Quantifying postharvest losses in Sub-Saharan Africa

with a focus on cereals and pulses

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by

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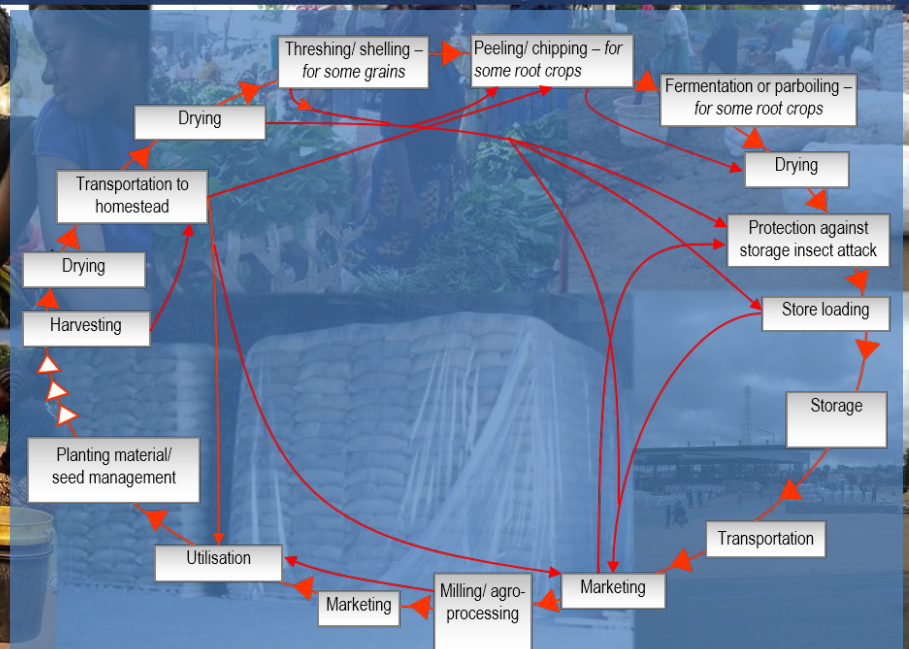
Quantifying PHL: Why?

- To understand how much food is being lost postharvest, where and why
- To help governments, development agencies, private companies and individuals better understand, target and prioritise their loss reduction interventions and policies
- Because we want to reduce the amount of loss and it is challenging to manage what is not measured
- To track progress on the major PHL reduction goals in SSA
  - Malabo Declaration to halve PHLs by 2025
  - SDG 12.3: By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses
  - *Rockefeller YieldWise initiative which aims to demonstrate how the world can halve food loss by 2030 – with an initial focus on staple crops, fruits, and vegetables in Kenya, Nigeria and Tanzania*

Postharvest systems are complex and dynamic, postharvest losses can occur in various ways



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Postharvest Loss Quantification Systems

- APHLIS – African Postharvest Losses Information System www.aphlis.net
- Food Balance Sheets - http://www.fao.org/faostat/en/#data/FBS
- Global Food Loss Index – Indicator 12.3.1 (SDG target 12.3)
  - Model linked to change in food losses for country X over time, refined through case studies (FLAs, CLPS) and review, validated using Food Balance Sheets accounting framework
  - Lowest hierarchical level = country commodity-specific

Other opportunities:

- LSMS - Living Standards Measurement Study -
  - nationally representative survey with HH demographics, agroecology, market, consumption, assets and income information, able to compare across countries (Burkina Faso, Ethiopia, Malawi, Mali, Niger, Nigeria, Tanzania, Uganda)
  - but v. low response rate to question on perceived % PHL *[> 88% missing responses in Malawi (2010/11); Tanzania (2008/09 & 10/11 & 2012/13)]* – and many HHs reporting 0% PHL.
  - no breakdown of % loss by PH stage, although some PH system details & loss causes captured
- Case studies with comparable methodology – using the elusive standardised loss assessment method
- Scalable remote survey techniques e.g. Interactive Voice Response (IVR)

APHLIS

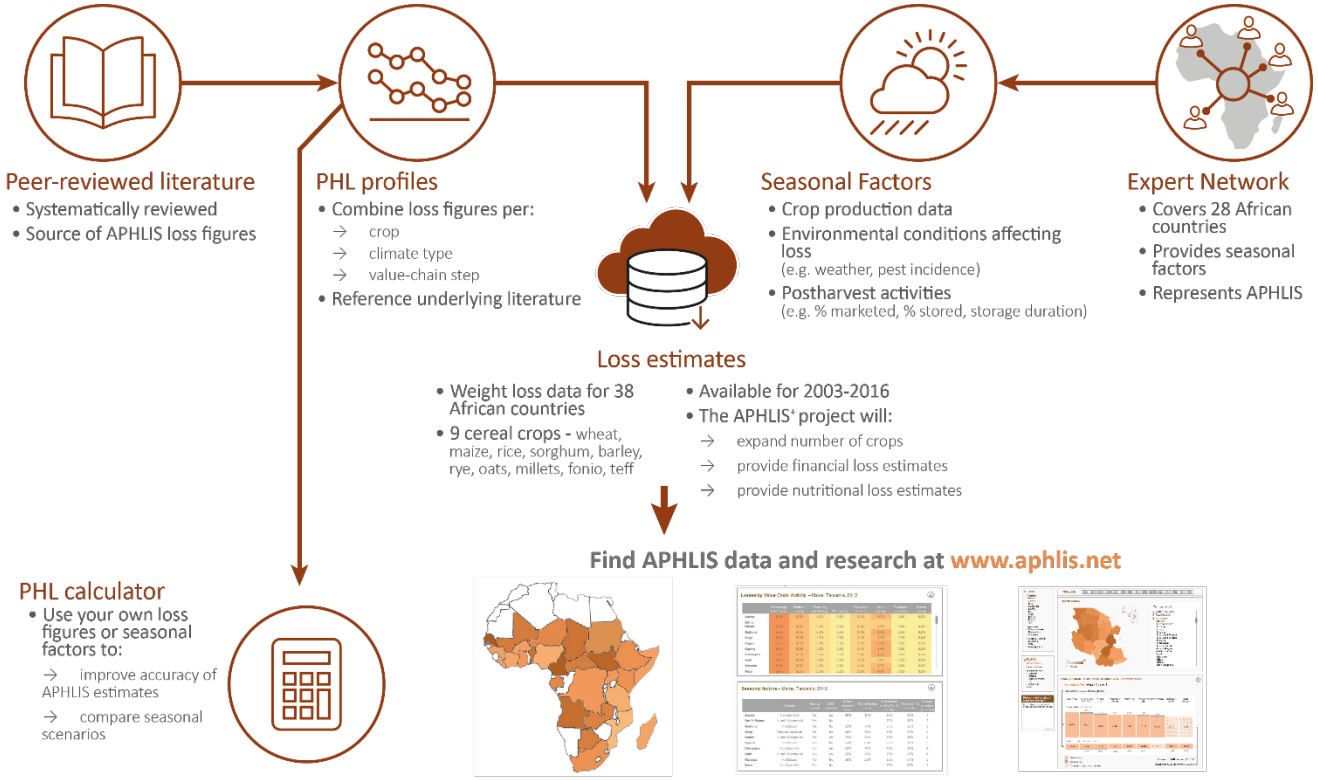
The African Postharvest Losses Information System

What is APHLIS?

APHLIS estimates the annual % postharvest weight loss of cereal grains in sub-Saharan African countries.

How APHLIS works

APHLIS bases its estimates on postharvest loss data from the literature which is further contextualised using seasonal factors submitted by a network of local experts.



APHLIS+ - expanding our scope

Funded by the Bill and Melinda Gates foundation from 2016 – 2020, the APHLIS+ project will add new crops and financial & nutritional loss estimates to the data provided by APHLIS.

BILL & MELINDA GATES foundation

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APHLIS
African Postharvest Losses Information System

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Postharvest Losses Dashboard - Maize, Iringa, Tanzania, 2012, Dry weight losses

CROP

Cereals
- Wheat
- Maize
- Rice
- Sorghum
- Barley
- Rye
- Oats
- Millets
- Fonio
- Teff

Legumes
- Common bean
- Groundnut
- Cowpea

Roots & Tubers
- Cassava
- Yam
- Sweetpotato

METRIC

Weight loss

Financial loss

Nutritional loss
- Calories
- Protein
- Carbohydrates
- Iron
- Vitamin A
- Zinc

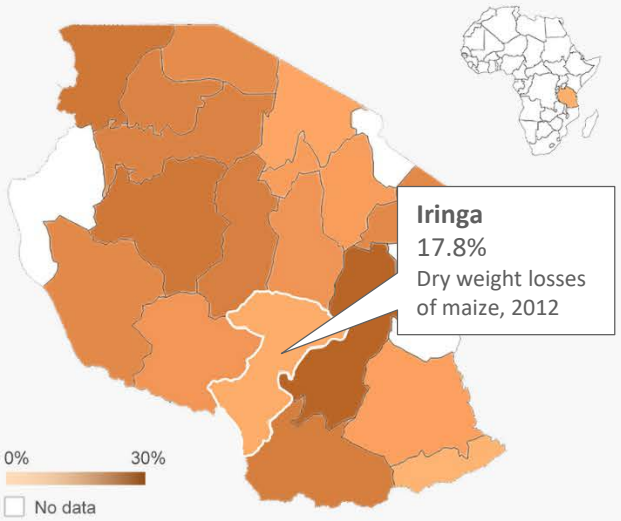
Did you find what you were looking for?

Please share any feedback, comments or suggestions here

TIMELINE

2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017

GEOGRAPHY



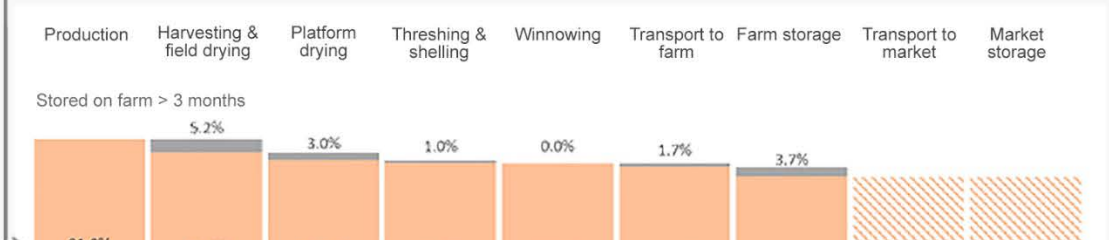
Filter results

- SOUTH SUDAN
- SWAZILAND
- TANZANIA
  - Arusha
  - Dar es Salaam
  - Dodoma
  - Iringa
  - Kagera
  - Kaskazini-Pemba
  - Kaskazini-Unguja
  - Kigoma
  - Kilimanjaro
  - Kusini-Pemba
  - Kusini Unguja
  - Lake Victoria
  - Lindi
  - Manyara
  - Mara
  - Mbeya
  - Mjini-Magharibi

VALUE CHAIN - Maize, Iringa, Tanzania, 2012, Dry weight losses

Percentage (%) | Weight (tonnes, t)

Production: 636,409 tonnes (100%)



Type of Postharvest Loss?

Quantitative (physical) loss

when the quantity of commodity available is reduced

% weight loss

Qualitative loss

when the value/quality of commodity is reduced

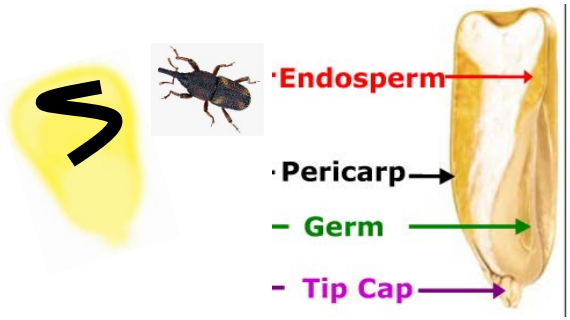
lowered grade

financial loss, nutritional loss, health hazard, seed viability loss

Nutritional loss

	Research findings on
	insect infestation of stored grain
Carbohydrates	▲ reducing-sugar content (wheat). ▼ starch (rice).
Nitrogen, Amino Acids, Protein	▼ Severe insect damage may reduce protein quality (maize, cowpeas). Rodents gained less weight from infested grain, as it is unpalatable so they ate less. ▲ Total Nitrogen content increased in wheat, finger millet, maize, grams, bean, cowpea; no change in rice. In sorghum & g/nuts no change or increase due to attack on endosperm not pericarp (which contains more N). Some loss of essential amino acids reported. For example, ▼ lysine & threonine, sorghum & green gram 3-4 mo, cowpea 6mo ▼ tryptophan (24%) in Bengal gram; methionine (50%) in field bean Nutritionally significant as lysine & threonine are limiting in cereal grains, and methionine & tryptophan in legumes.
Lipids/ Fats and Fatty Acids	▲ Increase in free fatty acids (maize, wheat, rice, sorghum, legumes, groundnuts, grams, beans, groundnut). ▲ Increase in fat content of heavily weevil infested maize.
Vitamins	B-vitamins: ▼ Losses in thiamine content (wheat, rice, maize, sorghum, millet, cowpea, grams, field bean) ▼ Losses in riboflavin content (sorghum, rice)
Minerals	
Other	▲Fibre due to hollow kernels, so less absorption of nutrients Insect by-products > bad odours, flavours, some carcinogens, allergens ▼ Reduced palatability, leading to reduced weight gains in rats ▲ moisture can activate enzyme systems resulting in deterioration Contaminants (e.g. excreta, fragments), and broken grain
Energy & Nutritional Change	~ Varies with nutritional composition of food & insects' feeding habits

Physical loss + Nutritional change due to deterioration



Financial loss

- Quality typically judged using visual characteristics
- Insect damage a key factor
- How does % damage relate to price discounting, for different crops, uses, places, & times in the season
- Seasonality; subjectivity
- % damage to % weight loss relationship in crops

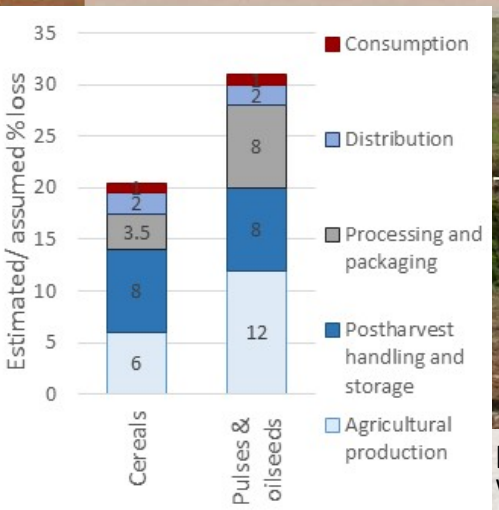
Commodity (location)	Chain level	Research	Key findings	Study
Maize (Zambia)	Storage	Insect damage/ grade – price relationship	Change in farmer's subjective assessment; accepted and sold damaged maize more easily near end of season. Different standards used depending on intended use.	Adams & Harman, 1977
Maize (Ghana)	Storage	Insect damage-price relationship	0.6-1% price discounting for every 1% increase in damage; 25-30% overall value loss	Compton et al., 1998
Maize (Malawi)	Marketing	Insect, mould damage and variety – price relationship		Jones et al., 2012
Maize (Rwanda)	Marketing	Insect damage – farm-gate level price relationship	Moderate discount for 5-10% grain damage, while 20-30% damage largely unmarketable. More tolerance to damage after several months storage 0.76% price discount per 1% damage, vs 1.28% at harvest	Jones et al., 2014
Maize (Benin)	Marketing	Insect damage – price relationship	10% increase in damage results in a 3-9% price discount. Discounts larger just after harvest than in lean period	Kadjo et al., 2016
Common beans (Tanzania)	Storage	Insect damage-price relationship	2.3% price discount for every one bruchid hole per 100 grains	Mishili et al., 2011
Cowpeas (Ghana)	Storage	Insect damage-price relationship	12-18% price discounting for insect damage ranging 2.6-70%	Golob et al., 1999
	Storage	Insect damage-price relationship	1.2% price discount for every bruchid hole in 100 grains	Langyintuo et al., 2003
	Marketing	Insect damage-price relationship	0.2-0.5% price discount for every bruchid hole per 100 grains	Langyintuo et al., 2004
	Storage	Consumer preference for quality	0.5% price discount for every bruchid hole in 100 grains; consumers willing to pay a premium for quality	Mishili et al., 2007

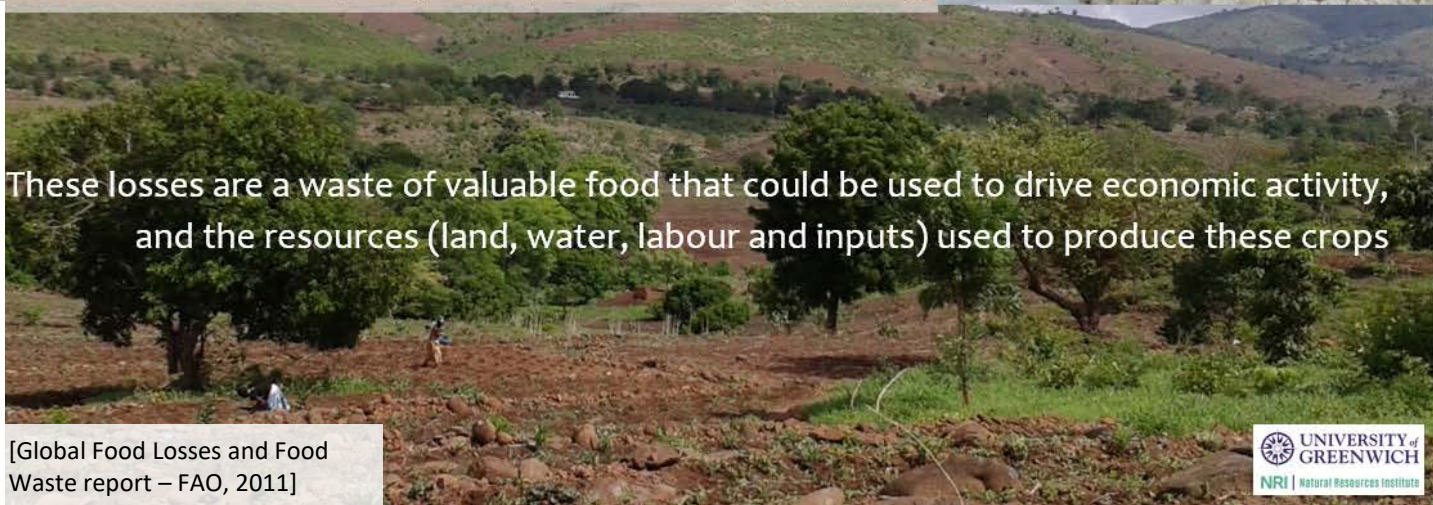
Source: extracted from Affognon et al., 2014; and Jones & Alexander 2016

Sub-Saharan Africa PHL Figures & Trends

13.5% of the grain produced across sub-Saharan Africa is **lost postharvest**
equivalent to US$4 billion per year,
or the annual caloric requirement of 48 million people

[Missing Food report - World Bank, NRI, FAO, 2011]





These losses are a waste of valuable food that could be used to drive economic activity, and the resources (land, water, labour and inputs) used to produce these crops

[Global Food Losses and Food Waste report – FAO, 2011]

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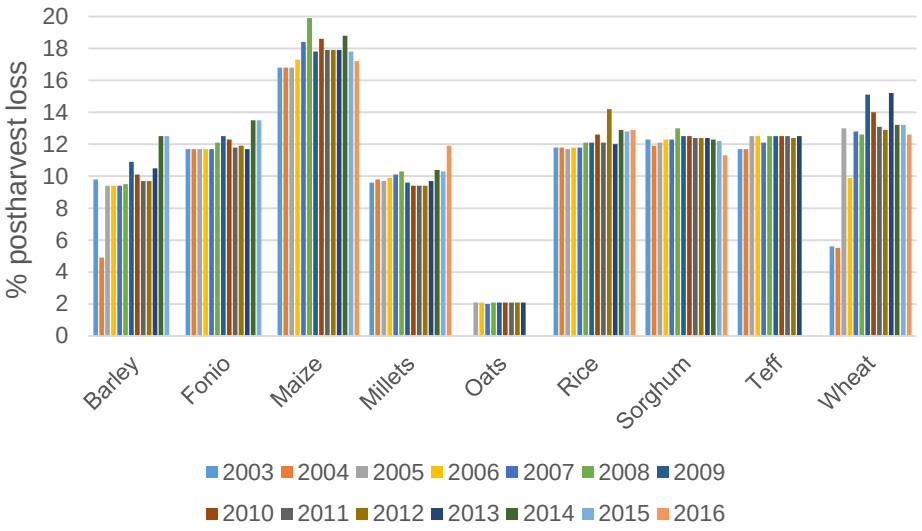
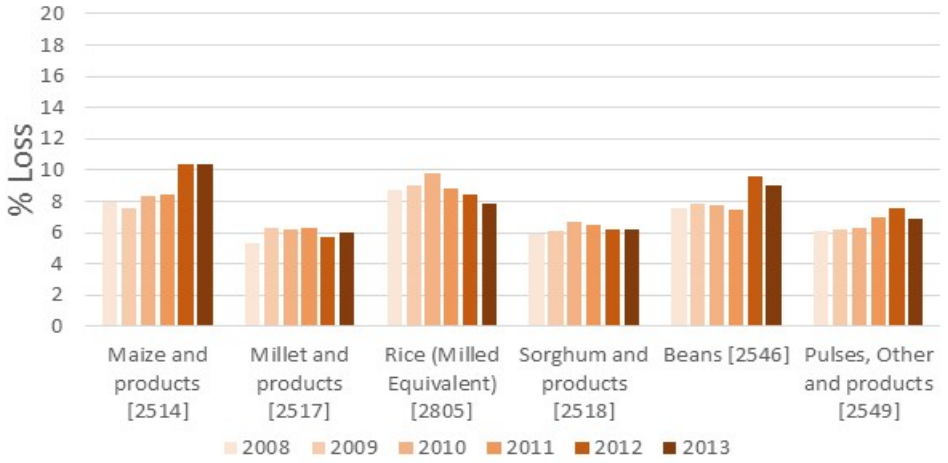
SSA PHL Figures and Trends *continued*

Cereal postharvest losses in sub-Saharan Africa
(Source: APHLIS www.aphlis.net)



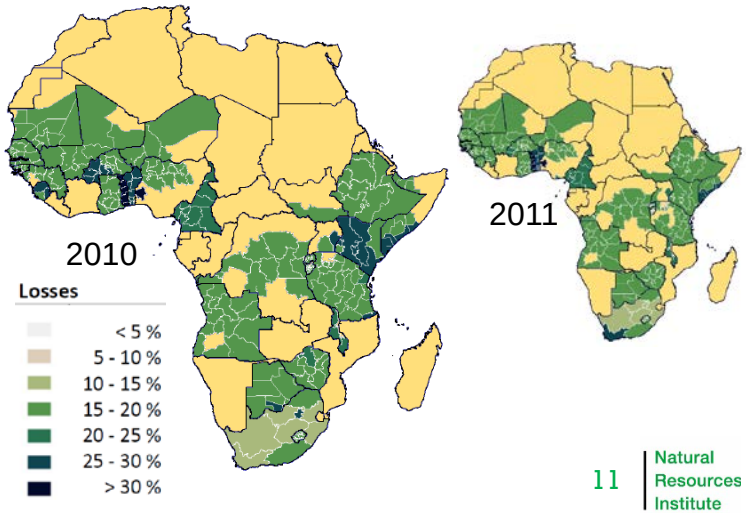
% postharvest loss of cereals and pulses, East Africa
(Source: Food Balance Sheet data)



Losses at different postharvest stages, sub-Saharan Africa, 2011
(Source: APHLIS www.aphlis.net)

	Harvesting/ field drying	Platform drying	Threshing and Shelling	Winnowing	Transport to farm	Farm storage	Transport to market	Market storage
Barley	4	-	3.5	0	2.5	0.6	1	2.4
Fonio	3.9	-	3.5	2.5	2.5	0.2	1	2.7
Maize	6	3.8	1.7	-	2.2	4.4	1.4	2.7
Millets	3.6	-	2	1.4	2.5	0.9	1	2.6
Oats	2	-	-	-	-	-	-	1.3
Rice	5.5	-	3.1	2.5	1.3	0.8	1	2.6
Sorghum	4.9	-	3.6	0	2.2	2.4	1	2.6
Teff	3.5	-	3.5	2.5	2.5	0.3	1	2.7
Wheat	5.4	-	3.5	0	2.5	4	1	2.4

MAIZE PHLs by province (Source: APHLIS www.archive.aphlis.net)



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At which PH stages do most PHLs occur and why?

PH stage		Loss causing factors	% wt loss		PHL measurement methods	When
			Range	Mz, Dod-2012		
Harvesting/ field drying		•Grain scattering •Grain left on plant	4-8	6.4	Harvest test area carefully & compare yield with farmer harvested area or after farmer's harvest collect up remaining grain and compare	Just before AND just after harvest
Transport from field		•Spillage	2-4	2.4	Weigh amount leaving field, and amount arriving at homestead Or follow the crop journey and collect up any spilt grain	At harvest
Further drying		•Livestock theft •Bio-deterioration (pests, mould etc.)	1-2	4	Placing plastic sheet under drying crib and collect left behind grains, or weigh & determine grain mc grain at start & end of drying compare anticipated weight decrease with actual weight loss. Plus quality losses	At harvest AND at end of drying
Threshing or Shelling		•Scattering/ spill •Left on seed head •Breakage	1-3	1.3	Sample threshed heads at random and weigh the remaining grain on them compare to same number and size of unthreshed heads & carefully thresh Scattered grain-plastic sheet under threshing area or collect. Weigh brokens.	At start of threshing
Winnowing		•Scatter/ spill	1-3	0	Plastic sheet on ground and weigh of spilt grain	
Sorting		•Grades/ usage			Only a loss if some gets scattered and left, how is down-graded used	
Packing		•Spillage			Plastic sheet on ground when loading grain into sacks or collect up grains	At loading
Farm-level storage		•Pest damage •Mould	2-5	5.3	Using visual damage scales calibrated for % wt loss Count and weigh loss assessment on samples Need to combine with farmer withdrawal records for accuracy	At start & month or bi-monthly intervals
Transport to market		•Spillage	1-2	1.7	Weigh amount leaving field, weigh amount arriving at market.	At start and end of grain's journey to market
Market or aggregation point storage		•Pest damage, mould •Sorting/conditioning •Water leakage •Spillage	2-4	2.7	Weigh amount of good quality grain entering and leaving the system, & spilt/discards NB some may be removed during conditioning, & may get further drying so record mc Visual scores use on samples to determine quality class at start and end	At start and end of aggregation/market storage. Plus spills during

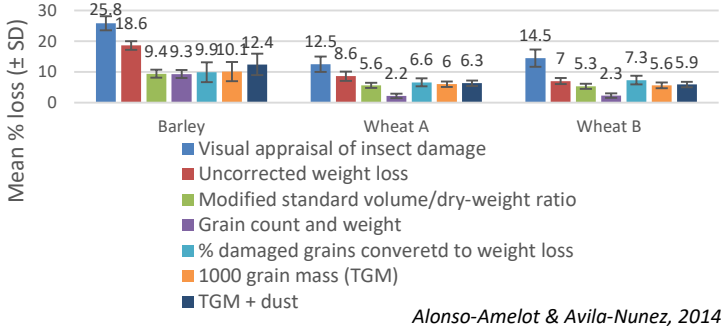
Adapted from Boxall (1986) and

Postharvest Loss Quantification and/or Measurement Methods

Include:

- Direct weighing and load-tracking
- Counting
- Surveys
- Records
- Price discounting study
- Food proximate analysis
- Mycotoxin analysis
- Carbon footprint/ Life Cycle Assessment

Few method comparisons



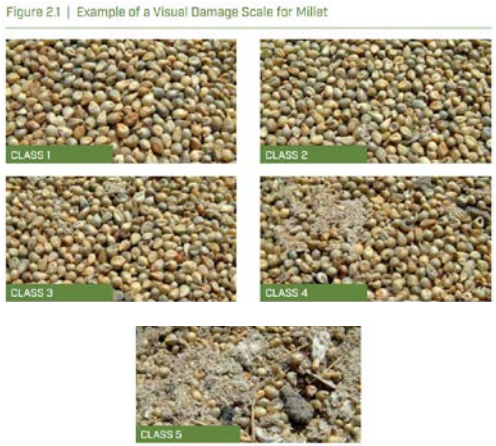
Alonso-Amelot & Avila-Nunez, 2014

Possible issues

- Double counting losses at different PH stages
- Grain withdrawals / consumption not factored in
- Not defining loss clearly
- Confusing % damage and % loss
- Quality loss and quantity loss, past focus on weight loss, how to combine quality & quantity loss in a single figure
- Subjectivity, agendas
- Spatial, temporal spread of PH activities
- Limited measuring, methods often unclear

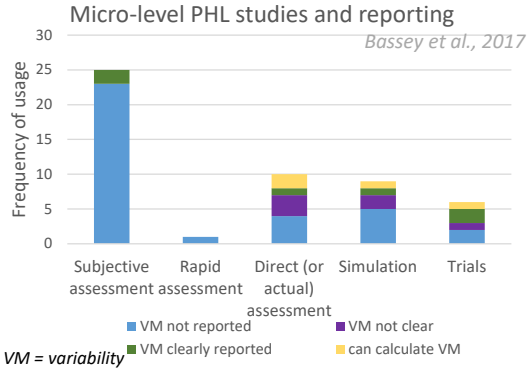
Count and weigh

Rapid loss assessment, visual scales



Hodges et al., 2014

- Storage & maize focus
- Extremes used as opposed to averages
- Treating partial damage as total loss



VM = variability

Comparing findings on level of PHL by PH stage

Comparing perceived critical loss points (CLPs) and measured loss from recent national food loss assessment (FLA) and other case studies, with APHLIS % dry weight loss estimates

PH stage	SSA	Zimbabwe			Burkina Faso						Uganda			DRC				Malawi	
	Maize	Maize			Maize			Sorghum			Cowpea			Maize				Rice		Maize	
	APHLIS % DWL	FP CLPs	FP % PHL	APHLIS % DWL	SHP CLPs	Meas. % loss	APHLIS % DWL	SHP CLPs	Meas. % loss	APHLIS % DWL	SHP CLPs	Meas. % loss	SHP CLPs	Meas. % PHL	APHLIS % DWL	SHP CLPs	APHLIS % DWL	SHP CLPs	APHLIS % DWL	FP % PHL	APHLIS % DWL
Harvesting	5.7	****	13.9	6.4	****	3.5	3.8	****	5.4	4.6	****	8.7	****	3.3	3.8		3.8	****	4.4	3	3.8
Field drying		****			****						****					****					
Transport (field to home)	2.3	**	4.6	2.4			1.9	****	0.3	2.2					1.9		1.9		1.3		1.9
Homestead drying	3.9	***	7.2	4			3.5								3.5		3.5	****			3.5
Threshing/ Shelling	1.6	****	3	1.3	****	5.6	2.3	****	0.47	3.6	****	1.1			2.3		2.3		3.1		2.3
Storage (home)	4.5	***	9.4	4.5 (8m)	****	2.7 (5m)	4.6 (7m)		0.02 (5m)	2.7 (7m)	****	35 (5m)	****	17 (?m)	4.6 (6m)	****	2.3 (12m)	****	1.2	1 (?m)	4.2 (10m)
Storage (coop/ aggregated)	/	*		/			/			/					/	****	/		/		/
Sorting & grading	/	*		/			/			/					/		/		/		/
Transport (farm> market)	1.5	*		1.7	****	0.3	1	****		1					1	****	1		1		1
Milling	/	*		/	****	20[a]	/			/			****	5	/		/		/	1	/
Marketing	/	*		/			/			/					/		/		/		/
Storage (market)	2.7			2.7			2.7	****		2.7					2.7	****	2.7		2.7		2.7
Total	17.8			17.2			20.9			12.7					18.2		17.2		13.9		19.3
Source:	A - 2015	B - 2015/6		A - 2015 Mash East	C - 2015/16 Hauts-Bassins		A - 2015 Hauts-Bassins	C - 2015/16 Boucle du Mouhoun		A - 2015 - Boucle du Mouhoun	C - 2015/2016 Nord		D - 2015/16 Northern Uganda (Apac & Lira)		A - 2008 Northern Uganda	E - 2015/16 Kwilu, Bandunu	A - 2011 Bandunu	E - 2015/16 Bas-Congo	A - 2011 Bas-Congo	F - 2014/2016 C. Malawi (Dowa & Ntchisi)	A - 2012 Central

Key: FP = Farmer perceived; SHP = Stakeholder perceived; Meas. = Measured; PHL=postharvest loss; DWL = dry weight loss

Sources: A = APHLIS; B = Mvumi et al., 2017; C = Tagnan et al., 2017; D = Muyinza et al., 2017; E = *Sumbu* et al., 2017; F = Ambler et al., 2017

Maize – CLPs: Harvesting, Threshing, Storage, [Milling – transformation, eqpt?]. *Sorghum* – H, Th, St plus transport

Rice – H, Dry, St – [usually threshing also a CLP]. *Cowpea* – H, Dry, Thr, St

Magnitude of loss differs by method, but mainly agree on which stages have most losses. APHLIS is an estimation tool where direct measurements not available.

There is a lot of other PHL data much from surveys or storage trials, this table compares a few with figures across different PH stages

Recent research on most effective PHL reduction methods

Capacity building

Need to invest in building PH skills & understanding throughout the agricultural innovation system & schools

Postharvest Agricultural Innovation System (AIS) strengthening

Loss reduction needs national recognition and commitment

Awareness raising - as many PH activities are private and invisible, with highly gendered roles

Consider PH issues when promoting new varieties, fertilisers etc.

Build capacity of AIS actors to compare practices and technologies and adapt to uncertain future scenarios

Better collaboration between those working on addressing and quantifying PHL at scale

AgResults incentivising private sector involvement in grain storage in Kenya:

– *636,090 hermetic devices sold, creating 189,419 extra MT of improved storage since 2016.*Impact comparison vs subsidised approaches

Quality sensitive markets to pull improved quality, farmer aggregation & financial access

Food Reserves (national or regional) offering large-scale, 'potentially' better controlled storage conditions

Technologies

No silver bullets, a technology-focus alone will not bring change

Hermetic bags effective & affordable, need promoting with PHM grain drying, hygiene, rodent management, market linkage, and financial access etc.

Diatomaceous earth grain protectants highly effective, minimal private sector involvement to date in SSA

Mobile drying, threshing services operating as private businesses

Outstanding challenges

- Drying of crops given increasingly variable climates, more high MC related PHLs e.g. aflatoxins
- Reducing harvesting losses
- Poor efficacy of many existing chemical grain protectants
- High risk of phosphine resistance (poor fumigations, v. limited other options in medium to large scale storage)
- Imbalance in support for tangible options vs skill knowledge building & linkages
- Better understanding of non-farm PH stage challenges and opportunities (transport, trader & large-scale storage, consumer food waste in SSA)
- Going from pilot to scale, unrealistic time -frames, oscillating interest in PHL reduction

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