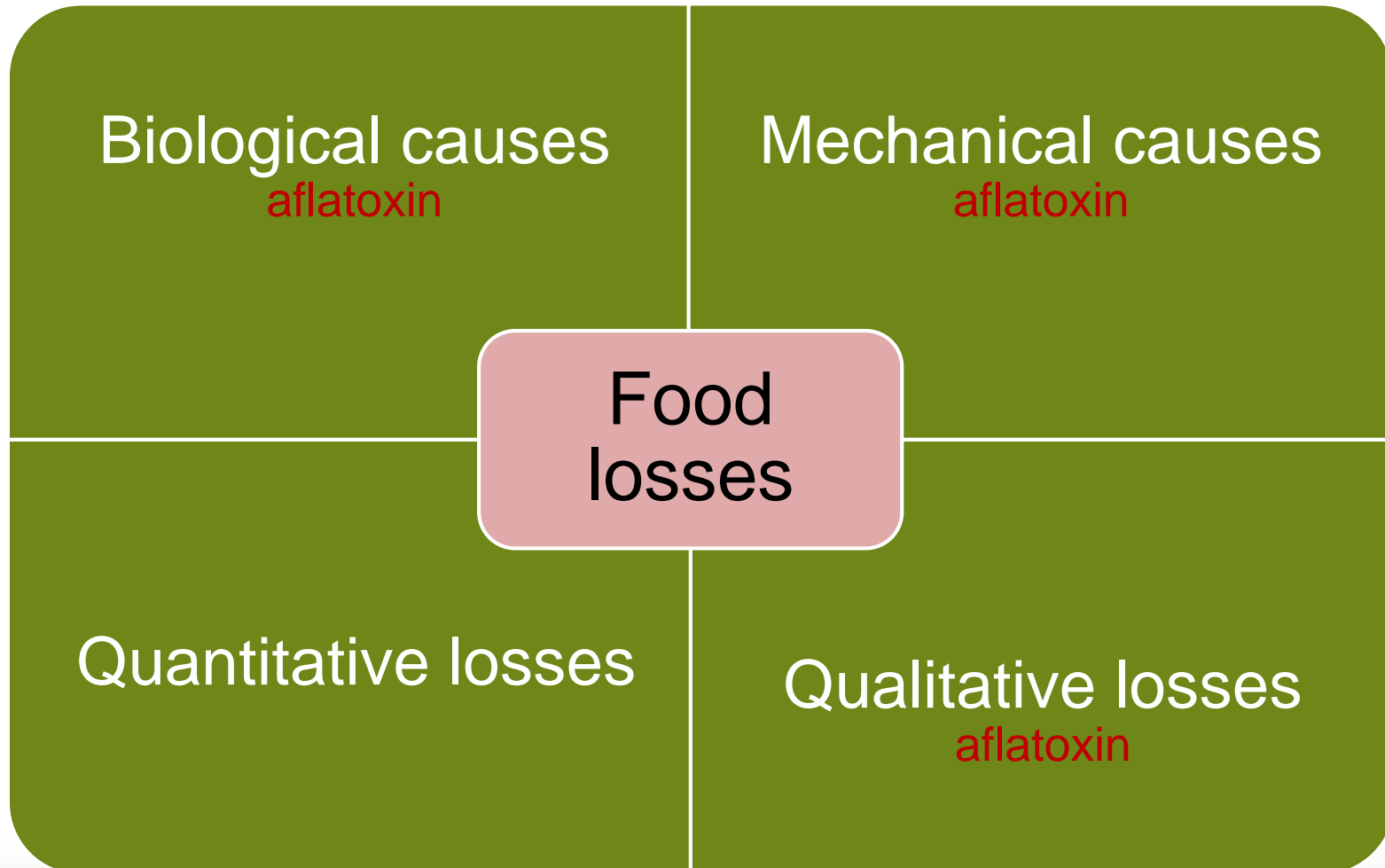


## Moisture increase due to insect respiration





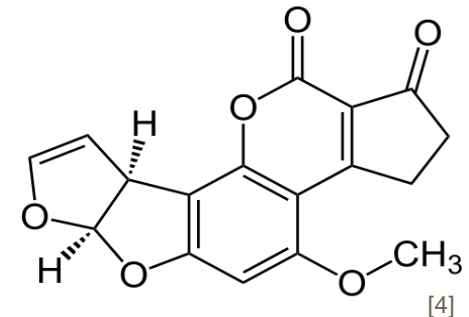
## Food supply chains of vegetable and animal commodities





## Facts about Aflatoxin

- Highly toxic metabolite produced by *Aspergillus flavus* fungus
- Fungus resides in soil and crop debris, fungus carried from field to store
- **Infects several crops like maize, cereals, ground nuts, oil seeds, spices etc. and produces toxin in the field and in stores**
- Contamination possible without visible signs of the fungus
- **Causes death, liver cancer, immune suppression, stunted growth**
- Impacts negatively animal productivity and trade







## Examples: aflatoxin infestation



[2]



[3]

[2]: [https://c1.staticflickr.com/5/4008/4684917072\\_11af04bcfd\\_b.jpg](https://c1.staticflickr.com/5/4008/4684917072_11af04bcfd_b.jpg)

[3]: [https://c1.staticflickr.com/3/2536/5754294416\\_49fa2487a3\\_b.jpg](https://c1.staticflickr.com/3/2536/5754294416_49fa2487a3_b.jpg)

# What happens to aflatoxin-contaminated products ?

## Small Scale Farmer

### Production



## Export - oriented Farmer

### Production



*A great amount of aflatoxin-contaminated food remains in the value chain!*

Livestock feed

Own consumption

Sale to local market

Sale to trader

Own consumption



Contaminated livestock products

Quality standards not met

Export

Market loss  
*Reduced milk productivity*  
*Livestock disease burden*  
*Reduced prices of products*  
*Discarded products*

**Human health impact**  
*Disease burden*  
*Reduced productivity*

Market loss  
*Supply shortage*  
*Discarded grain*  
*Litigation*  
*Human health impact*

Human health impact  
*Disease burden*  
*Reduced productivity*



# Aflatoxin in value chains

## Challenge of aflatoxin reduction

- Awareness is low, especially at producer and consumer levels
- No alternative to contaminated food, what to do with it?
- How can existing marketing incentives improve the situation of the rural poor population?

## Approaches

- Don't plant during the dry season
- Don't harvest when moisture levels are high, dry crops after harvest
- Use bio-control methods, e.g. nontoxigenic fungal strains
- Remove mouldy grains and store in airtight containers



# Climate change exacerbating post harvest losses



## Climate change impacts

- Harvesting and drying
  - Increased rate of crop drying in field and homestead
  - Increased fire risk
- Pest and disease management
  - Faster reproduction of insect pests and diseases – more rapid build-up of insects and fungi in stored produce
  - Increased pest reproduction/mobility lead to need to re-sort and treat grain mid-way through storage period
  - Increased risk of fungal rot and mycotoxin contamination of stored produce
  - Pest and disease territories expand e.g. to higher altitudes or previously cooler areas
  - Efficacy of some grain protectant active ingredients decrease, others increase
  - Higher pest incidence and carry-over during cold season increases need for thorough storage hygiene and management of residual infestation prior to storing new crop





## ... continued

- As well as
  - Increased risk of reduced seed viability especially for some legumes (e.g. groundnuts)
  - Increased bio-deterioration leading to shorter shelf life of products
  - Heat stress on humans, livestock, vehicles, machinery and additional cooling costs
- Reasons
  - High yielding cereal varieties are more susceptible to pest damage
  - Increased climate variability, change in cropping seasons
  - New pests often more damaging
    - larger grain borer (*Prostephanus truncatus*) has spread across much of SSA attacking farm stored maize and dried cassava roots
    - fall armyworm (*Spodoptera frugiperda*) causing serious damage in 2016/17





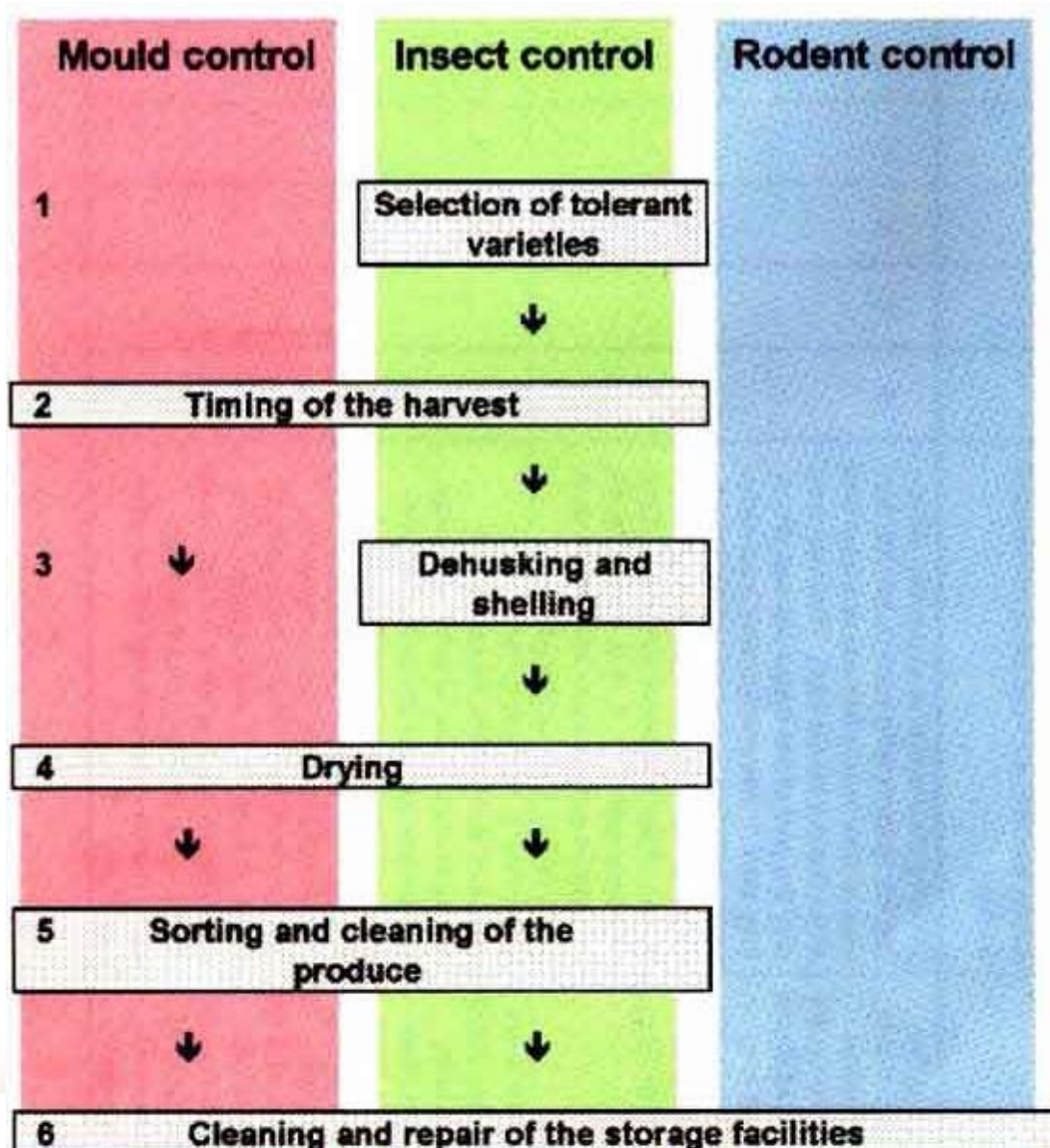
# Post harvest management – best practices



# Postharvest management

- The instant a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate
- Quality cannot be improved after harvest, only maintained
- Postharvest management to ensure that
  - quality produce reaches marketplace (appearance, texture, flavour, nutritive value and safety)
  - food safety and hygiene issues are taken care of
  - reduce loss (quantitative & qualitative) before, during and after harvest up to consumption





## Preventive measures

against mould, insects and rodents during production, harvest and post-harvest operations.

GTZ, 1997



# Best practices before harvest

Follow good agricultural practices

Grow crops and varieties which are less susceptible to post-harvest pest attack

Seed quality

- Purchase good quality seed, select seeds with care (storability, durability)
- Treat seeds with ash or ash-cow-dung combination to reduce pests
- Dry seeds to correct moisture level before storing
- Store seeds in dry, cool containers, safe from pests
- Use zeolite-based drying beads to reduce moisture in seeds
- Test seeds before storage and planting



## Best practices continued

### Soil fertility improvements

- Soil and water conservation, organic matter, soil cover, reduced tillage

### Soil moisture management

- Raised beds for vegetables, mulching, soil and water conservation

### Pests and diseases

- Identify pests and diseases and learn their life cycle
- Monitor fields and crops consistently
- Use biological controls (e.g. predatory insects eat pests)
- Use pest-resistant crop varieties
- Remove dead plants that show signs of disease





## Prepare before harvesting



Planning ahead is essential. Make sure you have all the necessary equipment, know where the drying and shelling will be done and how the grain will be stored. Mend all holes in sacks and make sure stores are in good repair.



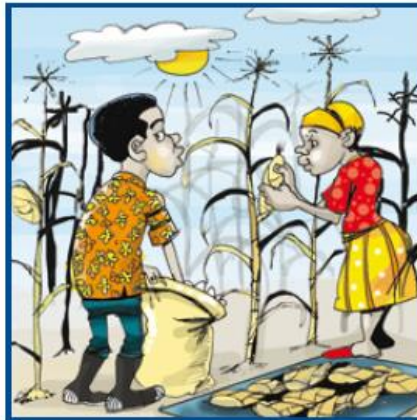
Good hygiene is essential, if you will put your grain into sacks then make sure they are cleaned in advance. If you are using a store then make sure the residues of the previous harvest are removed.



## Harvest the grain on time



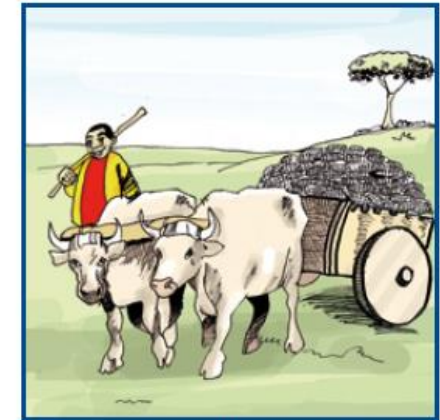
Harvest on time, when the crop is mature - some cobs start to droop; bean pods turn yellow.



Harvest mature cereals or beans on a sunny day and place on a mat, tarpaulin or in sacks.



If rain delays the maize harvest, then prevent water from entering the cobs by turning the cobs down.



As soon as possible transport crops from field to the homestead for further drying.



# Best practices during harvest

## Timing

- Follow standard harvesting guidelines for each crop
- Maintain production records to plan ahead
- Harvest during lowest temperature of the day
- Do not harvest when raining or dew or produce is wet

## Handling

- Use tools and techniques to minimize damage during harvest
- Create shady spot in the field to store harvested crops
- Use cartons, wooden crates and plastic containers



# Natural methods- Plant parts as traditional insecticides

Survey in Africa (Western Highlands of Cameroon; Tapondjou et al. 2000)

Identified plants	plant parts used	protected stored products
<i>Clausena anisata</i> (Rutaceae)	leafy branches	maize, beans
<i>Cypressus sempervivens</i> (Cypr.)	leafy branches	maize, beans, cowpea
<i>Capsicum frutescens</i> (Solanac.)	fruits	beans, cowpea
<i>Chenopodium ambros.</i> (Chenop.)	leaves	maize, beans, potato
<i>Eucalyptus spp.</i> (Myrtaceae)	leaves	maize, beans, cowpea
<i>Lantana camara</i> (Verbenaceae)	leaves	beans, potato

*Oil of neem seeds (dried in the sun) protect maize against pests a few months (JKI)*





# Biocide Aflasafe – for displacing aflatoxin-producing fungi



dead sorghum grains coated with a mixture of atoxigenic strains, a polymer and a blue dye



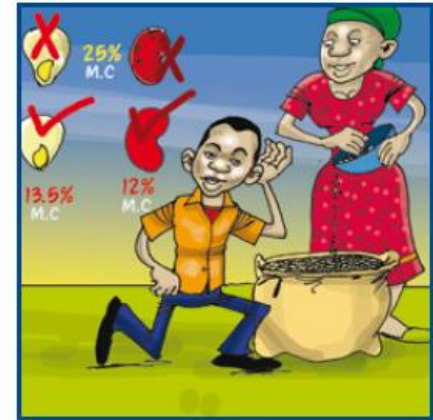
# Best practices after harvest

- Drying
- Shelling
- Sorting
- Transporting
- Storing
- Marketing





## Dry the grain



Dry cereals or beans on mats, tarpaulins or racks so they are not in contact with the ground and make sure farm animals are kept away... or use a maize drying crib for protected drying.

Don't let drying grain get wet, cover with a tarpaulin if it rains.

Dry grain until it is sufficiently dry, for example cereal grains 13.5%, beans 12% moisture content.

## Shell/tresh the grain



Use hands to shell beans or dehusk maize cobs. If any maize or beans are damaged then consume them, feed to animals or if unfit for consumption then destroy them, do not place in storage.

Shell maize cobs by hand or with a mechanical sheller to reduce damage to grain. Don't beat with sticks.

Dry grain further if it is above the required moisture content.



# Best practices after harvest

- Drying & Shelling
- **Sorting**
  - Remove damaged, diseased produce
  - Cleaning and sorting according to purpose: consumption, market, side product, seeds or planting material
- **Transporting**
  - Immediately after harvesting
  - Avoid weight on produce while stacking
  - Reduce rubbing by using straw
  - Prevent overheating
- Storing & Marketing





# Regional and traditional storage solutions

Post-harvest management in smallholder farms,  
Zimbabwe



**Drying crib**



**Granary**



## Importance of improved storage



WFP

Uganda:

maize quality after 100  
days of traditional storage  
(left)

and

storage using improved  
locally-  
produced silos (right)



## Where do the pests come from?

- from infested raw materials/ suppliers



**improve inspection!**

- from latent infestation in the premise



**improve sanitation!**

- from the outside environment



**improve structural design!**





## Clean the grain



Winnow grain or use a sieve to remove chaff and foreign matter, and broken grain. Be careful to remove insect damaged grain, mouldy grain and chaff and burn it. Other damaged grain may be fed to animals.

## Ensure good storage at home



If storing grain in sacks for more than 3 months then admix an insecticidal dust (see Sub Section 5.13).



Put grain in sacks and sew them shut.



In the house, store sacks on pallets of sticks or stones, away from walls. Check regularly for any problems.



To store grain in bulk, place in a silo or other container and follow instructions to prevent insect attack.





## Importance of on-farm storage

- Dry, well-vented, cool conditions
- Protection from rain, drainage
- Protection from rodents, birds, temperature fluctuations
- Keep storage bags off the ground
- Improved crop storage bags (or triple bagging for extra barrier)
- Plastic or metal containers with locking lids
- Maintain storage structures
- Keep stores and containers clean, maintain hygiene

Farmers' dilemma: "Sell for less or lose everything" if they can't store maize safely, either they lose a significant portion of their crop to pests OR have to sell their grain soon after harvest when supplies peak and prices are low





# Integrated storage protection based on three pillars

## Integrated Stored Product Protection in organic production

### Pest prevention

- Structural design
- Store quality
- Inspection
- Sampling
- Drying
- Cooling
- Sanitation
- Packaging

### Early pest detection

- Visual inspection
- Check:
- Temperature
  - Moisture
  - Movements
  - Structural design
  - Product density
  - Bioacoustics
  - Traps

### Pest control

- Physical
- Biological
- Biotechnical
- CO<sub>2</sub> / N<sub>2</sub> / DE  
(Diatoma-  
ceous earths)



## Elements of integrated pest management (IPM) in warehouses

- Storage buildings: Insects- and rodents-proof or gas-tight
- Grain storage: Small hermetic bags, big hermetic silobags, hermetic buildings
- Temperature-treatment: Cooling the product to  $< 13^{\circ} \text{C}$
- Heat treatments for empty structures or product drying
- Diatomaceous earths (DE)
- Biological control: release of „beneficial“ insects against „pest“ insects
- Use of plant parts as insecticides
- Phytochemicals (attractants, repellents, control agents)



## Improved storage bags



- Hermetic storage bags – triple bagging
  - Eliminate pests/molds by depleting oxygen levels
- Pesticide free
- Cow pea, millet, sorghum, maize
- Losses reduced by up to 90%
- Reusable and affordable (2.5 \$)
- Local business opportunity





## Improved storage solutions – metal silos



W. Ojanji/CIMMYT

- Affordable
- Galvanised flat iron sheets, non-chemical hermetic storage
- Airtight to keep out insects, aflatoxin
- For maize, beans, sorghum, millet, cowpea, pigeon pea
- Safe storage for years, sell when higher prices
- SME opportunity: local artisans can earn over 3,000 USD/year if they make 5 silos per month





FAO

## ‘Gorongosa silos’, Mozambique

- affordable, locally developed technology
- local materials (mud and clay or cement and iron rods)
- Durable (up to 20 years), with good maintenance
- Protect against fire, pests, disease
- Retain quality of the grain for up to ten months
- Reduces need for chemical treatment



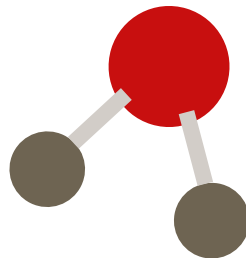


# Chemical methods- for stored product protection

## *Situation of Germany*

### Gases:

- Phosphine [PH<sub>3</sub>] from Al-/Mg-phosphide or bottled gas
- Sulfurylfluoride (structures only and nuts)
- [N<sub>2</sub> until 2004 ]
- Carbon dioxide [CO<sub>2</sub>] at normal / high pressure



### Contact pesticides:

- Pirimiphos-methyl (grain only)
- Pyrethrum (natural)
- Deltamethrine
- Diatomaceous earths (DE)

### Biocides:

- Chemical products that destroy or deter harmful organisms (e.g. vectors) outside of agricultural land



# Improved rice thresher cleaner technology

- Improved technology, participatory development
- Affordable
- Labor and time saving
- Improved rice quality, less damage
- Increased marketability of local rice





## Rice winnower



G. Aris/Land O'Lakes

### Rice winnower technology design group, Tanzania

- Group design and prototype
- Generates wind to separate rice from chaff and impurities



# Climate smart post harvest adaptation opportunities

- Accurate estimation of food stock requirements
- Protection and monitoring of grain to be stored for more than 3 months
- Use of low GHG emission food preparation methods
- Increasing farmer access to market information and transport options
- Use of early warning seasonal forecasts to project how climatic conditions might impact on food storage or marketing strategies
- Use of more water, energy and resource efficient processing, packaging and transport operations
- Ensuring plant breeders evaluate post-harvest as well as pre-harvest crop characteristics
- Helping farmers to learn from others' and their own experiments



How about perishable crops or animal products? Ideas for dairy, meat, vegetables and fruits

Group work



- A) At which levels (family, community, government) do greatest losses (stakeholders, hot spots) occur? What are the main causes of losses?
- B) Which measures should be taken to reduce losses in future?





## Importance of regional cooperation (I)

### Diagnosis:

- Stored plant products are transported throughout the region and beyond (trade)
- Stored product pests and diseases have become cosmopolitan
- Same problems in many parts of the world – similar solutions
- Causes for food losses are systemic and need systemic approaches to be reduced. Focusing on storage is only one part of the challenge.
- Quality aspects gain more importance in global value chains.
- More prevention, more Integrated (Storage) Pest Management (IPM): to make the future sustainable, less hazardous and without toxic residues!
- **Good stored product protection reduces losses, hunger and ecological footprint**



## Women in harvest- and post-harvest management

*What is the role of women and men in harvest, storage and processing in the SADC region?*



- Are women involved in diagnosis and assessment of pests?
- Who applies storage protection measures?
- If losses occur, who loses money? Is the income of women reduced?
- Do women deal with pesticides in storage protection?
- Do women process, package and sell products at family level or in self-help-organizations?
- Which are the experiences of women in marketing (transport, market place, storage)?
- Are children involved in harvesting, storing and processing of agricultural products?



# THANK YOU FOR YOUR ATTENTION



[3]: RLAT