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APHLIS – Postharvest cereal losses in Sub-Saharan Africa, their estimation, assessment and reduction

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APHLIS - AFRICAN POSTHARVEST LOSSES INFORMATION SYSTEM

- A TRANSNATIONAL NETWORK OF CEREAL GRAIN EXPERTS

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APHLIS explained

APHLIS provides estimates of the postharvest weight losses (PHLs) of cereal grains for Sub-Saharan Africa. These loss estimates support -

- agricultural policy formulation
- identification of opportunities to improve value chains
- improvement in food security (by improving the accuracy of cereal supply estimates), and
- monitoring of loss reduction activities

APHLIS is based on a network of local experts (see Annex 1). Each country supplies and quality controls its own data that are stored in an exclusive area of a shared database. The APHLIS website displays the loss estimates as maps and tables. The APHLIS Network members also have the opportunity to post a 'Country Narrative' that gives a commentary on these postharvest losses in the context of the postharvest systems and projects of their countries.

The loss estimates are generated by an algorithm (the PHL Calculator) that works on two data sets, the postharvest loss (PHL) profiles and the seasonal data. Each PHL profile is itself a set of figures, one for each link in the postharvest chain. These figures are derived from a very detailed search of the scientific literature followed by screening for suitability. They remain more or less constant between years. The seasonal data are contributed by the APHLIS Network and address several factors that are taken into account in the loss calculation. They may vary significantly from season to season and year to year.

APHLIS estimates are not intended to be 'statistics' although they are computed using the best available evidence; they give an understanding of the scale of postharvest losses using a 'transparent' method of calculation. The estimates are assigned by primary administative unit (province) and may be aggregated to country or to region. Provinces are usually large geographical units and may include several agro-climatic zones, consequently the loss figures are generalisations, i.e. may be at variance from those experienced in particular situations. APHLIS recognises this limitation and offers a downloadable PHL Calculator that enables practitioners to change the default values to those that are specific to the situation of interest and to obtain loss estimates at a chosen geographical scale. The PHL Calculator can also be used with hypothetical data inorder to model 'what if' scenarios.

*A*PHLIS offers a robust system for the estimation of PHLs, is transparent in operation and can capture improvements in loss estimation over time by the accumulation of new and more accurate data. It encourages the collection of new data and offers advice on modern approaches to loss asssessment. For the future, APHLIS is envisaged as a much broader communcition hub that informs, motivates and coordinates efforts to optimise postharvest mangement by (among others) -

- Expanding its scope to including other crops and by providing near real time information products for improved decision making.
- Improving data gathering by automatic uploading of weather data. This would support predictive models relating to grain drying problems, mycotoxin contamination etc. These functions would connect with other projects on mycotoxin control and climate change adaptation.
- Enhancing interaction between smallholders and other value chain actors through demand-driven and results-oriented information exchange and networking services delivered by young professionals.

This new vision brings modern ICT to bear on the problem of postharvest loss reduction, provides a cost-effective means to collect data and disseminate results, and with scaling out will have significant impacts on postharvest management and the livelihoods of smallholder farmers. This expansion creates a bottom-up Community Practice.

Preface

APHLIS[1] is a unique resource providing estimates of postharvest cereal weight losses in Sub-Saharan Africa. An important feature of the system is that it is supported by a network of African agriculturalists who submit and 'own'the country-specific data.

The first version of APHLIS focused on only East and Southern Africa and went live in 2009. The initial objectives and construction of APHLIS were described in 2011 in a report published by the European Commission[2]. In the foreword of that report the main emphasis was placed on the contribution of APHLIS to cereal supply calculations that lead to important decisions about national food security. Since then the focus of APHLIS has been broadened so that it is now aims to serve the needs of not only cereal supply calcualtions but also for the planning and execution of loss reduction activities.

During two further APHLIS projects, ending in 2014, the focus moved from cereal supply calculation to loss reduction and the system was expanded to cover nearly all countries in Sub-Saharan Africa. Furthermore, there was a significant upgrading of the APHLIS website and the features it offers to provide better information on cereal losses. These changes have included much improved interative mapping of losses and the addition of maps giving absolute losses (MT/km^2) that complement the relative loss maps (% weight losses). For several countries there are now webpages dedicated to country-specific narratives that explain and explore the loss values given within APHLIS and provide information on the local postharvest situation and losses projects. New information materials have been added to enable a better understanding of the signifcance of loss of quality and a series of tips for reducing the losses of smallholder farmers. A key feature of the system, the downloadable PHL Calculator that allows the practitioner to estimate losses at any given geographical scale using their own data, was upgraded with several new features to increase funcationality.

Besides the new technical features, the engagment of APHLIS with the development community over the last three years has shown that it can be developed further as a communication hub that informs, motivates and co-ordinates efforts to reduce postharvest losses. This report has been prepared to focus this interest and to meet the needs of users for an up to date reference that both explains how the system can be used, how it was developed, and what opportunties there are for further development. Some outputs of APHLIS over the last two years, particularly a 'Loss Assessment Manual' and a 'Quality Losses report' have been integrated into this text although both of these can be downloaded individually from the APHLIS website.

The manual is presented in four parts. Part 1 deals with the nature of cereal grain postharvest losses and places APHLIS in the context of agricultural development. Part 2 provides details of all the features of APHLIS. Part 3 explains how to generate new data using rapid methods of loss assessment, and Part 4 looks to a future where APHLIS could be expanded to APHLISplus, the basis to a Community of Practice dedicated to loss reduction through improved postharvest management.

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[1] APHLIS was developed as part of the European Commission's Joint Research Centre research programme by the Natural Resources Institute (UK) and the German Ministry of Food (BLE)

[2] Rembold F., Hodges R., Bernard M. and Leo O. (2011). The African Postharvest Losses Information System. Publications Office of the European Union, EUR Scientific and Technical research Series – ISSN 1018-5593. Pp 72

Acronyms and abbreviations

AIDCO	Europe Aid Co-operation Office
APHLIS	African Postharvest Losses Information System
AGS	Rural Infrastructure and Agro-Industries Division (of FAO)
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BLE	German Federal Office for Agriculture and Food
CFSAMs	Crop and Food Supply Assessment Missions
FAO	United Nations Food and Agriculture Organisation
FARA	Forum for Agricultural Research in Africa
GIEWS	Global Information and Early Warning System (of FAO)
JRC	Joint research Centre (of the European Commission)
LGB	Larger Grain Borer (*Prostephanus truncatus*)
MARS	Monitoring Agricultural Resources (JRC Unit)
MT	Metric tonne
NRI	Natural Resources Institute (United Kingdom)
PhAction	Postharvest Action (Global Postharvest Forum, formerly GASGA)
PHL	Postharvest loss
PFL	Prevention of Food Losses programme (FAO)

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Part 1 – The Nature of Cereal Grain Postharvest Losses

1. Introduction to cereal postharvest losses

APHLIS is a new and dynamic contributor to agricultural development, an area that has received an upsurge of interest following the food crisis of 2006/08. This chapter places APHLIS in the current context of agricultural development, mentions some important considerations in loss estimation, gives details of factors responsible for cereal losses, and compares losses of quantity (weight) and quality.

Postharvest operations for cereal grains follow a chain of activities (Fig. 1.1) starting in farmers' fields and leading eventually to cereals being supplied to consumers in a form they prefer (Goletti and Samman, 2002). When determining the losses that may occur in this chain it is conventional to include harvesting, drying in the field and/or on platforms, threshing and winnowing, transport to store, farm storage, losses incurred in transport to market and market storage. In some contexts cereal processing losses may also be included but this is not usually the case (Boxall, 1986). Losses are normally expressed as loss in dry weight of the cereal crop but losses of grain quality may be of equal or even of greater significance (see **Section1.5**).

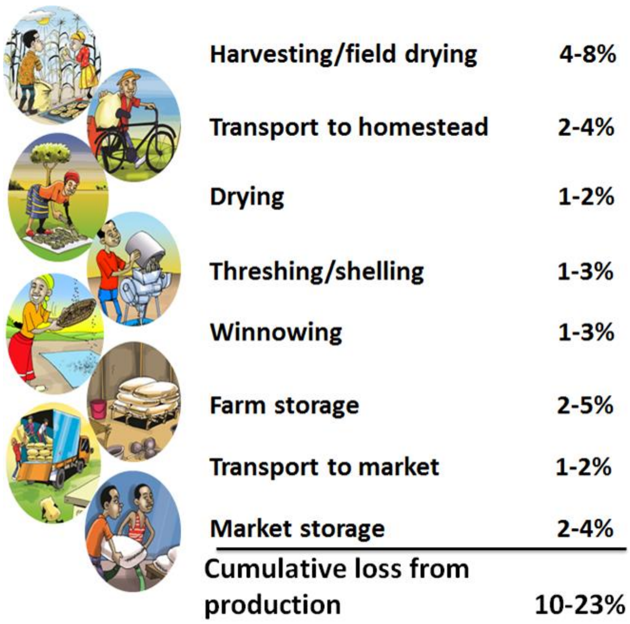


Figure 1.1: Links in the postharvest chain for cereal grains in Sub-Saharan Africa, showing typical weight loss ranges

1.1 The food crisis

Soaring food prices in 2006/08 and the risk of food shortages in the future have renewed interest in agricultural development in Sub-Saharan Africa (SSA). For the majority of the population of SSA, cereal grains are the basis for food security and a vital component in the livelihoods of smallholder farmers. Cereals constitute about 55% of the African food basket and for every 1% increase in food prices, food expenditure in developing countries decreases by 0.75% (FAO, 2006). In seeking to make improvements to cereal grain supply, an important element to consider is postharvest losses (PHLs) and major donors, including World Bank, African Development Bank, Rockefeller Foundation and Bill and Melinda Gates Foundation, are focusing on loss reduction.

Grain postharvest losses may be both the physical losses (weight and quality) suffered during postharvest handling operations and also the loss of opportunity as a result of producers being unable to access markets or only lower value markets due to, for example, sub-standard quality grain or inadequate market information. Wide ranging reviews of grain postharvest losses have been published by Greeley (1982), Boxall (1986 & 2001), Grolleaud (1997), *Hodges et al*. (2010), Hodges *et al*. 2013, and Hodges and Stathers, 2013.

Investment in reducing physical PHLs is an attractive option since grain supply can be increased without wasting other resources such as labour, water, land, and agricultural inputs. Nevertheless loss reduction will require its own investments.

APHLIS was developed initially to support cereal supply calculations. In the case of cereal supply balances, an estimate of how much grain may be available to consumers emerges when national cereal production/import figures are corrected for postharvest losses. Examples of cereal supply calculations can be seen in the Crop and Food Supply Assessment Missions (CFSAMs) on the website of FAO's Global Information and Early Warning System (GIEWS[3]). However, APHLIS loss data are equally useful to the other applications. Reliable estimates for postharvest weight losses are needed for at least three other purposes: guiding the development of agricultural policy, planning and prioritizing loss reduction programmes, and monitoring the success of loss reduction activities.

1.2 The importance of cereal losses

Losses of grain quantity (weight losses) and losses of grain quality both deprive the farmers of SSA of the benefits of their labours. The significance of grain losses has been reviewed recently in the 'Missing Food' report (World Bank, 2011). This report emphasises the importance of viewing cereal losses not just as a loss of food but as a loss of all the resources that go into creating food, i.e. labour, land, water, fertiliser, insecticide etc.. It suggests that the value of weight losses amounts to about US$4 billion for SSA, which exceeds the value of total food aid received by SSA in the decade 1998-2008, equates to the value of cereal imports to SSA in the period 2000-2007, and is equivalent to the annual calorific requirement of at least 48 million people. It should be noted however that values were only based on losses of weight and consequently they are under estimates of the total loss.

Prior to the 1970s, most figures for postharvest weight loss of cereals were anecdotal. In 1977, the UN Food and Agriculture Organisation (FAO) presented a survey on postharvest crop losses (FAO, 1977), which concluded that there were few well supported postharvest loss figures for cereals. This inspired the development of improved loss assessment techniques, first detailed in Harris and Lindblad (1978) together with documentation on the losses themselves (National Academy of Sciences, 1978 a&b). The development of new techniques went hand in hand with FAO's Prevention of Food Losses (PFL) programmes of the late 1970s to 1990s.

In the past, at least up to the 1970s, traditional farming practice was commonly seen as technically primitive and the cause of high PHLs. But traditional practice is an unlikely culprit since farmers have survived difficult conditions over long periods by adapting their practice to meet the challenges of prevailing circumstances (Greeley, 1982). Nevertheless, serious losses do sometimes occur and these may have resulted from agricultural developments for which the farmer is not pre-adapted. In the case of grains, these include the introduction of high yielding varieties that are more susceptible to pest damage, additional cropping seasons that result in the need for harvesting and drying when weather is damp or cloudy, increased climate variability, or farmers producing significant surplus produce, which because it is to be marketed rather than consumed by the household, is less well tended (Greeley, 1982). In addition, the arrival of new pests can be a problem, as in the case of the larger grain borer or LGB (*Prostephanus truncatus*) which arrived in Africa from meso-America in the late 1970s and has spread across much of SSA attacking farm stored maize and dried cassava roots (Hodges *et al.*, 1983). With the arrival of LGB in Africa, loss estimation gained a new lease of life since this pest is significantly more damaging than native storage pests and weight loss estimates for storage increased from around 5% to an average of more like 10% (Hodges 1986; Dick, 1988) although losses

[3] http://www.fao.org/GIEWS/english/alert/index.htm

for individual, unlucky farmers could be 20% or even 30% (equivalent to 100% grain damage). In the 1990s, procedures for rapid loss assessment in farm stores were developed and used very successfully for estimating farm weight loss of maize in Ghana due to LGB (Compton and Sherington, 1999) although to date they have not be applied widely.

There have often been demands for simplified loss figures. This for example has led to the postharvest losses of maize for a country or region being reduced to just a single figure representative of many years. However, such an approach is likely to be misleading since as noted by Tyler (1982) “postharvest losses may be due to a variety of factors, the importance of which varies from commodity to commodity, from season to season, and to the enormous variety of circumstances under which commodities are grown, harvested, stored, processed and marketed.” It is therefore important not only to work with figures that are good estimates at the time and in the situation they are taken but to be aware that at other times and situations the figures will differ. This necessitates regular recalculation of loss estimates with the best figures available, a task addressed by APHLIS.

1.3 The meaning and estimation of cereal postharvest weight losses

Weight loss is the standard international measure of grain loss because it is useful in quantifying the national impact of losses and for comparing losses across sites and years (De Lima, 1979a). Weight losses are normally expressed as loss in dry matter, i.e. this does not include any changes in weight due to changes in grain moisture content. The weight losses are estimated in two ways, 1) by collecting and weighing the grain excluded from the system, e.g. grain that is scattered or spilt at harvest, during threshing, transport etc., and 2) by determining what weight of grain remains after a postharvest activity, e.g. after farm storage where pests may have consumed some of the grain.

It is important to ensure that weight losses are calculated correctly (Boxall, 1986). For example, a series of loss figures, for the links in the postharvest chain, cannot simply be added since the amount of grain subject to loss is diminished at each step in the chain. So for example, if 10% of the potential crop is lost during harvesting and a further 10% is lost during threshing, then the cumulative loss over both stages totals 19% (not 20%). A further example of cumulative loss concerns farm storage. If grain remains in store over a long period and none is consumed by the household then any loss observed at the end of storage represents the loss over the storage period. However if, as usual, households consume grain then each amount that is removed will have suffered a different degree of loss; this must to be taken into account when estimating total loss. Correction for household consumption can make dramatic reductions in the size of the estimate of storage loss. A cumulative loss of 30% without household consumption could be reduced to 11% when that is taken into account (Fig. 1.2).

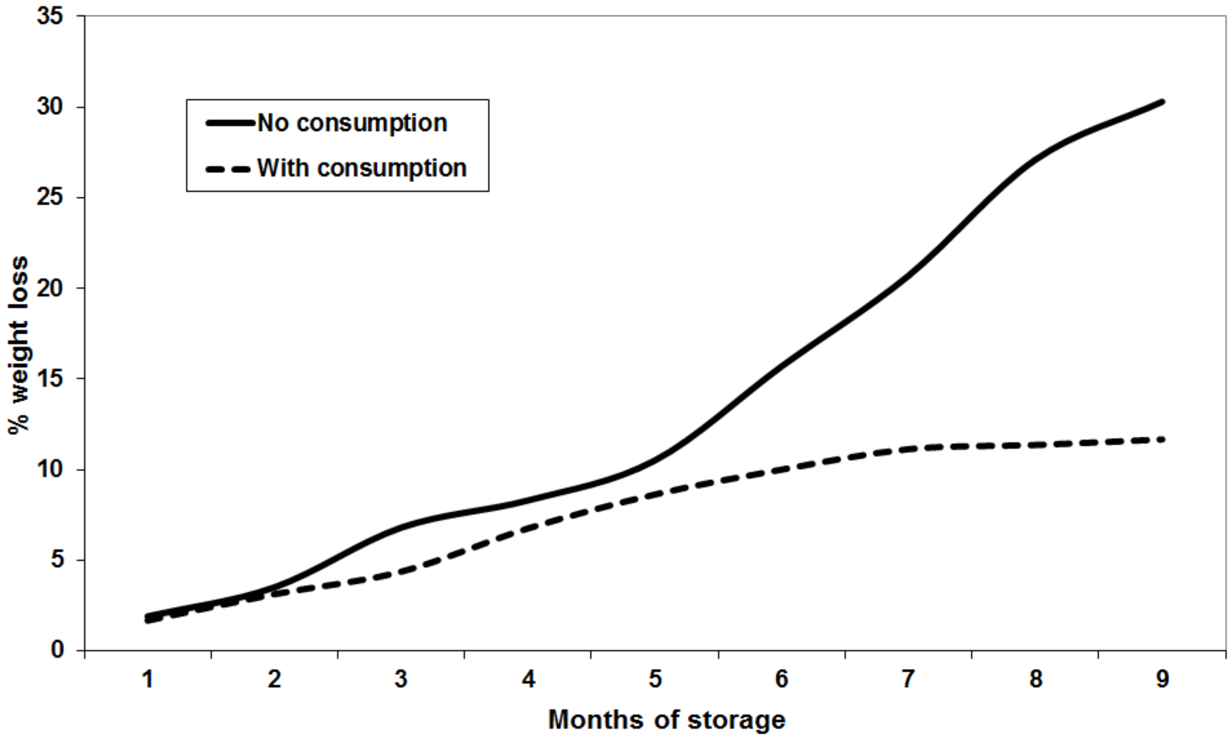


Figure 1.2: Cumulative % weight loss from maize cobs in Tanzanian farm stores infested with larger grain borer, as observed without household consumption or with a consumption calculation applied evenly so that by the 9th month all grain is consumed (data from Henckes, 1992)

Early studies on losses often did not take into account the grain that was removed from stores during the storage season as a result of household consumption, marketing etc.. A good example of a cumulative storage loss study is the pioneering investigation of Adams and Harman (1977) who measured storage losses in Zambia using a variety of modern methods (volumetric and gravimetric), offered an economic analysis of the observed losses and considered the costs and benefits of improvements to reduce them. The losses they found (4-5%) and subsequent studies on maize, particularly in east and southern Africa (Kenya – De Lima 1979b; Malawi - Golob 1981a&b), confirmed that on average farmers would lose 2-5% of the weight of their grain during the course of a typical storage season of about 9 months. They calculated cumulative losses, where the grain removed each month was accorded its own loss (which would be very little in the first three months) and then the total loss was calculated as a weighted average across all months. How APHLIS calculates losses is shown in **Section 3.3**.

1.4 Relative versus absolute weight losses

Weight losses may be presented in two ways, as an absolute loss which is the actual weight of grain lost (expressed in say MT or kilograms) or as a relative loss where the dry weight of grain lost is given as a percentage or proportion of the starting dry weight. APHLIS presents users with both absolute and relative loss values from production (e.g. the loss might be 17.5% from a production of 1000 MT, which is 175 MT, leaving 825 MT of grain supply). Only when the loss is expressed in absolute terms can the change in available grain supply be determined. It is important to remember that while relative losses may remain constant the absolute losses may change. For example, if grain production was increased to compensate for the 17.5% postharvest loss, mentioned above, and the relative losses remained the same then the absolute losses would increase at each link in the chain. This is one reason why reducing postharvest losses may be a more efficient way of increasing grain availability than by increasing production alone. Similarly, if relative losses are reduced at one link in the chain but remain constant at other links then the absolute losses at the other links will be greater since there is now more grain to be lost at those links (see Box 1.1).

Box 1.1: Reduction in the % lost at one link in the postharvest chain can result in greater absolute losses at the subsequent links in the chain

A farmers' group produces 100 MT of grain. They improve their harvesting technique and this reduces grain weight loss at harvest from 8% to 1%, a reduction of 7%. All other losses in the chain remain the same. In the table below it can be seen that with the harvesting improvement the loss increments (figures in red) at subsequent links actually increase because there is more grain left to lose.

	Without harvesting improvement			With harvesting improvement		
Postharvest link	**% loss**	**Grain remaining**	**Loss increment**	**% loss**	**Grain remaining**	**Loss increment**
Harvesting	8.0	92	8	1.0	99	1
Drying	4.0	88	3.7	4.0	95	**4**
Threshing	1.5	87	1.3	1.5	94	**1.4**
Transport to farm	2.0	85	1.7	2.0	92	**1.9**
Farm storage	5.0	81	4.3	5.0	87	**4.6**
Total grain loss			**19 tonnes**			**12.9 tonnes**

Before the improvement in harvesting technique (loss reduction) the grain available is 81 MT (100-19 MT). After loss reduction the grain available is 87.1 MT (100-12.9 MT). The cumulative loss has been reduced by 6.1 MT (87.1-81.0 MT) or 6.1% (6MT /100 MT), i.e. not 7% that was the original reduction in harvesting loss.

1.5 Weight loss versus quality loss

Quality losses are more difficult to determine than weight losses as they are usually expressed by several measures, such as the many factors included in an official grading standard (see Box 1.2). Furthermore a change in quality is not necessarily a loss until it has resulted in a decline in financial/economic value. It is at this point that the situation becomes complex. The relationship between the quality of grain and its value is not simple and varies from market to market and over the course of a season. For example, when grain is scarce, such as in the period just before a new harvest, there is little good quality grain on the market, consequently poor quality grain may sell for a price that is greater than that received for better quality grain just after harvest when grain is plentiful. Even if the relationship between quality and value is well understood (or given a nominal value) there are further problems

1) Data on grain quality, particularly at farm level are scarce. Part of the reason for this is that official grading of grain does not take place until it is in the formal market. But grain is often conditioned before it reaches the formal market so that the quality loss goes unrecorded.
2) Informal markets are often insufficiently quality conscious to distinguish between grades, and
3) Across formal markets, different countries are operating different grading systems for each grain type, so there are several measures of grain quality that are not equivalent, i.e. cannot be translated from one to the other.

Only in extreme cases does APHLIS include loss of quality. If the quality for grain has declined to the extent that it is no longer fit for human consumption then it is considered to be a 100% weight loss (Fig. 1.3), even if this means that it is downgraded to animal feed for which the seller may still receive some, but diminished, financial reward. But losses of quality or quantity may result in grain of lowered human nutritional value or present a health hazard, for example may be contaminated with mycotoxins, which are found especially on maize grown in more humid areas (Wagacha and Muthomi, 2008).

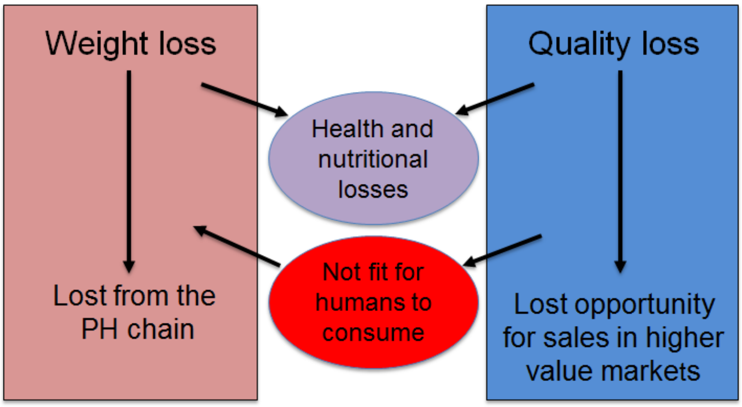


Figure 1.3: Relationship between losses of weight and losses of quality. If quality decline is extreme then food is not fit for human consumption (effectively a 100% weight loss).

1.6 How grain quality is valued

Grain quality issues differ depending on whether the grain is being traded on a formal or an informal market. In a formal grain market, the grain is traded at a specified standard and paid for according to the grade to which it conforms. Conversely, in an informal grain market grades are not enforced, consequently there is no pre-determined relationship between quality and price. There is very little data on the relative value of either weight or quality loss in either type of market. A detailed modelling approach to the estimation of total loss (quantitative and qualitative) was undertaken with farm stored maize in Cameroon, but this only considered insect damage (McHugh 1994). There are three studies that have attempted to place a value on the losses of smallholder cereal grains in Africa, where weight and quality losses are taken into account (Zambia - Adams and Harman, 1977; Ghana -Compton *et al.* 1998; Compton 2002).

In Zambia, cash cost estimates of losses showed that on average quality losses had twice the value of weight losses (Table 1.1). However, the authors of this study concluded that figures derived in this way had limited usefulness and should be viewed as a basis on which to compare losses in maize occurring during storage by smallholder farmers with those that may take place elsewhere in the postharvest chain, i.e. are likely to have more comparative than absolute value.

Table 1.1: The cost of losses during maize storage at two locations in Zambia, in Zambian Kwacha (Kw 1.2 = US$1) (from Adams and Harman, 1977)

		Direct			Indirect* (insecticides)
	Total direct + indirect costs	**Total direct costs**	**Weight**	**Quality**	
Chivuna	68.93	54.98	20.22	34.76	13.95
Chalimbana	26.12	21.47	3.51	17.96	4.65
Total	95.05	76.45	23.73	52.72	18.6
Mean all farmers	11.88	9.56	2.97	6.59	2.33

*Indirect losses are costs involved in the prevention of losses, in this case the application of storage insecticides

Quality in formal markets

For any one type of grain (maize, wheat, sorghum etc.) traded in a formal market, there may be several different quality grades. Cereals are bought and sold according to specific quality grades; these are usually determined by national or regional authorities. When seeking to purchase grain, a buyer will usually specify a particular quality grade in order to meet a particular end-use. For example, this could be for international export or food aid where high quality grain is required, for local consumption where reasonable but not such high quality is demanded, or for animal feed that requires only relatively low quality. In many cases, grades are specific to a national or regional marketing system. For example there are five different grades of maize specified by the US Department of Agriculture whereas there are only three grades in South Africa. When talking about commodity quality grades, people also refer to 'commodity standards'. A standard is a set of one or more quality grades and these are usually enforced by law.

The grade of a sample of grain is determined by careful analysis in a grain laboratory, according to a carefully defined method. The methods employed differ as each standard is different and the acceptable limits for each quality factor differ between grades and between the standards (Box 1.2).

Quality and value in informal markets

Only rarely has the value of quality losses been examined in informal markets, where specific grades are not enforced so in theory there would be a continuous relationship between price and quality (if there are grades enforced then there are price steps i.e. price and quality do not have a continuous relationship). It has been assumed that loss in value is equal to the weight of grain lost multiplied by the price of undamaged grain. However, when looking in more detail this appears not always to be the case, especially as in informal markets grain is often sold by volume and not by weight. In cases where weight losses reached up to about 5% due to insect damage, loss in maize value may be negligible because the volume of the grain is effectively the same as that of undamaged maize and the price is unaffected by low levels of damage, especially when slightly damaged grain can be mixed with good grain to obtain 'top quality' maize (Compton, 2002). The effects of quality deterioration, in this case insect damage, on the price of maize have been studied in an informal market in Ghana (Compton *et al*. 1998). Panels of experienced maize traders were asked to suggest prices for pre-prepared maize samples showing different degrees of insect damage. The relative price of damaged maize was quite consistent across the markets studied. At harvest a 1% increase in damaged grains decreased price on average by 1%, but later more damage was tolerated as maize became more scarce (Table 1.2).

Table 1.2: The relationship between market availability and the effect of insect damage on market price (from Compton *et al.*, 1998)

Availability of maize on the market	Maize given top price (% damaged grains)	Price of highly damaged maize (>90% damaged)
Plentiful (soon after harvest)	0-5%	Unlikely to sell
Moderate (mid-season)	0-5%	Unlikely to sell
Scarce (lean season)	0-7%	25%
Very scarce (bad years)	0-10%	30%

Box 1.2: Grain standards used in formal markets

A good example of a commodity standard is the one for maize in East Africa; this has two grades.

Quality variable		Maximum limits	
		Grade 1	Grade 2
Moisture content %		13.5	13.5
Foreign matter total %		0.5	1.0
of which	Inorganic matter %	0.25	0.5
	Filth %	0.1	0.1
Broken grain %		2.0	4.0
Defective grain, total %		4.0	5.0
of which	Pest damaged grain %	1.0	3.0
	Rotten and diseased grain %	2.0	4.0
	Discoloured grain %	0.5	1.0
	Immature/shrivelled grain %	1.0	2.0
Other grain %		0.5	1.0
Aflatoxin contamination (total)		10 ppb	10 ppb
of which	aflatoxin B1	5 ppb	5 ppb

Each grade has a certain maximum limit for each of a number of quality variables (features).

- Moisture content- for either grade the amount of moisture in grain must not exceed 13.5%
- Foreign matter - the grades differ in how much inorganic matter (stones etc.) is acceptable but are the same with respect to filth (rodent dropping, dead insects etc.).
- Broken grain – Grade 1 may only have half as much broken grain as Grade 2.
- Defective grain - in Grade 1 not more than 4% of grain can be 'defective' while in Grade 2 not more than 5%. Defective grain is the sum of four different types of damaged grain - pest damaged, rotten and diseased, discoloured, and immature/shrivelled). Notice that each different damage type has its own maximum limit. In the case of Grade 1 maize, if the maximum allowable limit for each damage type was added together it would be 4.5%. This would exceed the grade maximum which is only 4%. So to remain within the grade limit not all grain defects can be at the maximum.
- Other grain – the presence of other cereals or pulses (sorghum, wheat, millet, beans etc.), Grade 1 may have only half as many as Grade 2.
- Aflatoxin – this is a mixture of toxic products mostly from *Aspergillus flavus* but also certain other moulds that may infect maize and other grains. There is no difference between the grades in the maximum limit.

Besides grades and standards, there are also commodity segregations. For example maize may be of the flint type or dent type. There may be commercial uses of flint or dent which require them to be separated in trade. However, they are both subject to the same grading system, so in a store Grade 1 flint and dent grain may be segregated so that buyers can purchase what they want. But if flint and dent maize were mixed this would not affect their grade.

Factors other than just insect damage are important in establishing the quality/value relationship of maize in Ghana (Compton, 2002). At very low levels of insect damage these other grain characteristics were more important in the determination of price. However, at levels of 10% damaged grain, the effect of insect damage outweighs all other factors, except mould. These other factors include

Variety – small grained local varieties were preferred, with HYVs discounted by 10-15%.

Moisture content – Traders judged grain MC by feel, bite and sound. The major harvest is in the rainy season and very wet maize (26% MC) is heavily discounted (10-40%) at that time although maize even at 19% MC was not discounted.

Perceived age – The response to age varied, some areas preferring maize from the previous harvest, and other from the new harvest. Those preferring old maize discounted new maize by up to 10%. Those preferring new maize generally gave new and old, undamaged, maize the same price.

Colour – Yellow and purple grains are common in local varieties, but are disliked by consumers who say they discolour the flour. A sample containing 6% purple grains was discounted by 25%, although most traders did not discount.

Mould – Mouldy grain is rarely bought or sold. At low levels (less than 5% of grains discoloured by mould) mould is equivalent to insect damage in its effect on price. At higher levels, mouldy grain very rapidly declines in price, so that when discoloured grains reach levels higher than about 30% the grain has little or no remaining value.

1.7 Importance of quality losses

It is important to understand quality losses, and take them into account, as they probably have a more significant economic impact than weight losses. However, quality loss estimation is difficult because ultimately what is of concern is the loss of market opportunity/ income. Although reduction in quality can be measured, i.e. a reduction from grade 1 to grade 2 determined by the parameters of a grading system, the relationship between quality and value is complex. This may be because markets are insufficiently quality conscious to distinguish between grades, or grade 1 soon after harvest may actually sell for less that grade 2 six months after harvest when grain is scarce. Consequently, in the past most loss estimation has focused on weight loss. Nevertheless, quality loss is an important consideration because it is a direct loss of value; it may also impact on food safety and nutrition. It is likely to be a very convenient measure as a means to monitor loss reduction strategies, although if food security is a primary concern then weight loss will remain a key measure.

The question remains, how the two types of loss would be routinely combined to give a clearer picture of the significance of postharvest losses. In order to combine losses of quantity and quality to give a single estimate of loss, it is necessary to express both types of loss in the same units. The only units they could have in common are financial, thus both would have to be given a monetary value. At least in theory, it would not be difficult to put a maximum financial value on production, making assumptions about the rate of supply of grain to the market and the typical market price trends for top quality cereals. The value of weight losses from this system would be easy to estimate but the difficulty is that there are no substantial data on the magnitude of quality losses and, as already explained, the relationship between quality and value is complex. Although there have been some research studies in this area, under normal circumstances it is unlikely that practitioners would attempt to combine such loss data. Although in justifying and in evaluating loss reduction programmes they will need to refer to both types of loss.

The implications of this for APHLIS are that the weight losses it quotes are not necessarily the major component of economic losses and that engagement with quality loss is essential in any endeavour to help promote postharvest loss reduction. Put simply, if farmers do not receive better incomes from better quality grain then the resources they will devote to postharvest handling and storage will be insufficient to make a reduction in postharvest losses. Quality loss of cereal grains in developing countries appears to be initiated mostly at farm-level, so the potential remedies for the problem are needed at the same level. Consequently, APHLIS offers a series of web pages that document practical approaches that smallholder farmers can take to reduce losses.

The area of quality losses still remains relatively under-researched. There are clearly opportunities to use conventional grading systems to report on the postharvest performance of the smallholder; especially simple visual-scales that relate directly to these grades. However, a particular challenge remains; how to put a monetary value on both quality and weight losses so that they can be combined into a single loss figure – the postharvest value losses.

The next chapter considers in detail the factors that result in postharvest loss of cereal grains.

2. Why are there postharvest losses of cereals?

This chapter provides details of the factors that contribute to the decline of both the quantity (weight) and quality of grain.

2.1 The agents of weight and quality decline

Grain losses occur as a result of two main factors -

1) Grain being scattered or spilt during postharvest handling (harvesting, threshing, transport) leading to weight loss, and
2) Grain subject to biodeterioration that can lead to losses of both weight and. The organisms involved are mainly -
    - arthropods (mostly insects such as beetles and moths but also sometimes mites)
    - moulds, and
    - vertebrates (mostly rodents such as rats and mice but also sometimes birds)


Insects

Moulds

Rodents

These organisms were described in more detail in **Section 2.2**, but they are not the only cause of biodeterioration since this also includes natural changes to the chemicals within grain itself. These changes result in loss of grain quality; good examples are increases in

- rancidity of milled rice
- number of discoloured maize grain,
- number of yellow grains of milled rice
- number of non-viable seed grain

Pest problems and these natural chemical changes generally proceed more rapidly under higher temperatures and greater relative humidities; for every 10°C rise in temperature the speed of a chemical change is doubled. Besides happening more rapidly at higher temperatures and humidities, these changes can also happen more quickly due to pest attack. Good postharvest handling and storage can slow down all these loss making changes.

Grain quality decline may result from are poor handling that allows -

Contamination with foreign matter - Foreign matter includes organic matter (e.g. chaff, other types of grain) and inorganic matters (stores, soil). Some organic matter may be classified as filth (e.g. rodent droppings and hair, bodies of dead insects etc.). Contamination with foreign matter accumulates during the early stages of postharvest handling when there is insufficient care at harvesting, drying and threshing and then the accumulation of filth may continue due to the activities of insects and rodents.

Mechanical damage during handling - Rough handling of grain results in grain breakage, this may happen at any point during postharvest handling and storage but is especially a problem during threshing. For example, many farmers thresh maize by placing maize cobs in a sack and beating them with sticks. This results in a high proportion of broken grain. The presence of broken grain by itself is a reduction in quality for all types of cereals and an important reason for this is that broken grains are much more susceptible to other types of losses such as those mediated by moulds and by insects (discussed in more detail below).

Insufficient drying - Grain that is not dried to a safe moisture content very soon after harvest will start suffering quality decline due to attack by moulds. Moulds may develop on the surface of grain that is above the safe moisture content, which under hot tropical conditions is around 14%. High moisture content is also favourable for the development of insect infestation and for grain discolouration.

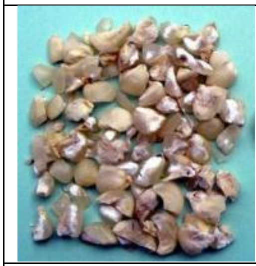
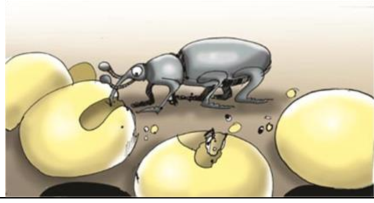
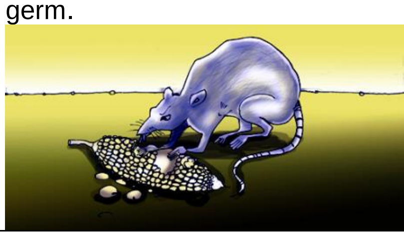
Insufficient protection during storage - Poor storage arrangements can allow the entry of water, access of insects and rodents, and chemical browning reactions that lead to grain discoloration.

Some of the factors by which grain quality may be judged are shown in Table 2.1. Most of these are a consequence of biodeterioration.

2.2 Insects, moulds and rodents

Postharvest losses due to biodeterioration may start as the crop reaches physiological maturity, i.e. when grain moisture contents reach 20-30% and the crop is close to harvest. It is at this stage, while the crop is still standing in the field, that storage pests may make their first attack and when unseasonal rains can dampen the crop resulting in some mould growth. A key issue is the weather conditions at the time of harvest. African smallholder farmers normally rely on sun drying to ensure that their crop is sufficiently dry for storage (Compton *et al.*, 1993). If weather conditions are too cloudy, humid or even wet then the crop will not be dried sufficiently and losses will be high. Climatic conditions at the time a crop should be drying are key to understanding the potential losses of durable crops. However, successful drying alone is not a remedy against all postharvest losses since insects, rodents and birds may attack well dried grain in the field before harvest and/or invade drying cribs or stores after harvest (Hodges, 2002; Meyer and Belmain, 2002).

Table 2.1: The factors that contribute to lowering the quality of cereal grain (from Hodges and Stathers, 2012)

<table>
<tr><td rowspan="6">High quality grain
</td><td></td><td>Foreign matter and filth
Grain may be contaminated with foreign matter that is either organic (e.g. maize cob cores, tassels etc.) or inorganic (e.g. stones). Examples of filth are rodent dropping and dead insects. Careful sieving can reduce much of the foreign matter content.</td></tr>
<tr><td></td><td>Broken grain
Most broken grain comes from poor postharvest handling especially shelling/ threshing, but may also be a consequence of pest attack.</td></tr>
<tr><td></td><td>Insect damage
Insects make holes in grains and hollow them out.
</td></tr>
<tr><td></td><td>Rodent damage
Rodents chew into grain and remove the germ.
</td></tr>
<tr><td></td><td>Mould damage
Mouldy grains have been dried too slowly or allowed to become wet. They have patches of mould growth on them and may also be discoloured. Some moulds also produce mycotoxins that are dangerous poisons, e.g. aflatoxin, but physical appearance is no guide to aflatoxin contamination.</td></tr>
<tr><td></td><td>Discoloured grain
Grain may be discoloured due to grain heating.</td></tr>
</table>

Insects

About thirty species of insects commonly infest grain. Most of the insect pests are either beetles or moths although there are some other types (not dealt with here). Insects have six legs and are usually easily visible since they are in the range of 1 to 15 mm long.

As well as attacking grain, several insect pests create other types of damage and all contribute filth to the grain through dead bodies and their droppings which include uric acid. Some species that bore into grain may also burrow into wooden or plastic structures so weakening them. The larvae of many moths produce large quantities of silken threads when moving over surfaces. This builds up into a webbing that can bind flour and grain together into a solid mass so blocking machinery or causing additional machine wear and breakdowns.

Insects that attack cereals are usually divided into two groups: primary pests and secondary pests. It is useful to distinguish between them as primary pests are usually more destructive than secondary pests, especially in short-term storage.

Primary insect pests are insects that can attack and breed in previously undamaged cereal grains. Such pests can also feed on other solid but non-granular commodities, but they are rarely successful on milled or ground foodstuffs. Examples of primary pests include the beetles such as the weevils (*Sitophilus* spp) (Fig. 2.1), the Lesser Grain Borer (*Rhyzopertha dominica)* and Larger Grain Borer (*Prostephanus truncatus)* (Fig. 2.2), and the Anjoumois Grain Moth (*Sitotroga cerealella)*. Many primary pests attack the commodity in the field prior to harvest. Some species spend their pre-adult life concealed within a grain, making them difficult to detect visually.

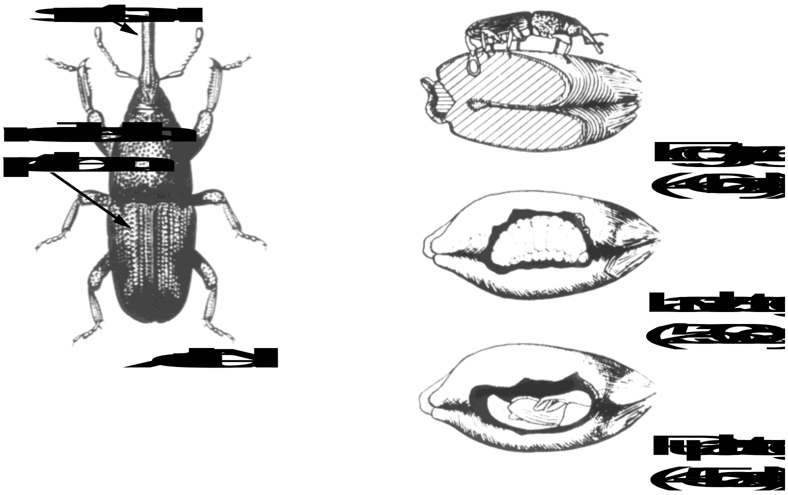


Figure 2.1: *Sitophlis zeamais* (adult life size 2.5-4.5 mm) showing its lifecycle in a wheat grain. Note at top right, a female weevil laying an egg in a hole it has made in the grain.

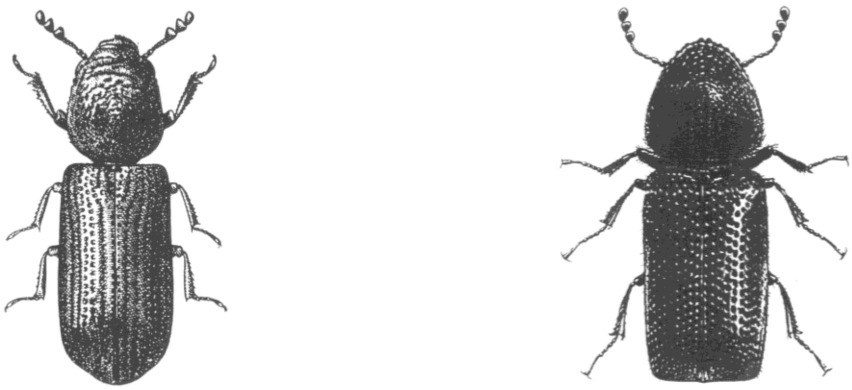


Figure 2.2: ***Rhyzopertha dominica*** **(left - life size 2-3 mm) and** ***Prostephanus truncatus*** **(right - life size 3-4.5 mm)**

Secondary insect pests are not capable of successfully attacking undamaged grains. They are, however, able to attack materials that have been previously damaged either by other pests (especially primary pests) or by poor threshing, drying and handling. They are also able to attack processed commodities such as flour and milled rice where they may form the majority of insects present. Secondary pest species appear to attack a much wider range of commodities than primary pests. Feeding stages of these pests live freely, i.e. not concealed within individual grains. Examples of widespread secondary pests are the beetles such as *Tribolium castaneum* (Fig. 2.3) and moths like *Cadra cautella* (Fig. 2.4).

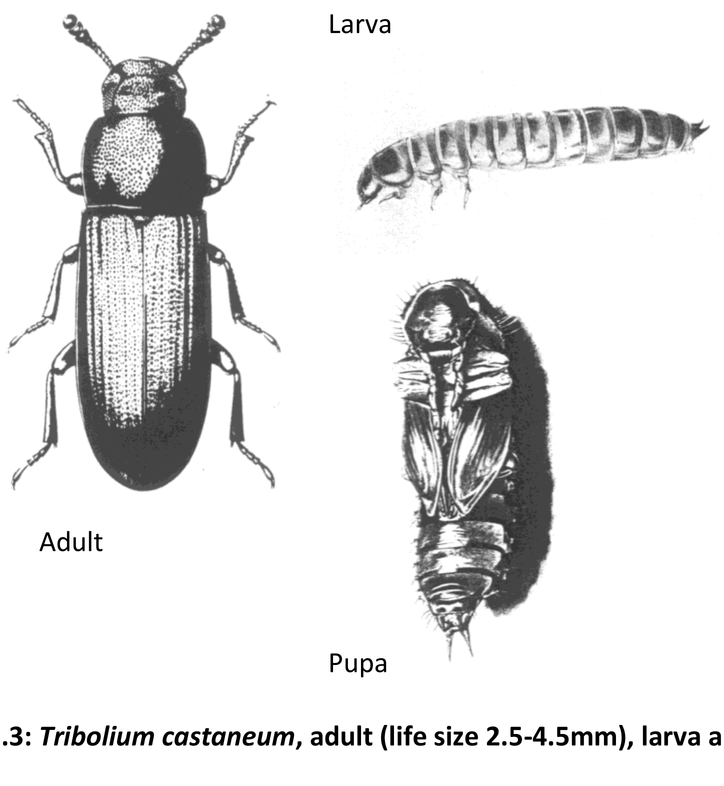


Figure 2.3: ***Tribolium castaneum*****, adult (life size 2.5-4.5mm), larva and pupa**

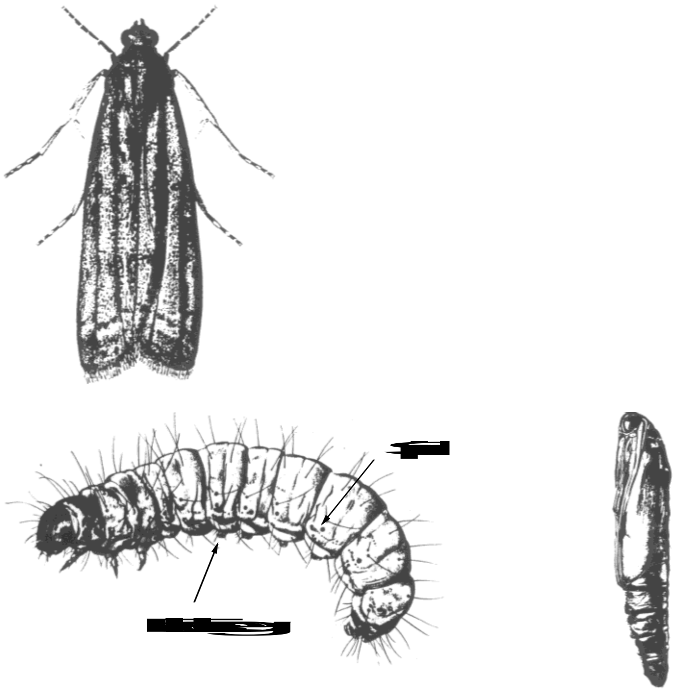


Figure 2.4: ***Cadra cautella*****, adult (wing span 11-28 mm), larva and pupa**

<u>Moulds</u>

The moulds, also called fungi, that are found on stored grain initially grow on the surfaces of grain and then slowly penetrate and destroy them (Fig. 2.5). These moulds have tube like filaments called hyphae that form the main part of their body. They reproduce by forming spores that are usually released in enormous numbers. Although many types of mould are very important as agents of natural decay, they also cause decay where it is not wanted such as on cereal grains.

Figure 2.5: Mould damaged maize cob

Mould growth on grain is only possible when the relative humidity at the grain surface layer is at more than 70%. The humidity at the grain surface layer is determined by the grain moisture content and for most cereals the corresponding moisture content in equilibrium with 70% relative humidity is about 14%. Keeping grain at or below this safe storage moisture content is essential if mould growth is to be avoided. Physiologically mature grain may become mould infected because when physiologically mature the plant's own defences against mould attack are lowered. However, the growing crop in the field can also become infected if subject to drought stress as this also reduces the plants defences against mould growth. Mould may also grow on moist grain that has been left exposed by the attack of field pests.

Mould growth can cause heating and caking of the grain, and subsequent discoloration due to either production of pigments or browning reactions occurring at the elevated temperatures. Caking and heat damage of grain are typical signs that mould growth has already occurred. Besides causing this type of damage, moulds may also produce toxic chemicals called mycotoxins. The range and status of mycotoxins in African produce has been reviewed recently by Wagacha and Muthomi (2008).

Mycotoxins are mould metabolites that, when ingested, inhaled or absorbed through the skin, cause lowered performance, sickness or death in man or animals. The amount formed depends on several factors, including temperature, moisture content, and type of grain. The resultant diseases in man and other animals are not contagious or infectious, and cannot be treated with drugs or antibiotics. Their effects depend on the animal species and the toxin concerned. Some animals appear to be more susceptible than others, and different mycotoxins affect different organs of the body, including liver, kidneys, skin and the nervous system. Mycotoxins may move in the food chain so that the possible concentration of mycotoxins in animal products, especially milk, could be a further source of danger to consumers.

There are many different mycotoxins that could contaminate grain. The most well-known is aflatoxin. This is produced by some strains of the mould *Aspergillus flavus* and is regarded as the most important mycotoxin in developing countries. It is a liver toxin that can induce cancer in susceptible animals, and is the most potent liver carcinogen known. Much circumstantial evidence suggests that it may be a factor in the high incidence of human liver cancer in some parts of the tropics and subtropics. Subsistence farmers in drought seasons, or situations of food insecurity, often have no choice but to eat mouldy maize and groundnuts. More than 125 people were reported to have died due to acute aflatoxicosis in Kenya when food insecurity, caused by a variety of climatic and social reasons, led to widespread consumption of maize contaminated with high levels of aflatoxins (Lewis *et al*., 2005). However, the chronic effects of aflatoxin ingestion may be a much greater issue since the poison accumulates in the liver, and frequently causes liver cancer after long exposure. The combination of aflatoxin ingestion and HIV/AIDS infection or malaria means that many may be dying or leading unproductive lives as a result of aflatoxin, but die from being rendered more susceptible to other diseases.

The growth of *A. flavus* can be very rapid under tropical or subtropical conditions, and aflatoxin has been found in a wide variety of foodstuffs including cereals, pulses, and oilseeds (especially groundnuts). There are a number of aflatoxins produced by *A. flavus* the most important of which is aflatoxin B1. The degree of aflatoxin contamination can be made part of a grain standard, which is the case with the East African maize standard (see Box 1.2). Here the total allowable contamination with aflatoxin is 10 ppm (1 part per million = 1mg in 1kg of grain). Of this 10ppm aflatoxin allowance, aflatoxin B1 should not contribute more than 5 ppm. Relatively simple test kits are now available for warning of the presence of aflatoxin on grain but accurate measurement and separate estimation of aflatoxin B1 requires careful testing with sophisticated equipment.

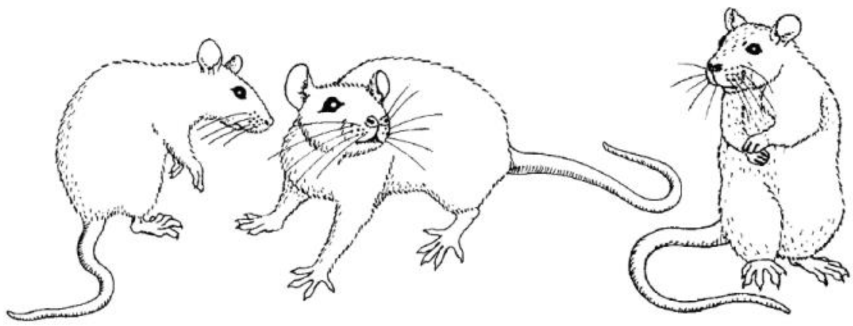
For growth *A. flavus* requires a minimum relative humidity of 82%. For cereals at typical tropical temperatures (20°-30°C) this would be equivalent to a moisture content of about 18%. It is therefore, clear that if cereal grain is maintained at about 14% it is safe from aflatoxin formation. However, during postharvest handling if moist grain is not dried quickly and thoroughly it is in danger of *A. flavus* infection and toxin formation. For this to happen the grain must be contaminated with the spores of *A. flavus* and the likelihood of this is greatly increased if the grain is allowed to come into contact with soil or other mouldy grain during postharvest handling. Good hygiene is thus important in avoiding contamination (Golob, 2007). However, it should be remembered that grain may become contaminated while on the plant in the field due to drought stress.

If mould damage and toxin formation has been avoided during postharvest handling and the stored grain remains at the safe moisture content then it should remain free of aflatoxin. The main danger then is water coming into contact with the grain, due to leakage or condensation. In large scale storage there is also a danger of hot spots occurring in the grain due to insect infestation, this results in high temperature and moisture which presents a danger, but these conditions have not been reported from small bulks of grain stored by smallholders or in sack storage.

APHLIS estimates the extent of weight losses described in this chapter. The following chapter considers what APHLIS does and how it does it.

Rodents

Rodent problems may vary from just the occasional damaged grain sack to severe damage that results in the collapse of bag stacks.



Grain may be eaten in the field or in store by rodents. Apart from the food eaten, spoiled or contaminated, there are additional ‘invisible’ losses such as the replacement or repair of packaging materials and the cost of rebagging spilled food. Much of the spillage arises when rodents attack food packaging to obtain nesting material; stacks of heavily infested bagged foodstuffs may ultimately collapse. Rats and mice gnaw inedible materials including electrical wiring, so their presence in buildings can constitute a fire hazard. Finally, rodents are capable of transmitting diseases to people either directly by bites, through the air or the handling of rodent carcasses; or indirectly through contact with food and water contaminated with rodent hair, droppings and urine.

Part 2 – The African Postharvest Losses Information System

3. What is APHLIS?

The African Postharvest Losses Information System (APHLIS) is a unique resource that provides estimates of weight losses from the postharvest chains for cereals in Sub-Saharan Africa (SSA) (Fig. 1.1). These losses are expressed as annual cumulative losses from production for the primary administrative units (provinces) of the APHLIS member countries (currently 36).

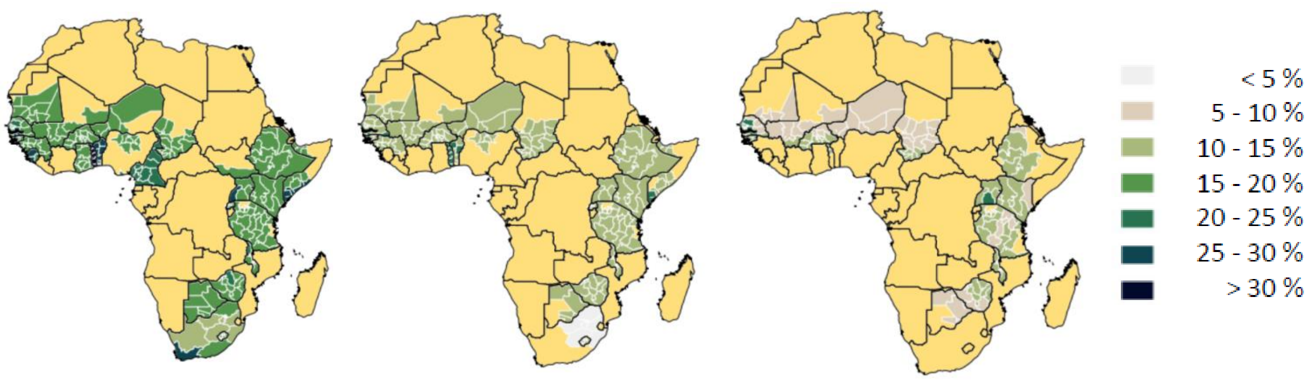
APHLIS has been created to provide weight loss data in support for

- agricultural policy formulation,
- the identification of opportunities to improve the efficiency of value chains,
- the improvement of food security planning by facilitating more accurate cereal supply calculations, and
- the monitoring of loss reduction activities.

Recently, Country Narratives (see **Chapter 6**) have been added to the system that put the estimated loss values into the context of the postharvest systems of each focus country. The narratives also give details of current and recent projects that could contribute to postharvest loss reduction.

3.1 How losses are displayed

APHLIS displays weight losses for eight cereal crops of Sub-Saharan Africa as either maps or tables (Fig. 3.1). In the case of tables the loss values are also aggregated to country and to region. To view the maps and tables visit the APHLIS website (http://www.aphlis.net).



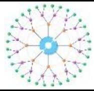
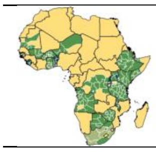
Maize **Sorghum** **Millet**

Regional PHL by cereal [% of total annual production]											
Cereal	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Wheat	5.6	5.5	13	9.9	12.8	12.6	15.1	14	13.1	12.9	15.2
Maize	16.8	17.3	17.1	17.9	18.9	20	17.7	18.8	17.8	18	17.6
Rice	11.8	11.8	11.6	11.8	11.8	12.1	12	12.6	12.1	13.6	12.2
Sorghum	12.3	11.8	12	12.3	12.3	13	12.5	12.6	12.4	12.4	12.3
Barley	9.8	4.5	9.4	9.4	9.4	9.5	10.9	10.1	9.7	9.7	10.5
Rye	-	-	-	-	-	-	-	-	-	-	-
Oats	-	-	2.1	2.1	2	2.1	2.1	2.1	2.1	2.1	2.1
Millets	9.5	9.9	9.8	10	10.2	10.7	10.1	9.9	10.4	10.1	10.4
Fonio	11.7	11.7	11.7	11.7	11.7	12	12.4	12.2	11.7	11.8	11.7
Teff	11.7	11.7	12.5	12.5	12.1	12.5	12.5	12.5	12.5	12.4	12.5

Figure 3.1: Cereal % weight losses in Sub-Saharan Africa 2012 as maps and tables

3.2 Key components of APHLIS

APHLIS consists of several elements, these are listed below and their interrelationship shown in Figure 3.2.

System feature		Website menu button
	The APHLIS Network of local experts who provide data and verify loss estimates.	APHLIS Network
	The shared database for entering and storing key data related to PHL estimation. The database can be updated by APHLIS Network members.	Login
	The PHL Calculator estimates a cumulative % weight loss from production using the information in the database and a PHL profile (the typical PHLs figures for each step in the postharvest chain) for the specific conditions in question. The Calculator estimates a PHL for each cereal crop by both country and by province.	Losses tables
	A GIS mapping facility to display the distribution of PHLs and other key factors in Sub-Saharan Africa.	Interactive losses maps
Country narratives, reviews	Links to narratives presenting the postharvest systems, the loss values and on-going postharvest projects, and reviews of key subject including tips for loss reduction.	Country narratives, Postharvest reviews
	A downloadable PHL Calculator in Excel. Defaults can be changed to user preferences and estimates made at preferred geographical scales. Data quality ratings and bibliographical references are displayed.	Downloadable Calculator

The scheme below indicates the inter-relationship between the various elements of APHLIS

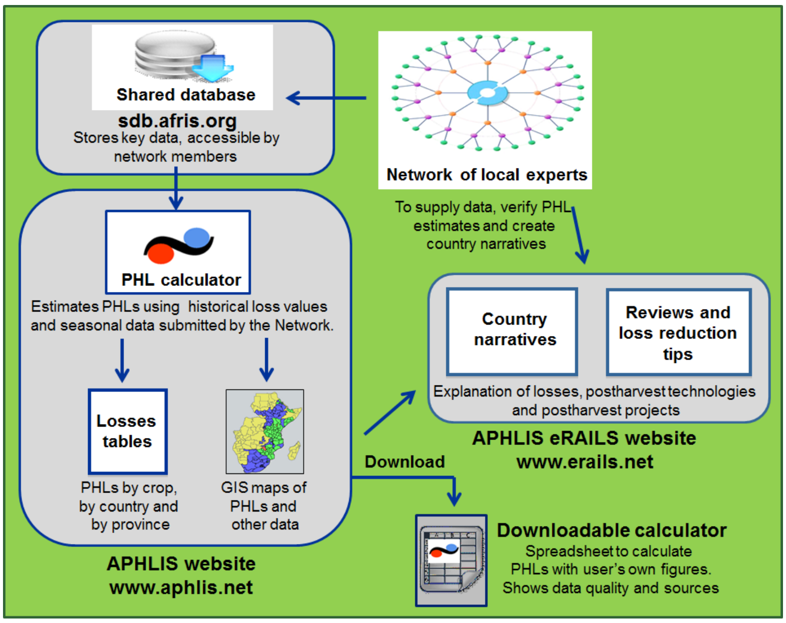


Figure 3.2: The inter-relationship between the various elements of APHLIS

3.3 Calculation of losses

Before the introduction of APHLIS, the origin and justification of weight losses values for cereal grains were not well founded. APHLIS generates loss estimates that are -

- Transparent in the way they are calculated
- Contributed (in part) and verified by local experts
- Adjustable year by year depending on circumstances
- Based on the primary national unit (i.e. province not just country level), and
- Upgradeable as more (reliable) data become available

Losses are estimated using an algorithm (the PHL Calculator) that operates on two distinct sources of data. The first is a set of figures that quantifies the expected loss at each link in the postharvest chain. This set of figures is derived from the scientific literature and called a postharvest loss profile (PHL profile). The website shows a rating of the reliability of each of the loss figures in a profile, indicates how such figures were derived, and gives their bibliographical references (see **Section 4.3**). The second source of data relates to factors that may affect losses on a seasonal or annual basis. These are referred to as seasonal data and are submitted by the APHLIS Network members.

The PHLs estimated by APHLIS are the cumulative % loss in weight from production of ready to consume grain incurred during harvesting, drying, handling operations, farm storage, transport and market storage.

The PHLs estimated by APHLIS -

1. Reflect losses of quantity (weight loss); quality change is only relevant if food is no longer fit for human consumption (and therefore considered a 100% weight loss)
2. Include grain spilt and scattered during handling
3. Are from one year's production, i.e. do not include carryover stocks from the previous season.
4. Are estimated for primary national units (provinces) which follow political rather than agro-climatic boundaries; loss estimates for any particular area may therefore hide wide internal variations
5. Do not take into account any cereal processing losses, e.g. milling losses.

An example of how APHLIS calculates a cumulative loss from a postharvest chain is shown in Figure 3.2. In this case maize production was 1000 MT. The % weight losses and the actual amount of grain lost from production (the loss increment) for each link of the chain are shown. For example the 5% loss at harvesting amounts to 50 MT (1000x 0.05) of lost grain, this leaves 950 MT of the original production.

		Weight loss	
	%	increment (MT)	Production remaining (MT)
Harvesting/field drying	**5%**	**50.0**	**950.0**
Drying	**1%**	**9.5**	**940.5**
Threshing/shelling	**3%**	**28.3**	**912.3**
Winnowing	**2%**	**18.3**	**894.0**
Transport to homestead	**2%**	**17.9**	**876.2**
Farm storage	**5%**	**43.8**	**832.4**
Transport to market	**1%**	**8.3**	**824.0**
Market storage	**2%**	**16 .5**	**807.5**
	19.26%	**192.6**	

Figure 3.3: An example of a cumulative weight loss calculation for a maize postharvest chain

3.4 PHL Profiles

When APHLIS has to estimate a % weight loss for a particular crop, in a particular province, a pre-determined set of PHL values for each step in the chain, called a PHL profile (see Table 3.1 for examples), is automatically inserted into the PHL Calculator.

Table 3.1: Examples of PHL profiles for different cereals in different climates and at different scales of farming

Climate cluster **Crop** **Scale of farming**	A* Maize Small	C Maize Large	B Sorghum Small	B Millet Small	A Rice Small
Harvesting/field drying	6.4	2	4.9	3.5	4.3
Drying	4	3.5	-	-	-
Shelling/threshing	1.2	2.3	4	2.5	2.6
Winnowing	-	-	-	-	2.5
Transport to store	2.3	1.9	2.1	2.5	1.3
Storage	5.3	2.1	2.2	1.1	1.2
Transport to market	1	1	1	1	1
Market storage	4	4	4	4	4
Cumulative % weight loss	17.9	11.3	12.6	9.3	11.4

* Climate codes – A – tropical savannah, B – arid and C – humid sub-tropical

One problem faced in seeking to provide PHL profiles is that PHL data have only been collected in a few parts of Sub-Saharan Africa. It is therefore inevitable that in the creation of the PHL profiles many different provinces will have to share the same data. This sharing was achieved by clustering together the data from provinces of various countries that are basically similar with respect to climate. The climates of Sub-Saharan Africa have been classified according to the Köppen system, and for the purposes of APHLIS are of four types, tropical savannah, arid, humid subtropical or sub-tropical highland. For each crop there is a PHL profile for each climate, so with eight crops (maize, sorghum, millet, wheat, barley, rice, teff and fonio) there is a total of 32 (4x8) profiles. Except for maize, the profiles are specific to the technologies associated with smallholder farming. For maize there are both smallholder and a large-scale farming profiles, this generates a further four profiles, to give a total of 36 profiles.

The creation of the PHL profiles is described in **Section 5.3**.

3.5 Seasonal data

Several ‘seasonal’ factors are taken into account in the loss calculation and these have a very significant bearing on the actual loss estimate. Seasonal data and their influence on the loss calculation are as follows -

1) The quantity of grain produced on small and large farms for each growing season.
2) Whether or not there is damp weather at time of harvest which would make drying the grain difficult. If there is rain at harvest then the value for the harvesting link in the PHL profile is increased to 16.3%, for more details see **Section 5.1**.
3) The proportion of grain that is marketed within the first three months, i.e. that will not enter farm storage for any significant time. This proportion of the production will not be subject to farm storage losses but instead will be reduced by transport and market storage losses.
4) The length of time that grain was stored on farm. If farm storage is less than 3 months then farm storage loss is reduced to 0%, if 3 to 6 months it will be only 50% of the loss profile figure, or if 6 months or more than 100% of the farm storage loss is applied.

5) In the case of maize, whether or not LGB (*Prostephanus truncatus*) is expected to be a significant pest. If LGB is a serious pest in that particular season then storage losses are multiplied by 2, for more details see **Section 5.3**.

Data on these seasonal factors are contributed by the APHLIS Network members or supplied by individual users for the downloadable PHL Calculator. Details of how seasonal data can be collected are presented in **Section 4.8**.

3.6 APHLIS estimates and geographical scale

At the geographical scale of province the loss values indicated by APHLIS do not necessary apply to any particular locality as losses are expected to vary considerably from one place to another but instead the values indicate the general extent of the problem. APHLIS also provides a means to estimate losses at finer geographical scale using a downloadable PHL Calculator presented on an Excel spreadsheet (see **Section 9**). This offers several advantages. Users can work with the most up-to-date or most relevant data. This is important when the subject of investigation is a district, farmer's group or even an individual farming household. It is also important when the political boundaries of provinces do not match natural agro-climatic boundaries. In this case, the estimates presented on the website may hide considerable heterogeneity and so better estimates could be obtained by including only areas within the same zone. Like the web-based version of the Calculator, the downloadable version also indicates the bibliographical references and gives a rating of the reliability of the data in much the same way as the website, so that users can determine the suitability of the PHL profiles for their purposes.

3.7 APHLIS estimates and data quality

As far as possible, PHL profiles (see **Section 3.4**) are specific to the crops and region for which they were developed. The downloadable PHL Calculator should not be used for the estimation of losses for other crops, farming systems or regions.

PHL estimates are based on the best data available, but this is not necessarily very accurate. In many cases the PHL profiles are very generalised, i.e. do not contain loss figures from the same cereal or from the same climatic area for all steps of the PH chain. This is indicated in both the web-based 'Losses Tables' (see **Section 4.3.4**) and in the downloadable PHL Calculator (see **Section 7.3**) by scoring each individual figure that makes up a generalised value in the PHL profiles.

If you possess more up-to-date, specific data then these could be used by substituting the default values of the PHL profile of the downloadable Calculator. However, note that PHL profiles can't be altered permanently on the spreadsheet. The APHLIS Network is always looking for new, well documented PHL figures which can be added to the web-based Calculator to make the PHL profiles more specific and more robust. If you have such figures then please contact the APHLIS Network using the 'Contact us' feature on the home page).

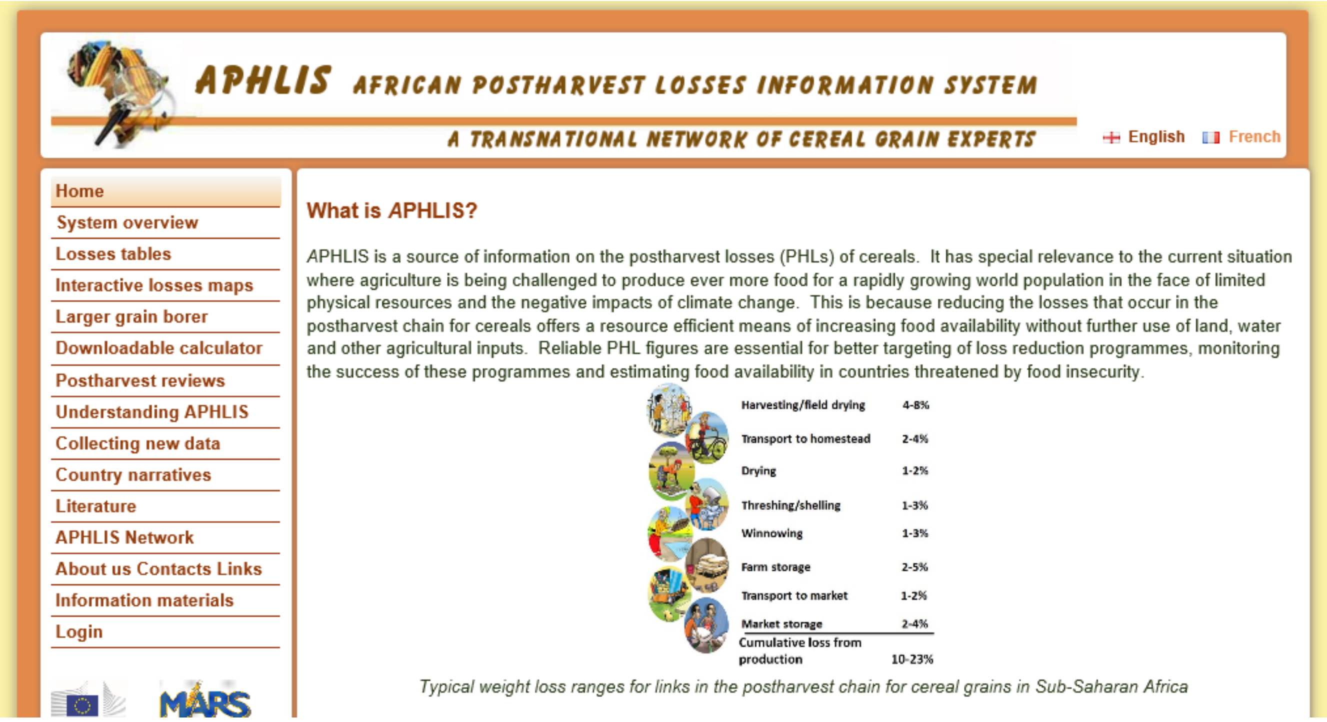
APHLIS outputs are available on the internet. The next chapter explains what the APHLIS web pages have to offer.

4. APHLIS on the web

The APHLIS website presents users with a wide range of information on cereals postharvest losses. This chapter gives details of what's currently on offer.

4.1 Website home page

The APHLIS website home page looks like this.

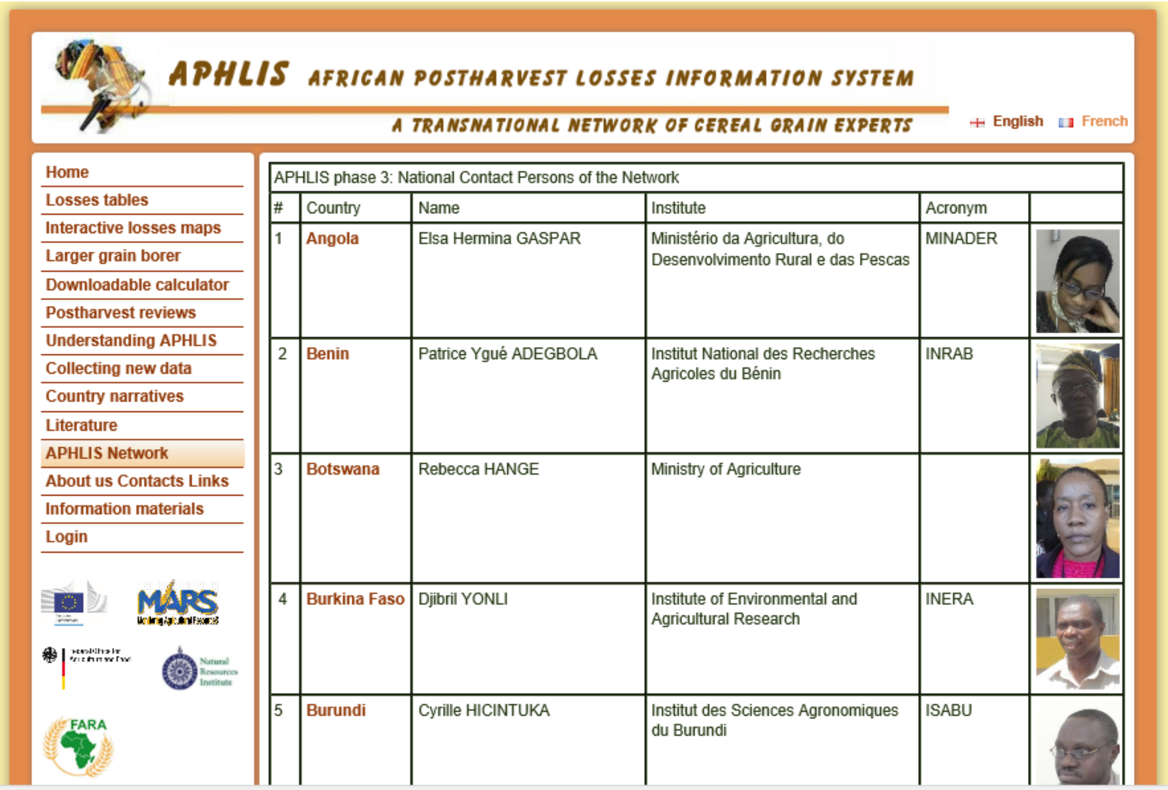


The menu bar on the left hand side offer access to -

System overview	A detailed explanation of how APHLIS works
Losses tables	Tables of PHL estimates by crop for country and province
Interactive Losses Maps	Maps showing distribution of losses, loss densities and other factors
Larger grain Borer	Summary information showing incidence of this important storage pest
Downloadable calculator	PHL Calculator available for download as an Excel spreadsheet
Postharvest reviews	A review of postharvest weight losses, quality losses and fully illustrated tips for farmers on postharvest loss reduction
Understanding APHLIS	Downloadable guide to understanding and using APHLIS
Collecting new data	Downloadable guide to collecting new loss data and data on seasonal factors that affect losses
Country narratives	Links to narratives presenting the postharvest systems, the loss values and on-going postharvest projects in several countries
Literature	Key bibliographical references to postharvest literature
APHLIS network	A listing of APHLIS country representatives with photos
About us, Contacts Links	Details about the APHLIS development team. Contact details for information and for submitting new PHL data. Links to websites concerned with APHLIS
Information materials	Downloadable leaflet, PowerPoint presentation about APHLIS, and advice on how to refer to APHLIS
Login	Login gives APHLIS Network members access to data entry

4.2 APHLIS Network Members

APHLIS Network members represent those countries that are included within APHLIS. The members are typically professionals working in the area of agricultural information or postharvest development and are given the opportunity to attend one or more APHLIS workshop to become familiar with the system. The member for each country is shown on the 'APHLIS Network' tab of the website menu; a full listing is shown in Annex 1.



Members have access to the data submission tables in the APHLIS database (see **Section 4.6**). The data for each country is kept separately and only accessible by the members and the system administrator. Members are asked to submit new data annually, this includes information on cereal production and on a several factors that affect postharvest loss values and that vary on seasonally/annually (these factors are mentioned in **Section 3.5**).

In case you need to contact a member, this can be done through the APHLIS administrator (info@aphlis.net).

4.3 APHLIS tables

The APHLIS website displays maps of loss values and gives tables of the same values that can be explored in much more detail. The maps give an excellent quick overview of losses and are dealt with in **Section 4.4**. The tables, which are arranged as a cascade, offer a great depth of information. Loss tables are accessible from the 'Losses Tables' button on the left hand column of the web page. The first table to appear shows African regional value for all cereals followed by a table where the losses are disaggregated into individual African cereal crops.

4.3.1 Regional figures

The first loss table shows regional total % weight loss by year; these are weighted averages for all provinces and all cereals. Below this is a disaggregation of the same losses by cereal type. On the website, just below these two tables you will find two further tables giving the associated absolutes losses (i.e. in metric tonnes (MT) rather than as a % weight loss), for brevity this has been omitted here. By clicking on a cereal name in the table below a table of the % weight losses by country for that cereal crop is revealed (and again a table of the associated absolute losses). **Section 4.3.2** shows the table that is revealed if 'Maize' was selected.

Weighted average according to reported figures

Regional total PHL for cereals [% of total annual production]										
2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
14.3	14.7	14.3	14.5	15.8	15.6	14.9	15.3	14.9	15.1	15.1

Regional PHL by cereal [% of total annual production]											
Cereal	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Wheat	5.6	5.5	13.1	9.9	12.8	12.7	15.1	14	13.1	12.9	22.9
Maize	16.8	17.3	17.1	17.9	18.9	20	17.9	19	18	18.2	17.8
Rice	11.8	11.8	11.7	11.8	11.8	12.1	12	12.6	12	13.9	12.1
Sorghum	12.3	11.9	12.1	12.3	12.3	12.8	12.5	12.6	12.4	12.4	12.3
Barley	9.8	4.9	9.4	9.4	9.4	9.5	10.9	10.1	9.7	9.7	24
Rye	-	-	-	-	-	-	-	-	-	-	-
Oats	-	-	2.1	2.1	2	2.1	2.1	2.1	2.1	2.1	-
Millets	9.6	9.8	9.7	9.9	10.1	10	9.7	9.4	9.8	9.6	9.4
Fonio	11.7	11.7	11.7	11.7	11.7	12	12.4	12.2	11.7	11.8	11.7
Teff	11.7	11.7	12.4	12.4	12.1	12.4	12.5	12.5	12.5	12.4	-

4.3.2 Country figures by crop

The table below shows maize losses by country. By hovering over the small Africa-icon next to a loss figure a map pops up that shows the distribution of losses. By clicking on one of the country names in this table a further table will be revealed that shows the % weight losses (and absolute loss) of the provinces of that country. Section 4.3.3 shows the table that is revealed if 'Malawi' was selected.

Weighted average according to reported figures

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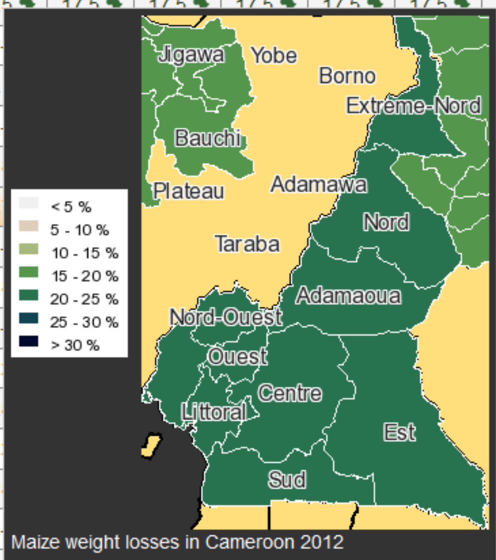
	Maize										
Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Angola	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	-	-
Benin	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25.3	-
Botswana	-	16.8	16.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16.4	-
Burkina Faso	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17.6	19.4
Burundi	18	-	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
Cameroon	17.7	17.7	17.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22	22
Chad	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17.5	-
Cote d`Ivoire	18	18	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
Democratic Republic of Congo	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
Eritrea	17.2	17.2	17.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
Ethiopia	-	-	17.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17.8	17.8
Gambia	-	-	14.2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	-	-
Ghana	18	18	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18	-
Guinea	-	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16	16
Guinea-Bissau	18	18	18	18	18	18	18	18	18	18	-
Kenya	-	-	-	-	22.2	18.3	19.3	25.7	18	18.1	25.5
Lesotho	-	17.4	17.4	17.4	17.4	16.7	16.1	17.2	16.4	15.5	17.1



Maize weight losses in Cameroon 2012

4.3.3 Provincial figures by crop

The tables below shows % maize weight losses (and absolute losses -MT) for the provinces of Malawi. By clicking on a loss figure for one of the three provinces a long table is revealed that displays details of the loss calculation and data sources pertinent to that estimation. Section 4.3.4 shows what would be revealed if the figure 19.5 is selected, i.e. % weight loss figures for maize in Central Province in 2012.

for Maize in : Malawi
Provinces of Malawi

Click on a loss figure *in the table below to see in detail how the figure was derived. Send us* ***your comments*** *if you have the feeling that the underlying data and assumptions could be improved.*

Please sent your comments to ***info(at)phlosses.net****.*

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Province	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Central	-	19.5	19.3	19.7	19.4	20.7	20.1	20.2	20.8	19.5	-
Northern	-	20.5	20.5	20.9	20.2	21.2	21	21	21.2	20.3	-
Southern	-	19.6	19.7	19.7	21.6	22.5	20.3	22.2	21.5	19.6	-

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Estimated Postharvest Losses (t) 2003 - 2013

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Province	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Central	-	210739	171142	262904	365508	313792	393851	423331	470653	360817	-
Northern	-	56539	46119	109244	100668	81950	116472	103845	120748	93704	-
Southern	-	116224	70940	183514	255017	206815	267156	194942	240464	244718	-

4.3.4 Details of loss calculation and data quality

Shown below are the details of the loss calculation for maize in the Central Province in Malawi in 2012. Data are presented for each season and for smallholder and larger farmers as well as of the quality of the data. These are revealed in a series of tables that are accessed by scrolling down on the website. The final table, which deals with quality of data used to construct the PHL profile figures for this province also gives bibliographical references to the data sources.

Weighted average

- Country : Malawi
- Province : Central
- Climate : Humid subtropical climate dry winter (Cwa)
- Year : 2012
- Crop : Maize

Annual production and losses		
	tonne	%
Production	1846011	100
Grain remaining	1485194	80.5
Lost grain	360817	19.5

Seasonal production and losses							
Season	Farm Type	Production (t)	Remaining (t)	Losses (t)	Production (%)	Remaining (%)	Losses (%)
1	small	1522185	1216585	305600	99.0	79.1	19.9
1	large	15804	13485	2319	1.0	0.9	0.2
Seasonal:		1537989	1230070	307919	100.0	80.0	20.1
2	small	308022	255124	52898	100.0	82.8	17.2
2	large						
Seasonal:		308022	255124	52898	100.0	82.8	17.2
Annual:		1846011	1485194	360817	100.0	80.5	19.5

PHL (%) Calculation

NB Annual averages are a weighted average of the seasons

In this particular case there are two seasons of maize cultivation. In the first season there are both smallholder and larger scale farming activities. In the second season there are only smallholders. The loss estimate for the first season is 20.1%, the second season 17.2%. The annual weighted average of the two loss estimates is 19.5%.

By scrolling down this table more details of the loss estimation process are revealed. First details of the seasonal factors for smallholders in Season 1 are given, then the PHL profiles used to calculate the loss, the losses expected for the grain that remains in store on-farm, and the losses from grain that is marketed in the first three months. There follow similar tables for large-scale farmers in Season 1, and smallholders in Season 2 (but not shown here). If you would like to see them then go to the website (http://www.aphlis.net).

PHL (%) Calculation: Season: 1 Farm Type: small		
Grain marketed within the first three months after harvest (%)	30	*If data is missing (no data) it is assumed that for subsistence farmers all grain is stored whereas for commercial farmers all grain is marketed.* *Note: Figures in this table are farm type specific (small or large farms). The value **Grain marketed within the first three months after harvest (%)** is used to determine the percentage of total production that is stored and marketed by this type of farm in this particular season (Season 1, Season 2 etc). The calculation only considers the portion that is produced by this type of farm. Consequently, the figures below for **Stored (%)** and **Marketed (%)** will only add up to 100% if all grain in a particular season is produced on this farm type. Otherwise the corresponding percent figures for the other farm type, in the same season, must be included to arrive at a sum of 100%.*
Rain at harvest	no	*If weather is damp at harvest, leading to exceptional mould damage to the crop, then the value is **yes** and the **Harvesting/field drying** losses figure in the PHL profile is replaced by **16.3%**.*
Storage duration (months)	12	*Effect of storage duration:* *1. 0-3 months % figure for storage is 0 (zero)* *2. 3-6 months the % figure of the PHL profile is divided by 2* *3. More than 6 months or in case of missing data (no data) the % figure in the general profile is used*
Larger Grain Borer	yes	*If the crop is **maize** and the value is **yes** then the **Farm storage** loss figure in the PHL profile is multiplied by **2**.*

	Destination	Stored (%)		Marketed (%)	
		69.3		29.7	
Stages	PHL profile (adjusted)	Remaining grain	Loss increment	Remaining grain	Loss increment
Harvesting/field drying	6.4	64.8	4.4	27.8	1.9
Platform drying	4	62.2	2.6	26.7	1.1
Threshing and Shelling	1.3	61.4	0.8	26.3	0.4
Winnowing	0	61.4	0	26.3	0
Transport to farm	2.4	59.9	1.5	25.7	0.6
Farm storage	9.1	54.5	5.4	25.7	0
Transport to market	1.7	54.5	0	25.3	0.4
Market storage	2.7	54.5	0	24.6	0.7
Total		**54.5**	**14.8**	**24.6**	**5.1**

Following the loss tables, for each scale of farming there is an assessment of the quality of the data that has been used to create the PHL profile. The individual loss estimates that have been used to derive each loss profile figure are rated for their specificity to the situation in which they are being used (by crop type, by climate type, by scale of farming, and by whether the estimate was derived from a measurement of loss or by a questionnaire survey). Where estimates are specific or measured then they are marked green/ given a '1' rating, where they are not specific or are questionnaire date they are marked red/ given a '0' rating. The average rating is then given in bold against each PHL profile figure. The same table shows the author for each loss estimate used to calculate the PHL profile figures. By hovering the cursor over these author names, the full bibliographical details are revealed.

PHL profile: Data quality display and references to sources

*PHL profiles are used to calculate losses, each profile consists of a series of values, one for each link in the postharvest chain. Each value in the PHL profile is formed from the average of several figures drawn from the available literature. All these figures are shown individually in the tables below. Separate PHL profiles are given for small farms and large (commercial) farms. The reliability of each datum contributing to the calculation of each PHL profile value is displayed in the table below. The assessment is based on how specific the figure is to the situation in which it is being used. To do this, each figure is assessed according to whether it is from the same **Cereal** type (maize, rice etc), same **Climate** type (is from same Koeppen code), same **Farm type** (from a small farm or large commercial farm), and if the **Method** of loss assessment was an actual measurement of loss or was a questionnaire survey or guesstimate. The result of the assessment is indicated using the **red/0** and **green/1** system as follows -*
0 A datum used in the calculation of a PHL profile value is not specific to this situation or is from a questionnaire survey or a guesstimate, i.e. is not measured.
1 A datum used in the calculation of a PHL profile value is specific to this situation or is measured.
*PHL profile figures based on more **'green/1'** data are considered to be more reliable than those based on more **'red/0'** data. Against each PHL profile value the number of **'red/0'** and **'green/1'** assessments is averaged, and displayed in bold, to give a general assessment of the value. Frequently some parts of the profile are more reliable than others, especially those where more loss data are available from the literature.*

References and individual loss figures % for small farms

Stages	Loss figure	Reference	Origin of figure			
			Cereal	Climate	Farm type	Method
	5.5	Egyir I.S. - 2011	1	0	1	0
	2.0	Boxall R.A. - 1998	0	0	1	0
	5.0	Vervroegen D. - 1990	0	1	1	0
	3.2	[illegible]	1	1	1	0
	6.5	[illegible]	1	1	1	0
	6.9	[illegible]	1	1	1	0
	9.9	[illegible]	1	1	1	0
	9.9	[illegible]	1	0	1	0
	5.8	[illegible]	1	1	1	0
	9.5	[illegible]	1	1	1	0
Harvesting/field drying	**6.4**		**1**	**1**	**1**	**0**
	3.5	[illegible]	1	1	1	0
	4.5	[illegible]	1	1	1	0
Platform drying	**4.0**		**1**	**1**	**1**	**0**
	1.0	[illegible]	1	1	1	0
	1.8	[illegible]	1	0	1	0
	1.0	[illegible]	0	0	1	0

Title:
Project for the identification of post-production grain losses and training on their eeduction in Wollo Region, Ethiopia. FAO terminal report, Action Programme for the prevention of Food Losses.

Source:
FAO terminal report, Action Programme for the prevention of Food Losses. United Nations Food and Agricaulture Organisation, pp. 17

Author:
Vervroegen D. and Yehwola F.

Year of publication: 1990

Region: Wollo Region

Geo focus: Ethiopia

4.4 APHLIS interactive maps

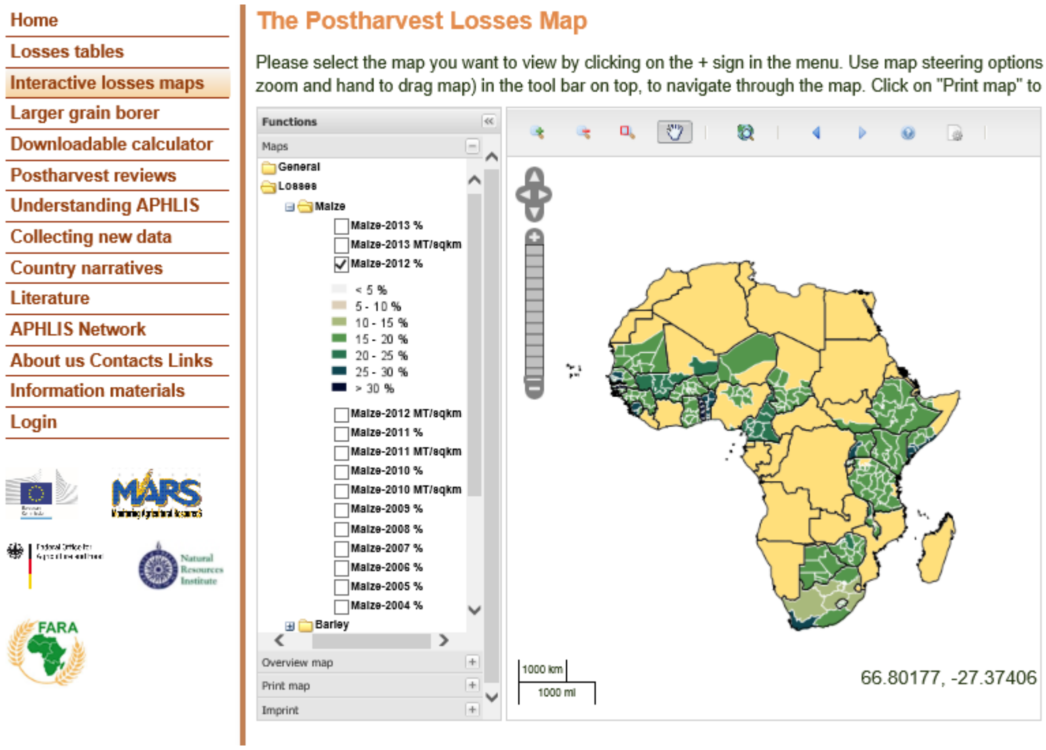
The mapping facility displays maps of losses and other key data. To access the map click the 'Interactive losses maps' button in the home page menu.

4.4.1 Displaying different maps

Once the map page is open select the map you want to view in the Maps menu. This offers the following –

- 'General' (shows province boundaries and the Köppen climate for each province as coloured shading),
- 'Losses' (shows % losses by year for each of eight cereals and loss density maps),
- Pests and diseases (shows annual incidence of when larger grain borer has been reported as a problem) and
- Names and 'Borders' (shows country borders, province names, country names and Köppen codes as symbols).

Each map is accessed by opening the directories (+ and -) then ticking the relevant box. Use map steering options (magnifying glass to zoom and hand to drag map) to navigate through the map (see Section 4.4.2). The figure below shows % weight loss values for maize in 2012 for the provinces of many countries.



Loss density may be displayed by unticking the Maize-2012% box and then ticking, for example, Maize-2012 MT/sqkm. This highlights the places where the absolute loss values are especially severe. It is useful to compare the maps of % weight loss with the loss density. For example in the case of rice and millet in Senegal (Fig. 4.1) the provinces with greater % weight losses do not necessarily have greater absolute losses (MT of loss). In the case of millet, Kaolack province (#5) has amongst the lowest % weight loss (5-10%), not least because there was no rain at harvest, whereas it has the highest loss density (15-20 MT/km^2) because it produces an exceptionally large millet crop for its land area. This suggests that it may be a good target for loss reduction measures. Similarly for rice, Saint Louis province (#10) is among the lowest for % weight loss (10-15%) but is the highest for loss density (15-20 MT/km^2).

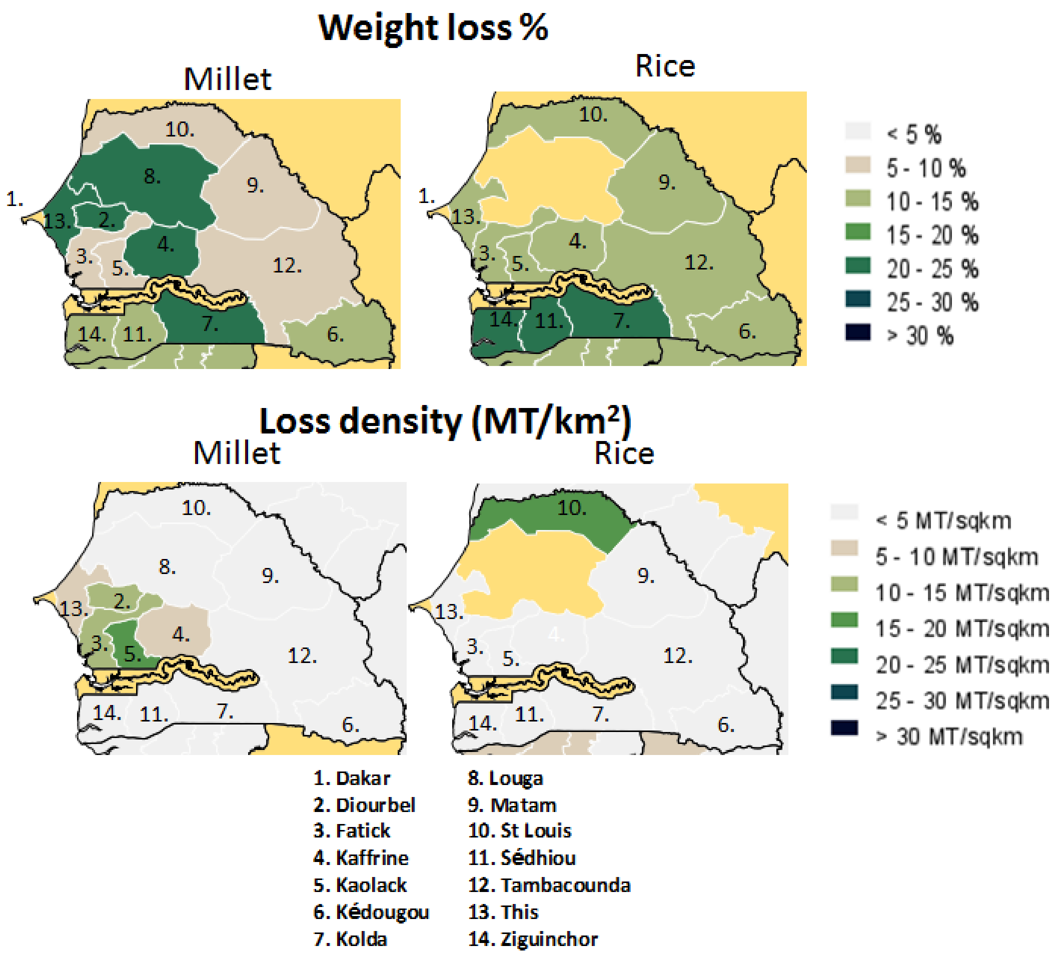
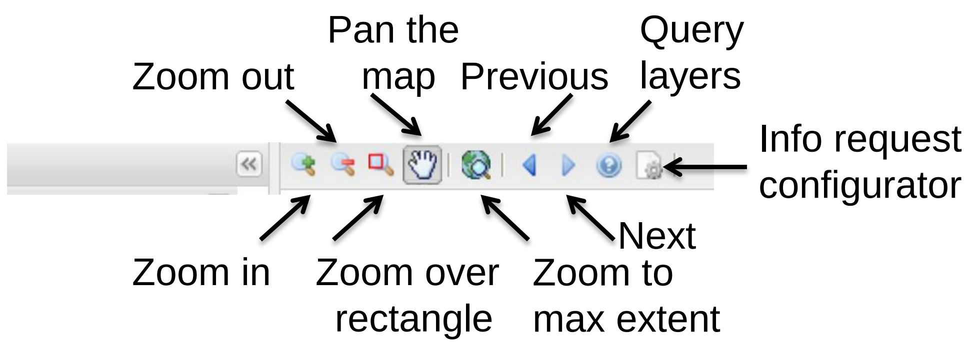


Figure 4.1: A comparison between the % weight loss maps of millet and rice in Senegal with the corresponding loss density maps

4.4.2 Controlling the map settings

Above the map is a control panel with a set of buttons like this –



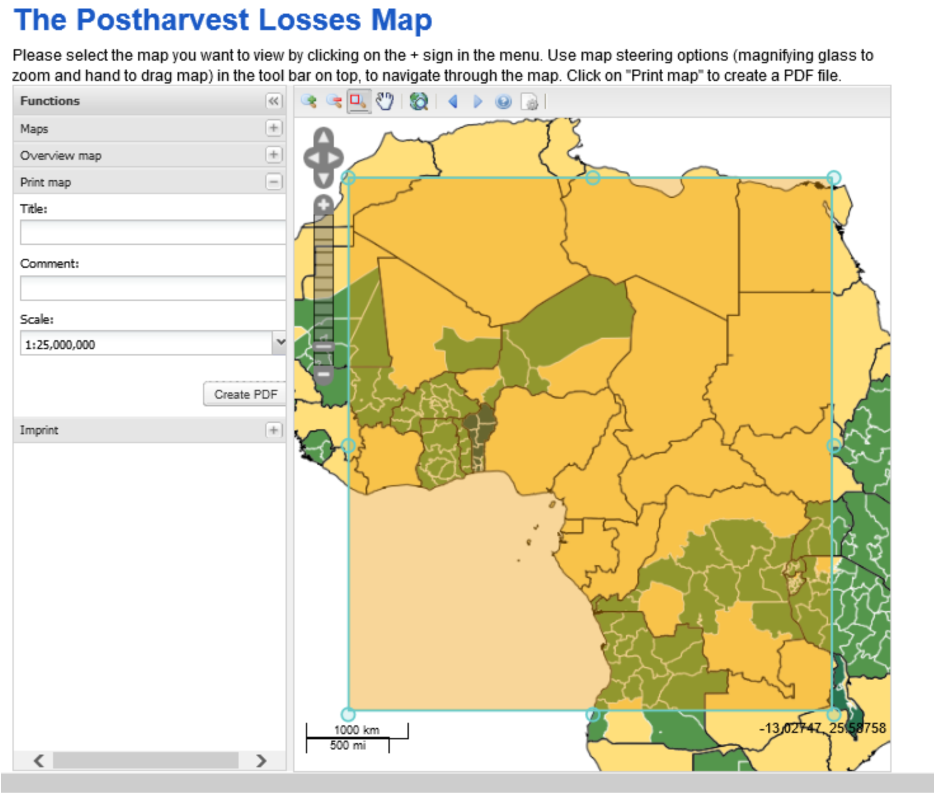
These button descriptions are self-explanatory in some case. The less obvious ones are

Queries layers – by pressing this button and then clicking on a particular province, the specific loss value of that province is displayed. This is especially useful when there is difficulty in distinguishing which colours of the legend correspond to which loss values or when you what to know the precise loss figure not just the range offered by the legend.

Info request configurator – by pressing this button you can see a listing of all the map layers that have been activated. It is then possible to deselect layers that are no longer required.

4.4.3 Printing maps

A further menu option on the map is **'Print Map'**. This allows you to download a selected area of the map as PDF file, which can be very useful for preparing reports. On opening the 'Print map' function a large rectangle appear over the map as shown below. Press the 'Zoom over rectangle' button in the map control panel to move or resize this rectangle so that it includes precisely the area of interest. When this is completed press the 'Create PDF' button to download a PDF.



4.5 System architecture

APHLIS was developed in the frame of three successive projects and has been improved continuously as new knowledge became available. Initially it was an on-line database of cereal weight loss estimates but then other modules and information products were added so that now it consists of three modules (Fig. 4.2). The process of improvement will continue and is achievable because the modular structure gives the flexibility required for up-grading and extending the system at low cost. The central module is the APHLIS website that can be found at www.aphlis.net. This processes data, calculates loss estimates and displays factual data and results as tables or as maps. The second module is the Shared DataBase (SDB) at www.sdb.afris.org . This is used for the decentralized management of seasonal data by the APHLIS Network. The third module of APHLIS is the regional information system of FARA www.erails.net. This is an easy-to-use decentralized content management system. The APHLIS Network uses it to publish and share information in various formats such as manuals, loss reduction tips and Country Narratives (see **Section 6**).

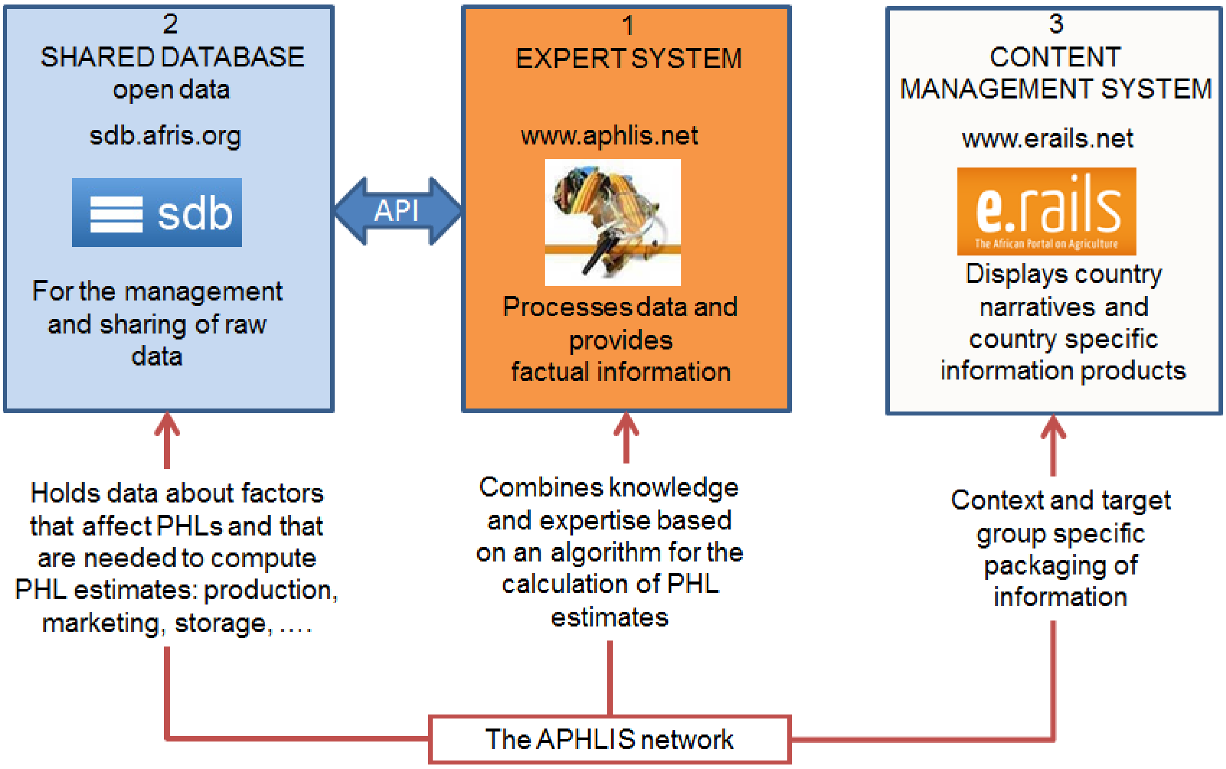


Figure 4.2: The three modules of APHLIS

4.6 Management of seasonal data

The APHLIS network updates seasonal data (see [Section 3.5]) on the SDB periodically. The SDB is a novel GIS enabled database system that allows for the management of numerical data for an unlimited number of variables and objects. Data is managed in data-matrices (Fig. 4.3 and 4.4) that assure the referencing and description of data according to international standards. Each national team has a set of data-matrices for the management of their own seasonal data. The export and import features of the SDB allow for off-line data management in Excel.

Variable: Production (mass) - 1st season - smallholder farms metric tonnes [MT] - Min: 0, Max: 10000000

Location	Date	Barley, other #040001010502 Barley, other	Maize (corn), other #040001010202 Maize (corn), other	Millet, other #040001010802 Millet, other	Oats, other #040001010702 Oats, other	Rice paddy, other (not husked) #040001010302 Rice paddy, other (not husked)	Sorghum, other #040001010402 Sorghum, other	Teff, other #04000101080204 Teff, other	Wheat, other #040001010102 Wheat, other
Gambella	2008								
	2009	0	13841.7	0	0	0	9770.96	0	0
	2010	0	9712.49	0	0	0	9257.85	0	0
	2011	0	10245.9	0	0	0	8214.64	0	0
	2012	5.448	10687.4	0	0	0	5497.36	27.087	2.97
	2013	17.3	11972.5	0	0	6	8232.2	0	0
	2014								
	2015								
Dire Dawa	2008								
	2009	0	317.406	0	0	0	9733.18	0	0
	2010	0	623.245	0	0	0	8821.94	0	0
	2011	2.811	505.268	0	0	0	15282.9	0	0

Figure 4.3: Example of a data matrix in the SDB, in this case for the cereal production of Ethiopia

Zwischenablage | Schriftart | Ausrichtung | Zahl

B1 | fx | Ethiopia - Cereal production 1st season small farms 2008 to 2015

	A	B	C	D	E	F	G	H	I	J
1	Datatablename	Ethiopia - Cereal p	Variable	Crop production > Harvest > Production (mass) - 1st season - smallholder farms(#22) (metric t						
2	Location	Interval	Barley, other (#38) Barley, other	Maize (corn), other (#39) Maize (corn), other	Millet, other (#40) Millet, other	Oats, other (#41) Oats, other	Rice paddy, other (not husked) (#42) Rice paddy, other (not husked)	Sorghum, other (#43) Sorghum, other	Teff, other (#44) Teff, other	Wheat, other (#45) Wheat, other
3	Gambella (#86)	2008 (#209)								
4	Gambella (#86)	2009 (#210)	0	13841.782	0	0	0	9770.963	0	0
5	Gambella (#86)	2010 (#211)	0	9712.493	0	0	0	9257.859	0	0
6	Gambella (#86)	2011 (#212)	0	10245.94	0	0	0	8214.646	0	0
7	Gambella (#86)	2012 (#213)	5.448	10687.412	0	0	0	5497.36	27.087	2.97
8	Gambella (#86)	2013 (#214)	17.3	11972.5	0	0	6	8232.2	0	0
9	Gambella (#86)	2014 (#215)								
10	Gambella (#86)	2015 (#216)								
11	Dire Dawa (#87)	2008 (#209)								
12	Dire Dawa (#87)	2009 (#210)	0	317.406	0	0	0	9733.185	0	0
13	Dire Dawa (#87)	2010 (#211)	0	623.245	0	0	0	8821.948	0	0
14	Dire Dawa (#87)	2011 (#212)	2.811	505.268	0	0	0	15282.958	0	0

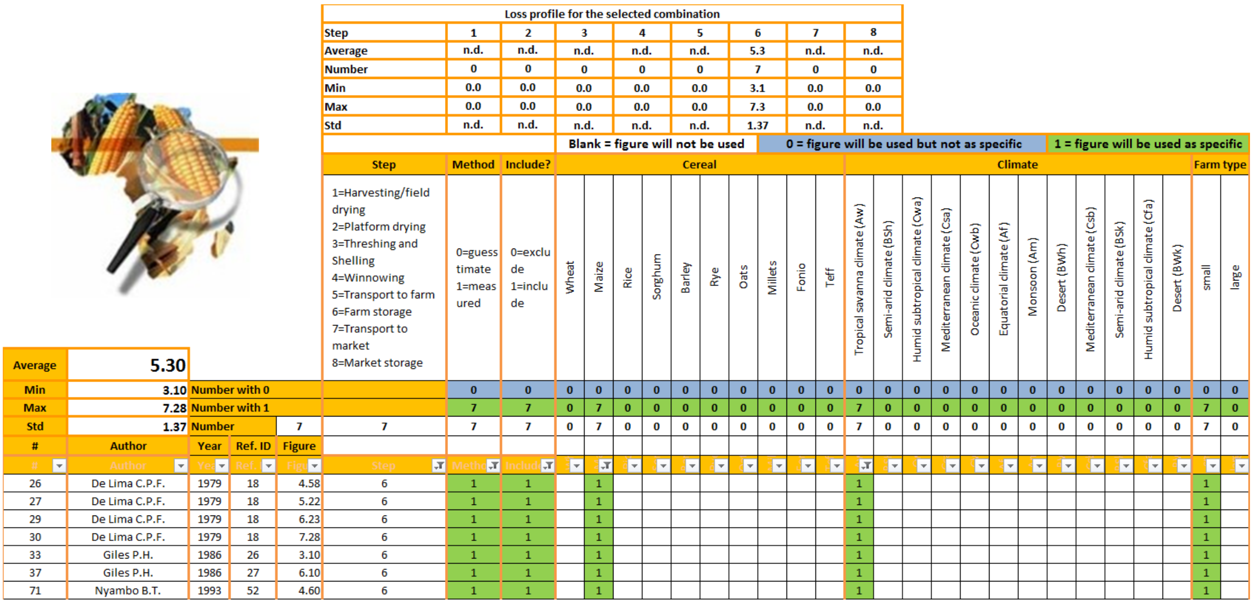
Figure 4.4: The same data-matrix in Excel for off-line data management

An Application Programming Interface (API) is used to filter and transfer the required data to the APHLIS database for the calculation of loss estimates and production of factual information. Data is transferred automatically every 24 hours. Calculations of estimates are undertaken at database level. This allows for an easy adjustment of the algorithm when new findings that suggest improvements become available. Simple select statements are used to extract and display the results on the various APHLIS pages. New data can be integrated easily at low cost by the definition of additional data-matrices. If desired, new seasonal indicators (variables), that might be required for the calculation of improved estimates, can be added without complex and costly programming. All that would be required is to define further data-matrices, adjust the filter of the API and then adjust the calculation in the APHLIS database.

Data that is entered into the SDB by the APHLIS Network is a public good and can be used by other interested parties. Visitor can download the data from the frontend of the SDB or use the API for automatic data transfer. In return APHLIS automatically benefits from data that is entered by other people who use the SDB for the management of their data.

4.7 PHL Profile management

The APHLIS PHL Calculator works by adopting a loss profile for the loss situation in question (in terms of crop, scale of farming, and climate – see **Section 3.4**). The management of the profiles, in particular their updating with new data presents a challenge. To simplify this procedure a 'PHL-reporter', a 'PHL-profiler' and a 'PHL-transformer' spreadsheet were developed. The 'PHL-reporter' spreadsheet (Fig. 4.5) enables experts to check and easily update the loss figures that are extracted from the scientific literature for the definition of loss profiles.



Loss profile for the selected combination								
Step	1	2	3	4	5	6	7	8
Average	n.d.	n.d.	n.d.	n.d.	n.d.	5.3	n.d.	n.d.
Number	0	0	0	0	0	7	0	0
Min	0.0	0.0	0.0	0.0	0.0	3.1	0.0	0.0
Max	0.0	0.0	0.0	0.0	0.0	7.3	0.0	0.0
Std	n.d.	n.d.	n.d.	n.d.	n.d.	1.37	n.d.	n.d.

Blank = figure will not be used; 0 = figure will be used but not as specific; 1 = figure will be used as specific

Step: 1=Harvesting/field drying 2=Platform drying 3=Threshing and Shelling 4=Winnowing 5=Transport to farm 6=Farm storage 7=Transport to market 8=Market storage

Method: 0=guesstimate 1=measured

Include?: 0=exclude 1=include

Average	5.30
Min	3.10
Max	7.28
Std	1.37

#	Author	Year	Ref. ID	Figure	Step	Method	Include?	Wheat	Maize	Rice	Sorghum	Barley	Rye	Oats	Millets	Fonio	Teff	Tropical savanna climate (Aw)	Semi-arid climate (BSh)	Humid subtropical climate (Cwa)	Mediterranean climate (Csa)	Oceanic climate (Cwb)	Equatorial climate (Af)	Monsoon (Am)	Desert (BWh)	Mediterranean climate (Csb)	Semi-arid climate (BSk)	Humid subtropical climate (Cfa)	Desert (BWk)	small	large
Number with 0						0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number with 1						7	7	0	7	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7	0
Number				7	7	7	7	0	7	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7	0
26	De Lima C.P.F.	1979	18	4.58	6	1	1		1									1												1	
27	De Lima C.P.F.	1979	18	5.22	6	1	1		1									1												1	
29	De Lima C.P.F.	1979	18	6.23	6	1	1		1									1												1	
30	De Lima C.P.F.	1979	18	7.28	6	1	1		1									1												1	
33	Giles P.H.	1986	26	3.10	6	1	1		1									1												1	
37	Giles P.H.	1986	27	6.10	6	1	1		1									1												1	
71	Nyambo B.T.	1993	52	4.60	6	1	1		1									1												1	

(Column groups: Cereal = Wheat … Teff; Climate = Tropical savanna climate (Aw) … Desert (BWk); Farm type = small, large.)

Figure 4.5: The PHL reporter with filters set to check the profiles used for smallholder farm storage losses of maize in a tropical savannah climate

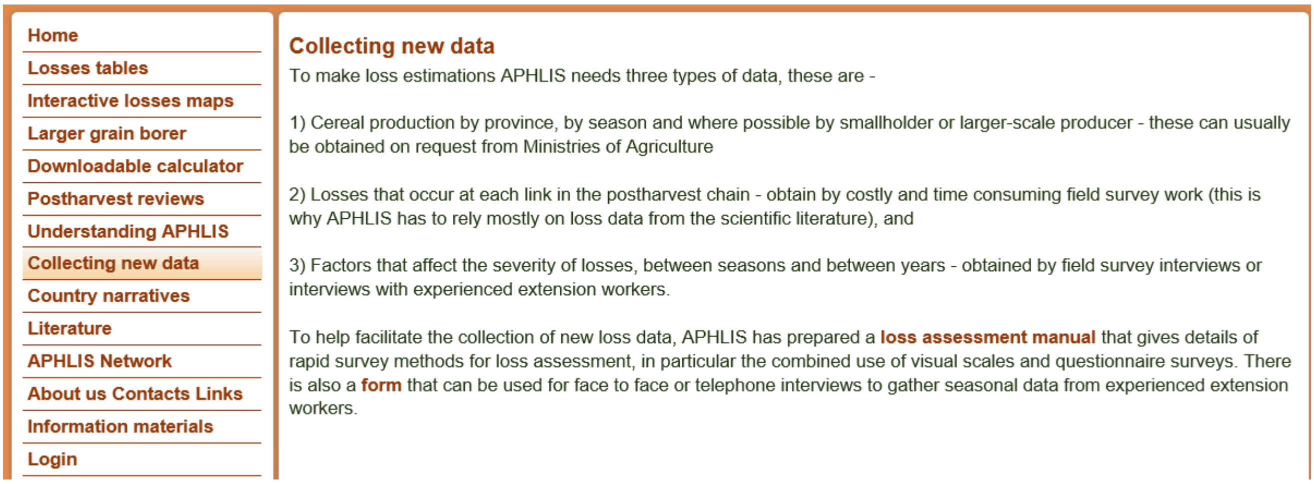
The 'PHL-profiler' is used to automatically generate loss profiles for all possible crop, climate and farm-type combinations. The resulting list of profiles is used to update the corresponding tables in the APHLIS database. The 'PHL-transformer' is used to format the list in order to fit to the requirements of the off-line PHL Calculator.

The tables and maps described in this chapter display loss estimates that are based in part on loss data from the scientific literature. The next chapter describes this data and the ways that it has been transformed and grouped for the creation of PHL profiles

4.8 Submitting new data to APHLIS

To provide loss estimates APHLIS requires two types of data. It needs estimates of the -

- The extent of losses for each link in the postharvest chain, and
- Seasonal factors that affect losses.



4.8.1 New data on weight losses

The loss figures for each link in the chain are already set as defaults in the PHL Calculator (on the website and the downloadable Excel spreadsheet). However, these defaults are based on a relatively small set of data from published studies and the 'grey' literature. The numbers are relatively small (Fig. 5.1). Much of this data is shared between different crops, different climates and scales of farming (smallholder and larger scale) so that within the Calculator the PHL Profiles (see **Section 3.4**) are not entirely specific to the situation or are only partially specific. Consequently, there is still a need for more postharvest weight loss data that could be used refine the loss estimates. The loss assessment methods described in this manual can be used to help gather more data on losses.

4.8.2 New data on seasonal factors

The collection of data on seasonal factors (see **Section 3.5**) is also very important, since PHL Calculator uses this data to create the difference in losses between seasons and between years. The collection of data on seasonal factors is potentially very time consuming if this is obtained by interviewing individual farmers. However, this could be made much easier if knowledgeable extension workers are interviewed by mobile phone. An example of an interview form to help with this is shown in Annex 3.

When new data on PHLs and on seasonal factors are available then they can be assembled in the form of a simple table (Table 4.1) and submitted to APHLIS by e-mailed (info@aphlis.net). APHLIS Network members with a login and password can submit this data directly into the APHLIS database.

Table 4.1: Seasonal factors data for maize in 2012 for the three provinces of Malawi

Maize, Smallholder, Season 1	**North**	**Central**	**South**
% marketed in 1st 3 months	66.5	39.3	44.7
Length of farm storage	6.5	6.3	6
Rain at harvest	No	No	No
Problems with LGB	Yes	Yes	Yes
Maize, Smallholder, Season 2			
% marketed in 1st 3 months	65	36.3	16.7
Length of farm storage	4	3.7	3.7
Rain at harvest	No	No	No
Problems with LGB	Yes	Yes	Yes
Maize, Large scale, Season 1			
% marketed in 1st 3 months	91	10	-
Length of farm storage	7	-	-
Rain at harvest	No	No	-
Problems with LGB	Yes	Yes	-

4.8.3 New Postharvest weight loss data

These data are required for improving the PHL profile figures (see **Section 3.4**). New data together with details of how they were gathered should be e-mailed to info@aphlis.net. The data will be assessed and if suitable will be added to the database and will be drawn upon for the calculation of PH Loss Profile figures.

4.8.4 Other observations

Any other useful observations on losses, postharvest practice or postharvest projects can be submitted to the country member for posting in the Country Narratives described in **Chapter 6**. Country members are listed under 'APHLIS Network' in the menu of the APHLIS web page but their e-mail addresses are not disclosed. To make contact send a message to info@aphlis.net and mention which country and person you wish to contact.

5. The postharvest loss data that underlie APHLIS estimates

In order to make PHL estimates, APHLIS requires data on losses from all links in the postharvest chain. These data are used to create PHL profiles described in Section 3.4. This data was obtained during a thorough survey of the available literature, both published and 'grey'.

Since the 1970s, efforts have been made to assess the grain losses suffered by African farmers. Most estimates of loss have focused on grain once it has entered farm storage, while few data have been generated on losses at harvesting, drying, threshing/winnowing, during transport or market storage (Fig. 5.1). Of this data most have been collected using questionnaire surveys or are just guesstimates rather than by actual measurement. The main exception is farm storage (Fig. 5.1) where most estimates result from measurement. When surveying the available literature on losses many estimates had to be excluded as the methodologies were considered unreliable or unsuitable. The age of the data used is variable with peaks in the late 80s, early 90s and late 2000s (Fig. 5.2).

	No. loss figures used		
	Measured	Q'aire	Excluded
Harvesting/field drying	8	15	14
Transport to homestead	2	13	0
Drying	0	2	0
Threshing/shelling	4	14	3
Winnowing	1	4	2
Farm storage	31	13	28
Transport to market	0	2	0
Market storage	0	3	0

Figure 5.1: The loss data used within APHLIS are either measured loss estimates or are opinions expressed in questionnaire surveys

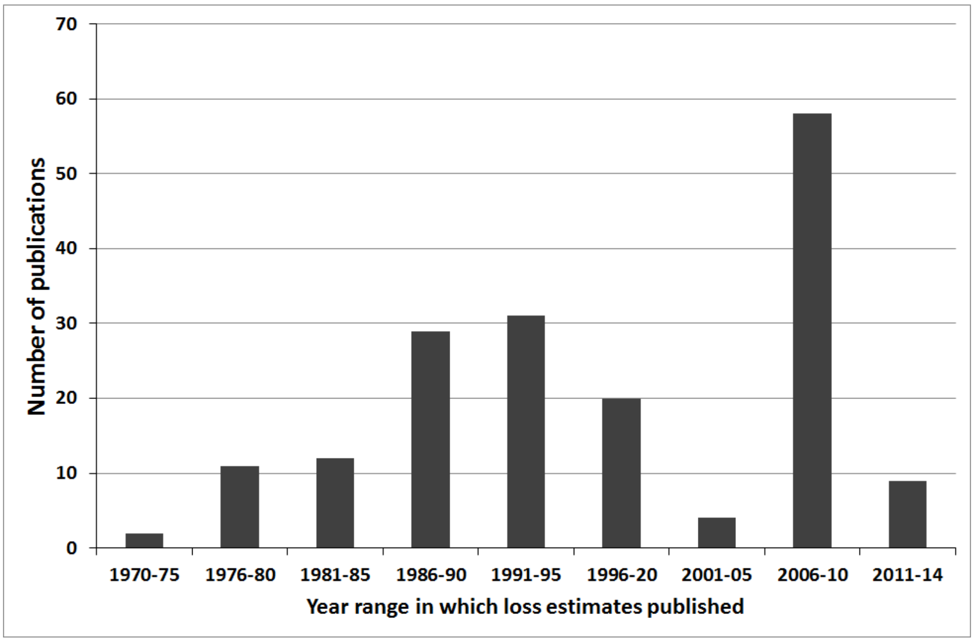


Figure 5.2: The age range of loss data used for APHLIS loss calculations

5.1 Non-storage losses

Harvesting and drying

Of special interest is the harvesting/drying loss of 16.3% for Swaziland (Table 5.1). This was measured for two seasons when maize was harvested under damp conditions. These losses indicate what might be expected when climatic variations in the future lead to crops being harvested in unfavourably wet weather. More typical harvesting/drying losses are shown by the two figures from Zimbabwe 9.5% and 5.8% (Table 5.1). The only figure found for harvesting/drying losses of African paddy rice is 6.9% and is from Madagascar. This is rather high compared to Asian losses which for China are 5.21% (IDRC, 1989 quoted in Grolleaud, 1997), several Asian countries combined 4.0% (Calverley, 1996) and Bangladesh 1.95% (Huq and Greeley, 1980). The figures for harvesting and drying of sorghum and millet (11.3% and 12.2% respectively) appear also to include threshing losses. Platform drying, which raises the maize off the ground for longer-term drying, has been associated with losses of 3.5% (Zambia) and 4.5% (Zimbabwe).

Threshing and shelling

There are two threshing/shelling loss figures for maize, both from Zimbabwe (Table 5.1). For smallholder farming the losses are low, 1-2.5%, which might be expected since the process is usually by hand and may be contained within jute bags so there is little spillage, whereas the large scale figure is 3.5% and may reflect the greater spillage associated with mechanical shelling. The available data attributes rather higher threshing losses to rice, a 6.5% measured estimate from Madagascar and 6% from questionnaire survey in Ethiopia for cereals (generally).

Winnowing

Winnowing losses are relevant to most grains except maize. There are virtually no loss figures available. Winnowing losses of rice in Madagascar were measured at 2.5% while questionnaire survey results relating to cereals in Ethiopia average 5% (Table 5.1).

Transport

Losses incurred from transport from field to store are little known and are likely to be highly variable. For paddy rice in Madagascar they have been measured at 2.25% whereas ‘commonly applied’ figures or those from questionnaire surveys for other cereals range from 1% to 3%. There is at least some consensus on the general magnitude. For transport to market there is only a single ‘commonly applied’ figure offered, 1% for maize (Table 5.1).

5.2 Storage losses

One of the earliest investigations of storage weight loss using modern methods was of maize cob storage in Malawi by Schulten and Westwood (1972). They followed the increase of weight loss in local, improved and hybrid maize varieties stored in traditional structures (Fig. 5.3). This study demonstrated two important points 1) there are big differences between hybrid and local/improved varieties in the rate of increase in loss, and 2) there is very little loss during the initial periods of storage (first three months). For these reasons, farmers may keep losses low by selling hybrids soon after harvest while keeping local and improved varieties long-term for their own consumption.

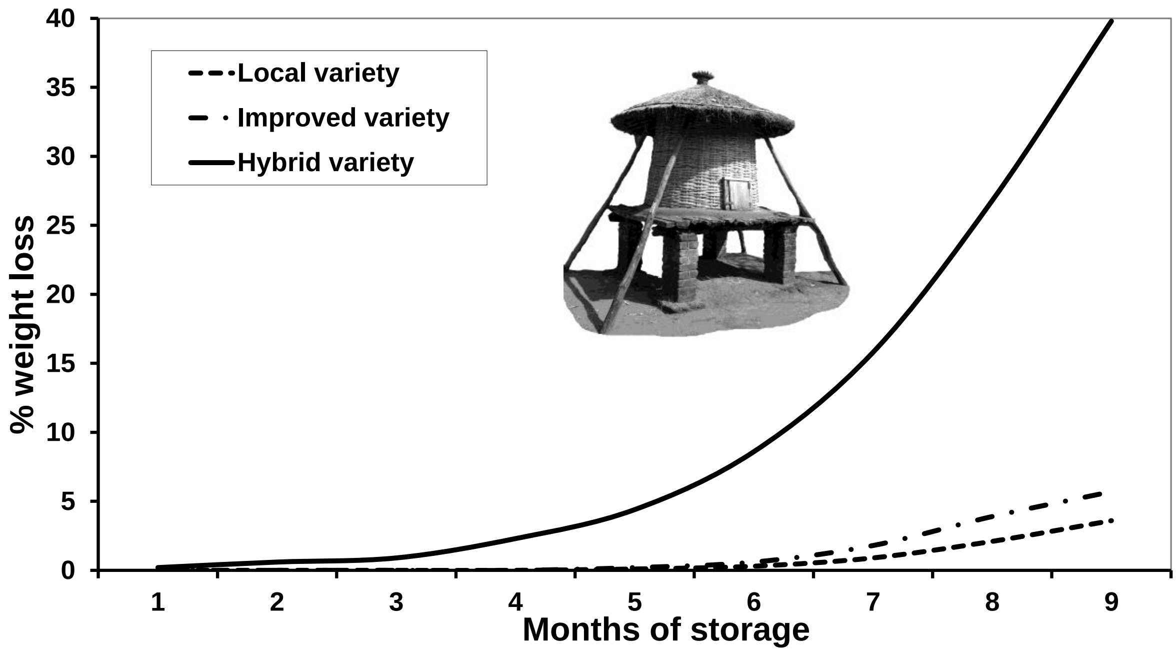


Figure 5.3: % Weight loss of different maize varieties stored traditionally in Malawi but with no household consumption and no insecticide treatment (based on data from Schulten and Westwood, 1972)

A good example of a storage loss study is the pioneering investigation of Adams and Harman (1977) who measured storage losses in Zambia using a variety of modern methods, offered an economic analysis of the observed losses and considered the costs and benefits of improvements to reduce losses. The losses they found (4-5%) and subsequent studies on maize, particularly in East Africa (Kenya – De Lima 1979b; Malawi - Golob 1981 a&b), confirmed that on average farmers would lose from 2% to 5% of the dry weight of their grain during the course of a typical storage season of about 9 months.

APHLIS uses storage loss estimates from the literature and those submitted by the APHLIS Network as the basis of its calculation of cumulative postharvest weight loss. If storage loss figures are to be combined so that they can be used by APHLIS then they must be standardised. The original loss figures quoted in the literature come from a variety of studies undertaken over different time periods and may or may not have taken grain removals, such a household consumption, into account. Where necessary, for the purpose of APHLIS, these loss figures from the literature have been adjusted to a 9-month storage period and also adjusted for household consumption, assuming that the grain was consumed at an even rate over 9 months. The storage loss is standardised to a 9-month period by considering the shape of the curve of loss over time of the original study and then obtaining a 9 month loss figure by extrapolation or interpolation. Alternatively, if there is insufficient data to suggest a loss curve then it would be assumed that three, six and nine months of storage would account for 15%, 30% and 55% of weight losses respectively. In any case, the majority of storage studies are about 9 months long; this is the duration of a typical storage season. APHLIS currently works with 75 adjusted, loss figures. The best quality data are considered to be the measured estimates using modern methods. Other methods such as questionnaire surveys or guesstimates are expected to be less reliable although the measured estimates may not be much better than other approaches when they are being applied to much wider circumstances than those from which
they are derived.

Table 5.1: % Weight loss figures for activities in the postharvest chain, except farm storage, from various east/southern African countries

Country (data source)	Ethiopia (1)	Ethiopia (2)	Swaziland (3)	Zambia (4)	Zimbabwe (5)	Zimbabwe (6)	Uganda (7)	Uganda (7)	Uganda (7)	Madagascar (8)
Crop	Cereals	Cereals	Maize	Maize	Maize	Maize	Maize	Sorghum	Millet	Rice
Data quality*	Q/G	Q/G	M	Old M data and data from outside Zambia	Commonly applied figures, origin ?	Q	M ?	M ?	M ?	M
Harvesting and drying										
Field drying										
Small-scale	2	5	16.3[R]	13.5[p]	9.5	5.8	17.4[T]	11.3[T]	12.2[T]	6.85
Large scale	2	-	16.3[R]	13.5[p]						
Platform drying										
Small-scale	-	-	-	3.5	4.5	-	-	-	-	-
Large scale	-	-	-	3.5	-	-	-	-	-	-
Threshing/shelling										
Small-scale	1	6	-	-	1	2.5	-			6.5
Large scale	1	-	-	-	3.5	-	-	-	-	-
Winnowing										
Small-scale	0	5	-	-	-	-	-	-	-	2.5
Large scale	0	-	-	-	-	-	-	-	-	-
Transport to store										
Small-scale	2	3	-	-	1	-	-			2.25
Large scale	2	-	-	-	-	-	-	-	-	-
Transport to market										
Small-scale	-	-	-	-	1	-	-	-	-	-
Large scale	-	-	-	-	-	-	-	-	-	-

*Q/G – Questionnaire/Guesstimate, M - Measured [R]rain at harvest [p]includes production losses? [T]includes threshing

Data sources

1. Boxall 1998
2. Vervroegen and Yehwola 1990
3. De Lima 1982
4. Lars-Ove Jonsson and Kashweka 1987
5. Odogola and Henriksson 1991
6. Mvumi et al. 1995
7. Silim et al. 1991
8. Repoblika Malagasy 1987

Table 5.2: Some examples of corrected estimates of % weight loss during storage of cereal crops; original estimates standardized for 9-months storage period and an even household consumption pattern. Figures arranged by country and prevailing climate classification (Köppen code) and with an indication of the quality of the data source

Country	Climate code	Farming scale	Original estimate	St'ized estimate	Quality rating	Authors
Maize cob storage with LGB infestation						
Tanzania	Aw	small	34.0	11.6	M	Golob and Boag 1985
Tanzania	Aw	small	20.0	7.8	M	Hodges *et al.* 1983
Tanzania	Aw	small	31.0	11.6	M	Henkes 1992
Tanzania	Cwb/Aw	small	5.1	5.1*	M	Ashimogo 1995
Malawi	Cwa	large	5.0	1.7	Q/G	Singano (pers. comm.)
Cob storage no LGB infestation						
Ethiopia	Aw	small	8.0	5	Nk	SSEAD 1997
Kenya	Aw	small	5.2	4.6	M	Nyambo 1993
Kenya	Aw	small	6.2	6.2*	Mu	De Lima 1979b
Kenya	Aw	small	15.0	6.1	M	Giles 1986b
Tanzania	Aw	small	1.9	1.9*	M	Bengtsson et al. 1991
Kenya	BSh	small	6.2	6.2*	Mu	De Lima 1979b
Malawi	BSh/Aw	small	4.5	2.4	M	Golob 1981a
Malawi	Cwa	small	7.6	4.4	M	Binder et al 1994
Malawi	Cwa	small	2.1	1.2	M	Golob 1981b
Swaziland	Cwa	small	4.05	4.4	M	De Lima 1982
Zambia	Cwa	small	9.0	4.1	M	Adams and Harman 1977
Maize grain with LGB infestation						
Tanzania	Aw	small	19.7	7.6	M	Golob and Boag 1985
Tanzania	Aw	small	8.0	3.3	M	Henkes 1992
Maize grain no LGB infestation						
Ethiopia	Aw	small	9.0	5.5	Nk	SSEAD 1997
Kenya	Aw	small	18.0	7.8	M	Giles 1986b
Zambia	Cwa	small	2.6	0.9	M	Adams and Harman 1977
Zimbabwe	Cwa	small	7.01	7.01*	M	Keterere & Giga 1990
Ethiopia	Cwa	small	2.6	0.8	Nk	Kidane and Habteyes 1989
Sorghum threshed						
Eritrea	BWh/BSh	small	14.9	5.5	M	Haile 2006
Eritrea	BWh/BSh	small	13.0	5.7	M	Haile 2006
Sudan	BWh/BSh	small	5.3	2.5	M	Seifelnasr 1992
Ethiopia	Cwa	small	15.4	5.5	Nk	Kidane and Habteyes 1989
Sorghum unthreshed						
Kenya	Aw	small	10.2	4.7	M	Nymabo 1993
Wheat						
Eritrea	BSh	small	6.5	3.1	M	Haile 2006
Eritrea	BSh	small	0.7	0.1	M	Haile 2006
Ethiopia	BSh	small	0.1	0.1	Nk	SSEAD 1997
Malawi	BSh/Aw	small	0.5	0.5	Q/G	Singano (pers. comm.)
Ethiopia	Cwa	small	2.1	0.7	Nk	Kidane and Habteyes 1989
Malawi	Cwa	small	15.0	5.8	Q/G	Singano (pers. comm.)
Barley						
Ethiopia	Cwa/Cwb	small	2.5	0.9	Nk	Kidane and Habteyes 1989
Ethiopia	Cwa/Cwb	small	2.0	0.7	Nk	Kidane and Habteyes 1989

Millet						
Namibia	BSh	small	1.5	0.7	M	Hodges *et al.* 2006
Rice						
Malawi	BSh/Aw	small	0.1	0.1	Q/G	Singano (pers. comm.)
Malawi	Cwa	small	2.0	0.6	Q/G	Singano (pers. comm.)
Teff						
Ethiopia	Cwa	small	0.3	0.3	Nk	Kidane and Habteyes 1989

* household consumption included in original estimate

Data quality rating		**Köppen climate classification**	
Measured, using modern methodology	- M	Aw	Tropical savannah
Measured, methodology uncertain	- Mu	BSh	Arid steppe, hot
Questionnaire	- Q	BWh	Arid desert, hot
Guesstimate	- G	Cwa	temperate dry winter, hot summer
Not known	- Nk	Cwb	temperate dry winter, warm summer

5.3 Clustering provinces to share loss data

A problem faced in seeking to estimate PHLs over a wide geographical area is that for many locations there are no specific loss data. It is therefore inevitable that many different locations (provinces) would have to share the same data whether for smallholder or large-scale farming. This can be achieved by clustering together the provinces of many countries that are basically similar with respect to factors known to influence postharvest losses. Factors that could affect storage losses would be expected to be the type of crop stored, prevailing climate and storage type. Climate is a key determinant of grain storage losses (McFarlane, 1988), since the biodeterioration factors that are the main agents of loss are dependent on conditions of temperature and humidity (see **Section 2.1**). This is reflected in the type of store used by farmers to prevent biodeterioration (see **Annex 2**). At one extreme, in hot humid climates farmers typically use very open storage structure to allow a substantial airflow and continuous drying and at the other extreme in hot dry climates farmers can use sealed stores, with no airflow, since the crop enters store fully dried (Compton *et al.*, 1993). Intermediate climates have stores designed with intermediate airflows. Crop type and climate therefore offer a simple and easily understood approach to clustering provinces and cross checking by store type may be a useful way of judging cluster boundaries. Thus in Table 5.2, storage loss estimates for each crop type are grouped according to the climate classification codes of the Köppen system (Peel *et al.,* 2007) for the locations where the estimates were made.

To give the 'consensus' loss figures for each loss category, under each climate code, the standardized estimates were summarised by removing outliers, avoiding the use of 'questionnaire/guestimate' data where there is sufficient 'measured data, and then averaging what data remained. The 'general' loss figures derived are listed in Table 5.3. These show some variation by crop type. Maize (without LGB infestation) as grain or cobs typically loses 4-5%, sorghum grain 2-4%, wheat 3-5%, millet 1%, barley, paddy rice and teff 1% or less. Apart from maize and sorghum the actual number of individual figures contributing to the loss estimates for the other crops is low and so less reliance can be placed on these generalisations. However, teff is an interesting case as it is well known to suffer few losses in store due to its very small grain size making it resistant to insect attack so the very low figure for storage loss is probably realistic even if the data source is poor. Indeed in Ethiopia one way to prevent infestation of maize grain is to admix teff, which fills the inter-granular spaces preventing insect pest damage (Haile, 2006).

Table 5.3: Consensus % weight loss estimates in storage for various crops grouped by climate classification for the locations where estimates were made, adjusted to a 9-month storage period and an even household consumption pattern

Crop	Climate code	Small/large scale farming	Variety	% weight loss	Number of estimates
Maize cobs with LGB infestation	Aw*	Small	local	10.3	3
	BSh	Large	local	2.7	2
		Small	local	13.3	2
	Cwa/Aw	Large	local	2.1	2
		Small	local	10.0	3
Maize cobs no LGB	Aw	Small	local	5.3	9
	BSh	Small	local	4.3	2
	Cwa	Small	local	4.5	7
		Small	HYV	9.5	1
Maize grain with LGB infestation	Aw	Small	local	5.4	2
	Cwa	Small	local	3.3	2
Maize grain no LGB	Aw	Small	local	5.4	8
	Cwa	Small	local	4.2	3
Sorghum grain	BSh/BWh	Small	local	2.2	16
	Cwa	Small	local	3.9	4
Sorghum panicle	Aw	Small	local	2.8	2
		Small	improved	11.0	1
Millet	BSh	Small	local	1.1	3
	Cwa	Small	local	1.3	2
Wheat	BSh	Small	local	3.1	2
	Cwa	Small	local	5.8	2
Barley	Cwa/Cwb	Small	local	0.8	2
Rice	Aw	Small	-	1.2	2
	BSh	Small	-	0.1	1
	Cwa	Small	-	0.4	2
Teff	Cwa	Small	local	0.3	1

*See legend of Table 5.3 for meaning of climate codes

The situation with maize is more complex since it may or may not be infested by LGB. The incidence of LGB is reported by the APHLIS Network members and recorded in the provincial loss tables for maize under seasonal factors and for convenience displayed in an APHLIS map (Fig. 5.4). If cobs or grain are infested by normal storage pests, not LGB, weight losses from range from 4-5% (Table 5.4).

Figure 5.4: APHLIS interactive maps showing the reported distribution of significant infestation by LGB (*Prostephanus truncatus*) in 2013

When cobs are infested by LGB losses are about doubled (although it should be noted that the figure for BSh rely on questionnaire survey so may be on the high side). Others arrived at a similar conclusion, losses doubling from about 5% to about 10% (Hodges *et al.* 1983; Dick, 1989; Boxall, 2002). This is not surprising as it is well known that LGB is more damaging on stabilised grain, as it is found on the cob, than on shelled grain (Cowley *et al*. 1980). Shelling grain and storing in sacks (as well as addition of insecticide) are the standard recommendations to limit LGB losses (Golob, 2002).

Table 5.4: Comparison of the % weight loss estimates for maize stored as grain or as cobs with or without LGB (*Prostephanus truncatus*) infestation

Storage form	No LGB	LGB present	Climate code	Incremental increase due to LGB
Cobs	5.3	10.3	Aw	**1.9**
	4.3	13.3	BSh	**3.1**
	4.5	10.0	Cwa	**2.2**
Grain	5.4	5.4	Aw	**1.0**
	4.2	3.3	Cwa	**0.8**

In general, the data on storage losses are too few to make comparisons between crops stored under different climates. Maize and sorghum offer modest data sets but with considerable variation between estimates in the method of data collection. In the case of maize there were no consistent differences between climate classifications in the observed losses (Fig. 5.5). This may be due to the inadequacy of the data or could be interpreted as resulting from the appropriate adaption of farmers working under different conditions, where they have adjusted their postharvest technology to minimise grain losses. In the case of sorghum, losses might appear somewhat lower under hot dry conditions 2.5% (BSh) compared to temperate conditions 3.9 (Cwa) but the widely overlapping error bars for these two estimates suggest that the current data set are inadequate to confirm a genuine difference.

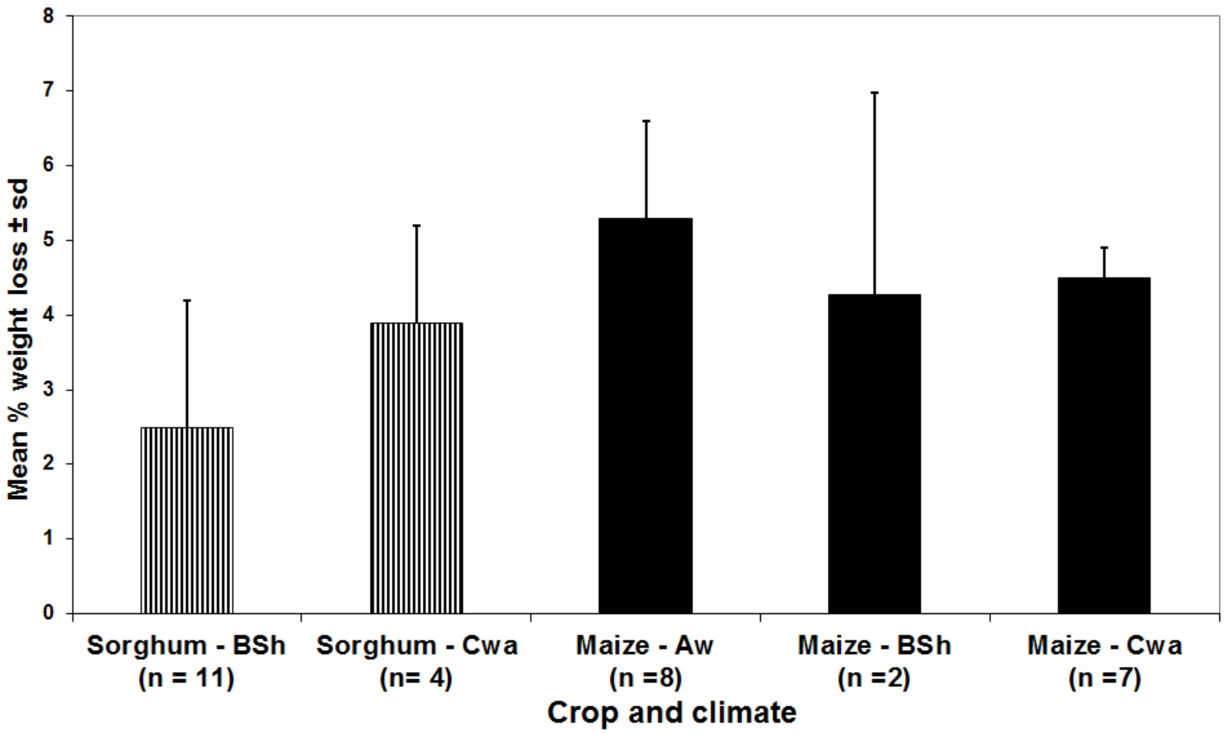


Figure 5.5: Mean % weight loss ±sd of stored sorghum grain or maize cobs (not LGB infested) under different climatic conditions

5.4 Factors with most influence on APHLIS loss estimates

To investigate the sensitivity of PHL estimates to a range of settings of the APHLIS PHL Calculator, loss values were recalculated while altering a single variable. The first factor to vary was the choice of climate type. In this scenario, PHL values for both smallholder and large-scale farming were little affected by climate type (Table 5.5), with very low coefficients of variation between climates for the loss values of each cereal. However, there were noticeable differences in PHL values between cereals, with maize suffering between 22% and 70% greater PHLs than other cereals, there is very little difference between the PHLs of wheat, paddy rice or millet, while the PHLs of sorghum are intermediate between these and maize. Large-scale farming resulted in lower weight losses for all cereals but otherwise the differences between cereals were retained, more or less in proportion.

Table 5.5: Effects of climate on postharvest losses of various cereals in smallholder and, in parenthesis, large-scale farmers' granaries*

Climate/crop	Maize	Sorghum	Millet	Wheat	Barley	Paddy rice
Aw	18 (12)	13 (7)	10 (6)	14 (10)	10 (6)	11 (11)
Bsh	17 (12)	12 (7)	10 (6)	13 (8)	10 (6)	10 (10)
Cwa	17 (11)	14 (9)	10 (6)	15 (10)	10 (6)	11(11)
Cwb	17 (11)	14 (9)	10 (6)	15 (10)	10 (6)	11 (11)
BWh	17 (12)	12 (7)	10 (6)	13 (8)	10 (6)	10 (10)
Coefficient of variation	0.03 (0.05)	0.08 (0.14)	0.00 (0.00)	0.07 (0.12)	0.00 (0.00)	0.05 (0.05)

*Conditions: grain harvested, dried and stored, no grain marketed, 9 months farm storage, no rain at harvest, no LGB infestation (only relevant to maize)

To investigate changing other APHLIS defaults, a detailed study was made of the most affected cereal, maize, under a range of scenarios (Table 5.6). When grain remains on farm for the whole storage season (9 months), PHLs range from 18% if there is no rain at harvest or LGB infestation. Losses rise to 22% if there is LGB infestation, to 27% if there was rain at harvest, and to 31% if there is both rain at harvest and LGB infestation. Large-scale farming reduces all these losses by about one third (Table 5.6) but is more similar to the performance of smallholder farming when there is rain at harvest (24%). This assumes that large-scale farming is little better than smallholder farming in mitigating the effects of untimely rainfall.

Table 5.6: Effects of altering the values of seasonal factors on estimation of maize losses from smallholder farmers (large-scale farmers in parenthesis) following different periods of farm storage*

Seasonal factors	Duration of on-farm storage						
	2 months			5 months		9 months	
% grain marketed	0	50%	100	0	50%	0	50%
No rain at harvest and no LGB	13 (9)	14 (11)	16 (12)	16 (10)	16 (11)	18 (12)	17 (12)
LGB infestation	13 (9)	14 (11)	16 (12)	18 (12)	17 (12)	22 (14)	19 (13)
Rain at harvest	22 (23)	24 (24)	25 (25)	25 (24)	25 (24)	27 (24)	26 (24)
Rain at harvest and LGB	22 (23)	24 (24)	25 (25)	27 (24)	26 (25)	31 (26)	28 (26)

*Conditions: maize grain under Aw Climate

For smallholder farming, increasing the farm storage period from 2 to 9 months raises maize PHLs from 13% to 18%, but from 13% to 22% if there is LGB infestation (Table 5.6). For large-scale farmers, the rise in losses is more modest as storage periods increase from 2 to 9 months, with a rise from 9% to 12%, and from 9% to 14% in the presence of LGB infestation (Table 5.6). As expected, the actual storage period has little effect on the losses incurred due to rain at harvest, rising from 22% to 27% in smallholder farms and 23 to 24% in larger farms, as it assumes that most losses due to rain at harvest are incurred in advance of storage (even though the damaged maize may have been put in store).

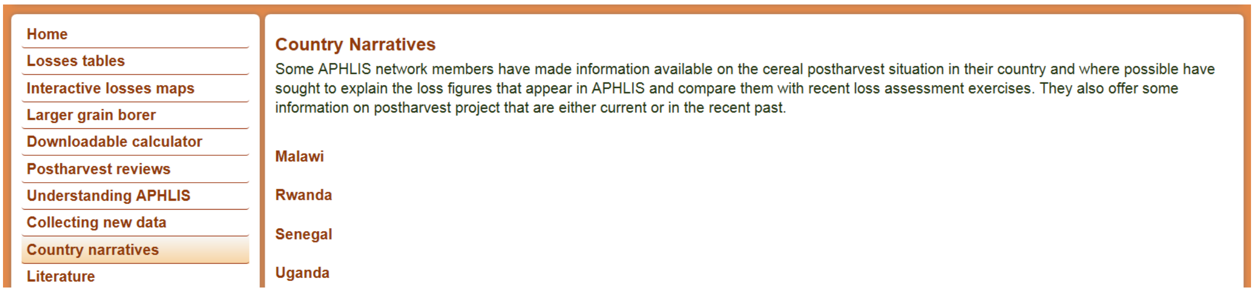
Early marketing of 50% of the grain, so that the farm storage period for half of the grain is reduced, in any of the scenarios makes very little or no difference to the overall PHL (Table 5.6), with a slight decrease when farm storage of the remaining grain is long (9 months) or slight increase when farm storage of the remaining grain is short (2 months). In the case of the increased losses, this happens because it is assumed that during a short period of farm storage all grain is consumed directly and not subject to losses while some modest transport and market storage losses are introduced when grain is marketed. Similarly, if 100% of grain is marketed, this results in a larger loss than if all grain was stored for only 2 months and then consumed.

It is clear that as currently set, the losses estimated by APHLIS are largely unaffected by the choice of climate type. Much stronger affects are noticeable due to cereal type, rain at harvest, length of farm storage, and in the case of maize, LGB infestation. Estimation of annual losses may also be affected by the number of cereal harvest annually, where one harvest may suffer quite different losses than others, e.g. where one harvest is closer to the rainy season.

The extent and variation in losses are of national importance and relevant to development planning. National experts have an opportunity to put these losses into their national context in 'Country Narratives' that are described in the next chapter.

6. APHLIS Country Narratives

Some APHLIS Network members have created narratives to explain the loss figures for their countries in the context of the local postharvest situations. Country Narratives are accessed via the APHLIS menu and are prepared in a standard template so they each follow the same pattern.


Home
Losses tables
Interactive losses maps
Larger grain borer
Downloadable calculator
Postharvest reviews
Understanding APHLIS
Collecting new data
Country narratives
Literature

Country Narratives

Some APHLIS network members have made information available on the cereal postharvest situation in their country and where possible have sought to explain the loss figures that appear in APHLIS and compare them with recent loss assessment exercises. They also offer some information on postharvest project that are either current or in the recent past.

Malawi

Rwanda

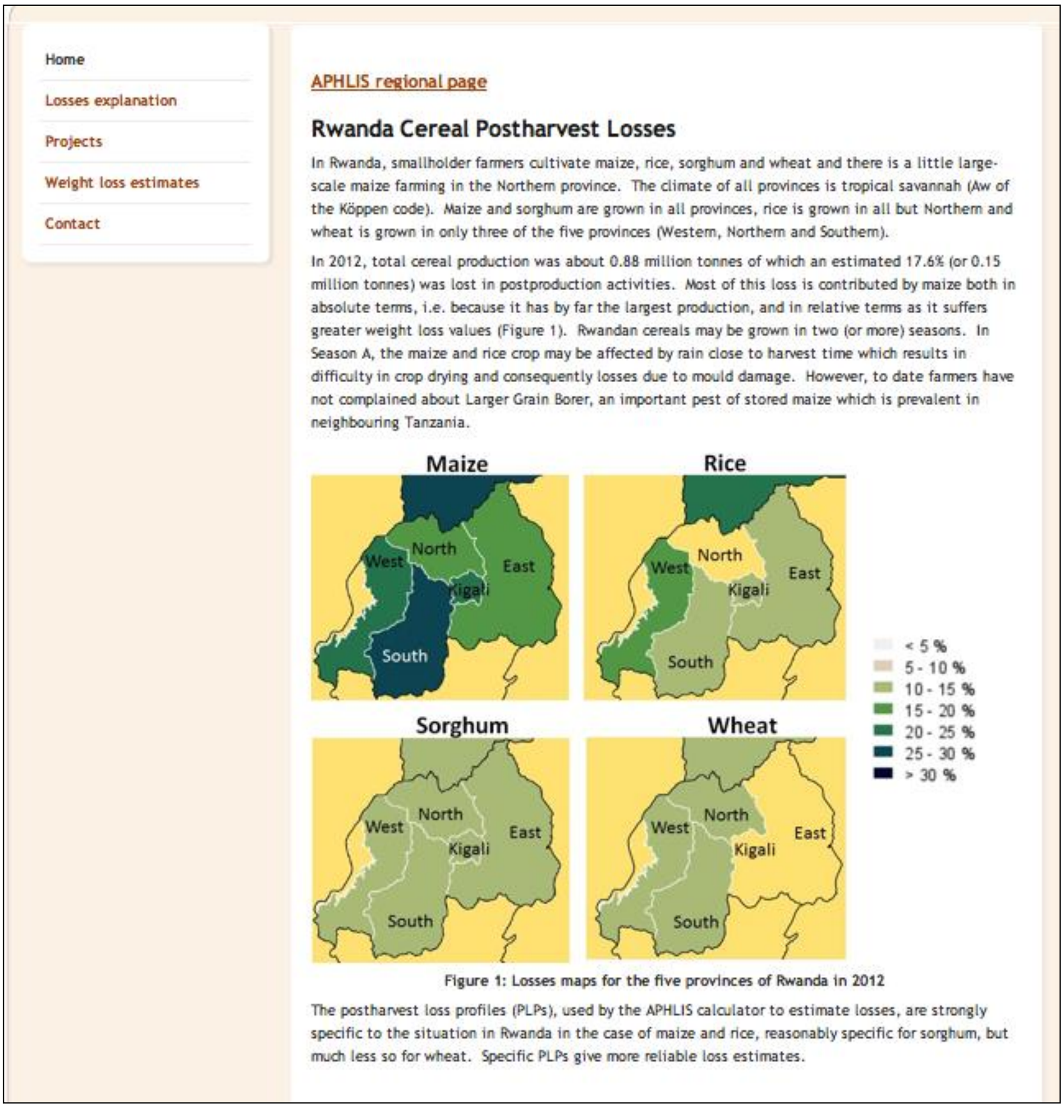
Senegal

Uganda

Click on one of the country links to reveal a 'Home page' that gives a country summary of cereal postharvest losses and a further menu that offers : 'Losses explanation' - a detailed account of the postharvest situation; 'Projects' - a description of recent and current project activity related to cereals postharvest; and, 'Weight loss estimates' - a link back to the losses tables on the APHLIS site. The screen shots below show a selection of the information posted on the Country Narratives of several countries.

6.1 The Home page

The Home page is for Rwanda and gives a summary of losses


Home
Losses explanation
Projects
Weight loss estimates
Contact

APHLIS regional page

Rwanda Cereal Postharvest Losses

In Rwanda, smallholder farmers cultivate maize, rice, sorghum and wheat and there is a little large-scale maize farming in the Northern province. The climate of all provinces is tropical savannah (Aw of the Köppen code). Maize and sorghum are grown in all provinces, rice is grown in all but Northern and wheat is grown in only three of the five provinces (Western, Northern and Southern).

In 2012, total cereal production was about 0.88 million tonnes of which an estimated 17.6% (or 0.15 million tonnes) was lost in postproduction activities. Most of this loss is contributed by maize both in absolute terms, i.e. because it has by far the largest production, and in relative terms as it suffers greater weight loss values (Figure 1). Rwandan cereals may be grown in two (or more) seasons. In Season A, the maize and rice crop may be affected by rain close to harvest time which results in difficulty in crop drying and consequently losses due to mould damage. However, to date farmers have not complained about Larger Grain Borer, an important pest of stored maize which is prevalent in neighbouring Tanzania.

Figure 1: Losses maps for the five provinces of Rwanda in 2012

The postharvest loss profiles (PLPs), used by the APHLIS calculator to estimate losses, are strongly specific to the situation in Rwanda in the case of maize and rice, reasonably specific for sorghum, but much less so for wheat. Specific PLPs give more reliable loss estimates.

6.2 Losses explanation

The 'Losses explanation' provides a commentary about the losses under five heading.

1. Agricultural background to cereals

This gives a summary of cropping details important for loss estimation in Zimbabwe.

1. Agricultural background to cereals

All provinces in Zimbabwe produce maize, sorghum and millet. These three cereal crops are grown by smallholders in a single season with a harvest in June (Table 1). Wheat and barley are also grow but as a winter crop using irrigation and harvested in November but recent yields have been much reduced and data are not available to allow loss calculations.

Table 1: Cereal cultivation in Zimbabwe according to harvesting season and scale of farming

Cereal	Seasons	Harvest months across provinces	Scale of farming
Maize	1	June	Smallholder
Millet	1	June	Smallholder
Sorghum	1	June	Smallholder

2. Seasonal factors that affect loss estimates

This section provides a summary of the seasonal factors that are included in loss estimation. The example below is for the three provinces of Malawi.

2. Seasonal factors that affect loss estimates

The seasonal factors shown in Table 2 are used to modify the postharvest weight loss estimations of the APHLIS calculator and so affect the magnitude of losses. In 2012, data on seasonal factors was collected by interviews with agricultural extension staff (Central – 3, North – 2, South- 3) through phone calls and where possible face to face interview, using the APHLIS seasonal data interview form (see Annex 2 of the 'Loss Assessment Manual' downloadable from the APHLIS web site). There was considerable variation in both the amount of grain marketed during the first three months after harvest (2-100%) and the length of the farm storage (2-9 months). Nowhere in Malawi was there any evidence of damp weather at time of harvest (Table 2) so it can be concluded that crop drying is not a problem (that is considered a problem when more than 50% of farmers are affected). In the case of maize, larger grain borer (LGB – *Prostephanus truncatus*) infestation was reported as a problem in all three provinces. The pest is well known by farmers and a significant cause of loss. If the losses were calculated without taking LGB into account then 46,730 tonnes are not lost giving a cumulative loss from production of 16.4% instead of 17.6%.

Table 2: The seasonal data by crop and by province that have been used to adjust the loss estimations for 2012 (C= Central, N = North, S = South)

Cereal	Season	Scale of farming	Seasonal factors											
			Rain at harvest			% grain marketed at harvest			Duration of farm storage (months)			Larger Grain Borer a problem		
			C	N	S	C	N	S	C	N	S	C	N	S
Maize	Season 1	Small	No	No	No	39	67	45	6	7	6	Yes	Yes	Yes
		Large	No	No	No	10	91	0	-	7	9	Yes	Yes	Yes
	Season 2	Small	No	No	No	36	65	17	4	4	4	Yes	Yes	Yes
Millet	Season 1	Small	No	No	No	25	100	4	7	3	7	No	No	No
Rice	Season 1	Small	No	No	No	75	59	32	4	7	5	No	No	No
	Season 2	Small	No	No	No	45	100	42	2	4	5	No	No	No
Sorghum	Season 1	Small	No	No	No	48	100	2	6	5	4	No	No	No
Wheat	Season 1	Small	No	No	No	38	-	-	4	2	3	No	No	No

3. ***The scale of losses***

A commentary is provided on the scale of loss by crop and by year, the example below is from Rwanda.

3. The scale of losses

Over the period 2008-2012, the estimated weight losses of maize were in the range of 16-25% while for other cereals 11-17% (Fig. 1 and Table 3). In 2012, on a total cereal production of about 0.88 million tonne, these losses amount to nearly 0.15 million tonnes (Table 4) or about 17.6% of production, most of which is attributable to maize.

In the case of sorghum and wheat the degree of loss has been stable over the last five years. This is due to the fact that there has been no data available on the season factors that affect losses (Table 2). In the case of maize and rice the situation is different since from 2011 some seasonal data have been supplied. Consequently, maize losses estimates have risen from about 17% to around 25% and rice losses 11.6% to as high as 17% (Table 3). The main factor responsible has been rain at harvest in Season A, so for example in the case of rice in Western province the annual loss in 2012 is estimated to be 17% but if the calculator is set with no rain at harvest then the estimate falls to 12%. This suggests that loss data prior to 2011 are likely to be underestimates.

Table 3: Annual % postharvest weight losses by province and by cereal crop in Rwanda for the last five years

Provinces	Cereal	2008	2009	2010	2011	2012
East	Maize	16.4	16.5	16.6	25.3	16.7
Kigali		17.3	17.3	17.2	16.2	25.0
North		16.1	16.2	16.7	27.5	16.6
South		16.9	16.4	17.0	17.0	25.1
West		16.9	17.0	16.8	25.0	24.5
East	Rice	11.6	11.6	11.6	15.0	11.8
Kigali		11.6	11.7	11.8	11.7	11.9
North		-	-	11.9	11.9	-
South		11.6	11.6	11.6	11.7	13.7
West		11.6	11.6	11.8	15	17
East	Sorghum	12.4	12.4	12.4	12.4	12.4
Kigali		12.4	12.4	12.4	12.4	12.4
North		12.4	12.4	12.4	12.4	12.4
South		12.4	12.4	12.4	12.4	12.4
West		12.4	12.4	12.4	12.4	12.4
East	Wheat	-	-	-	-	-
Kigali		-	-	-	-	-
North		13.7	13.7	13.9	14.1	14.3
South		14.1	13.8	14.1	14.5	14.5
West		14.2	14.1	14.0	14.0	14.3

This is followed by graphs showing the contributions of each link in the postharvest chain to these losses.

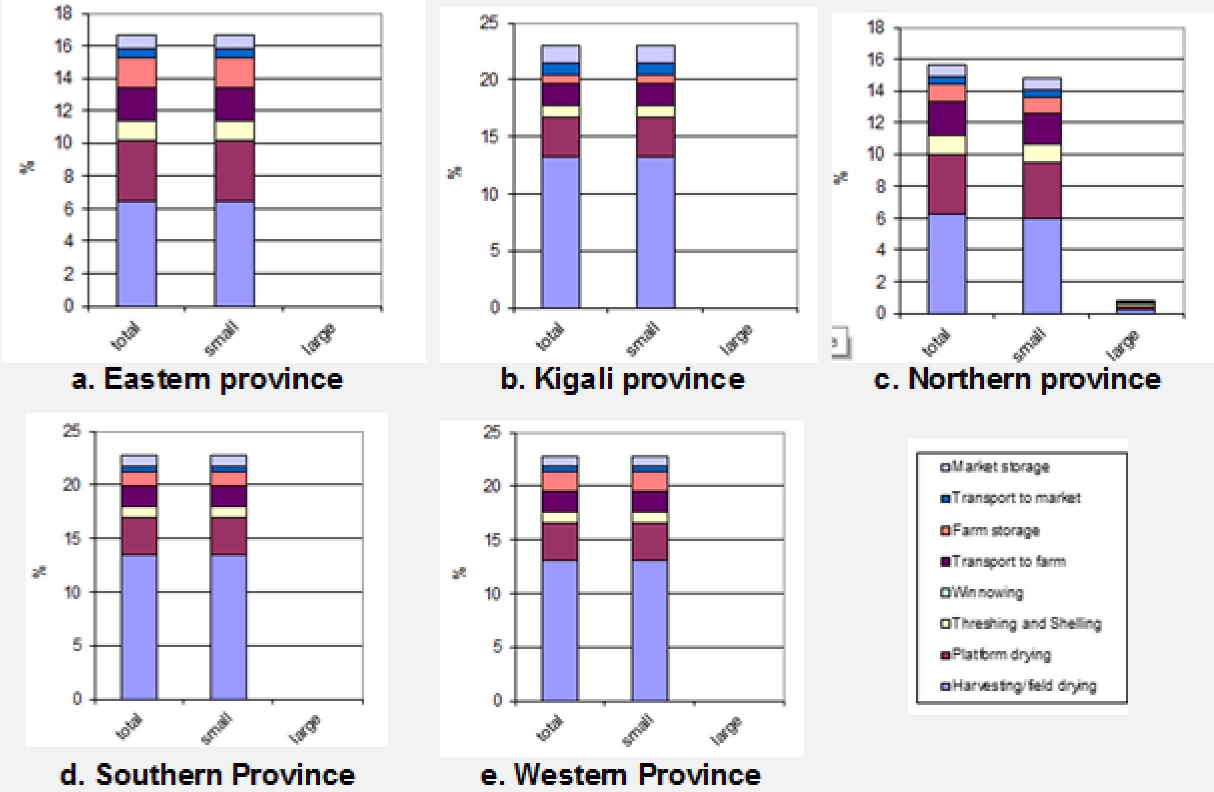


Figure 2: % contribution of each link to the overall cumulative postharvest loss for maize in each province of Rwanda for 2012 (small = smallholders, large = large-scale farming)

4. The Postharvest Situation

Details are presented of the postharvest situation. These vary considerably according to the amount of information available to the authors and their own knowledge of the subject. The example below is from Malawi and is just a small portion of a long account.

1. The postharvest situation

Harvesting– smallholders harvest by hand. Typically the plants are cut and then stooked in the field to allow further drying until the seed heads (cobs, panicles, etc.) are plucked. Others pluck the cobs or panicles direct from the stalks.

Drying– undehusked maize cobs may be placed in open topped cylindrical baskets (Fig. 3) for up to two months, until there is an opportunity for shelling, this allows further drying. Additionally, it allows smallholders to engage in other important farming activities and return to the business of shelling at a less busy time. Some farmers place dehusked maize cobs in drying cribs for just a month before shelling (Fig. 4). In the case of millet and sorghum, the panicles are placed on mats, on the roofs of grass thatched houses or on platforms for further drying before threshing. In contrast, rice is threshed immediately after harvesting and is then dried further on mats or tarpaulins.

Figure 3: Open topped maize cob basket with undehusked maize cobs

Figure 4: Drying crib holding dehusked maize cobs

Figure 5: Mudded granary for the storage of shelled/threshed grain

Figure 6: Some of the storage insecticides used by smallholders in Malawi

5. Relevance of PHL Profiles

A description is given of the extent to which the APHLIS PHL profiles are specific to each cereal crop. The example below is for millet and sorghum in Senegal.

5. Degree of relevance of Postharvest Loss Profiles for main cereal crops

The APHLIS calculator generates a cumulative loss estimate from production for a particular cereal grain using a set of postharvest loss figures; one figure for each link in the postharvest chain (Table 5). This set of figures is called a Postharvest Loss Profile (PLP). The figure for each link in the chain is the average of all the data available in the scientific literature for that crop, in that climate and at that scale of farming. Data from unpublished reports may also be included where these are judged to be of sufficient accuracy. Ideally, the data from which each PLP figure is derived is restricted to the specific crop, climate and scale of farming in question. However, due to scarcity of data this is not always the case and some sharing of data has been necessary. In addition, it is preferable that the data used in the PLP are measured rather than being derived from questionnaire surveys, which are generally considered less accurate, but due to the scarcity of data those from questionnaire surveys are often included.

Below we consider the PLP figures for each of the cereal crops of Senegal, the number of values used to derive each PLP figure and the extent to which the figures are derived from values that are specific and measured, rather than non-specific and derived from questionnaire surveys. If the reader needs more details or wishes to know the references to the literature from which the values were obtained then these can be seen in APHLIS as part of the breakdown of provincial loss estimates (accessed through 'Losses tables' when clicking on provincial estimates for particular crops).

Millet and sorghum

The PLPs for millet and sorghum (Table 5) cultivated by smallholders are less specific/measured than those for maize, reflecting the fact that there have been fewer studies on these two cereals after harvest. Some of the PLP figures e.g. for transport, are overall neither specific nor measured. In the case of millet there are no PLP differences between the climate types while fro sorghum the PLPs differ in the value of storage loss.

Table 5: Millet and sorghum – Postharvest Loss Profiles for smallholders showing the PLP figures for each link of the chain in a tropical savannah (Aw) and hot arid/desert (Bsh/Bwh) climate, the number of estimates from which each figure is derived and an overall rating of each figure

Stages	Climate	Loss figure	No. of estimates	Cereal	Climate	Farm type	Method
Harvesting/field drying	Aw	3.5	2	0	1	1	0
	Bsh/Bwh	3.5	2	0	0	1	0
Platform drying	Aw	-	-	-	-	-	-
	Bsh/Bwh	-	-	-	-	-	-
Threshing/shelling	Aw	2.0	2	1	0	1	0
	Bsh/Bwh	2.0	2	1	0	1	0
Winnowing	Aw	2.5	2	0	1	1	0
	Bsh/Bwh	0	1	0	0	1	0
Transport to farm	Aw	2.5	2	0	1	1	0
	Bsh/Bwh	2.5	2	0	1	1	0
Farm storage	Aw	1.2	4	1	1	1	1
	Bsh/Bwh	0.5	2	1	1	1	0
Transport to market	Aw	1.0	1	0	0	1	0
	Bsh/Bwh	1.0	1	0	1	1	0
Market storage	Aw	2.7	2	0	1	1	0
	Bsh/Bwh	2.7	2	0	0	1	0

6.3 Projects

The projects page provides a description of current and recent postharvest 'Projects'. The page below is taken from the Malawi narrative.

6. Current and planned loss assessment activities/loss reduction projects

There are several projects, mainly on maize and rice, concerned with the development of small metal silos and grain bags. Additionally, there is some research work on evaluation of maize lines for their susceptibility to LGB. The following are the details of the projects being implemented:

1. Small metal silos and Super Grain bags (Fig. 7) are being evaluated for their effectiveness in controlling storage insect pests (LGB and maize weevil). The research in Malawi is managed by Mr Charles Singano of the Crop Storage Section of the Chitedze Agricultural Research Station (Dept. of Agricultural Research Services). The study is part of a sub-regional project implemented by CIMMYT and coordinated by Dr Tadele Tefera based in Kenya. It is anticipated that these storage methods will offer Malawi a means of protecting maize stocks that will minimise the use of insecticides, so cutting costs and improving the safety of grain products. Additionally, there is an activity on storage of seed rice in metal silos and Super Grain bags which started in February this year in order to check the viability of the seed after storage.

Figure 7: Small metal silos (left) and Super Grain bags (right) being sampled as part of an trial testing efficacy against larger grain borer (*Prostephanus truncatus*) and maize weevil (*Sitophilus zeamais*)

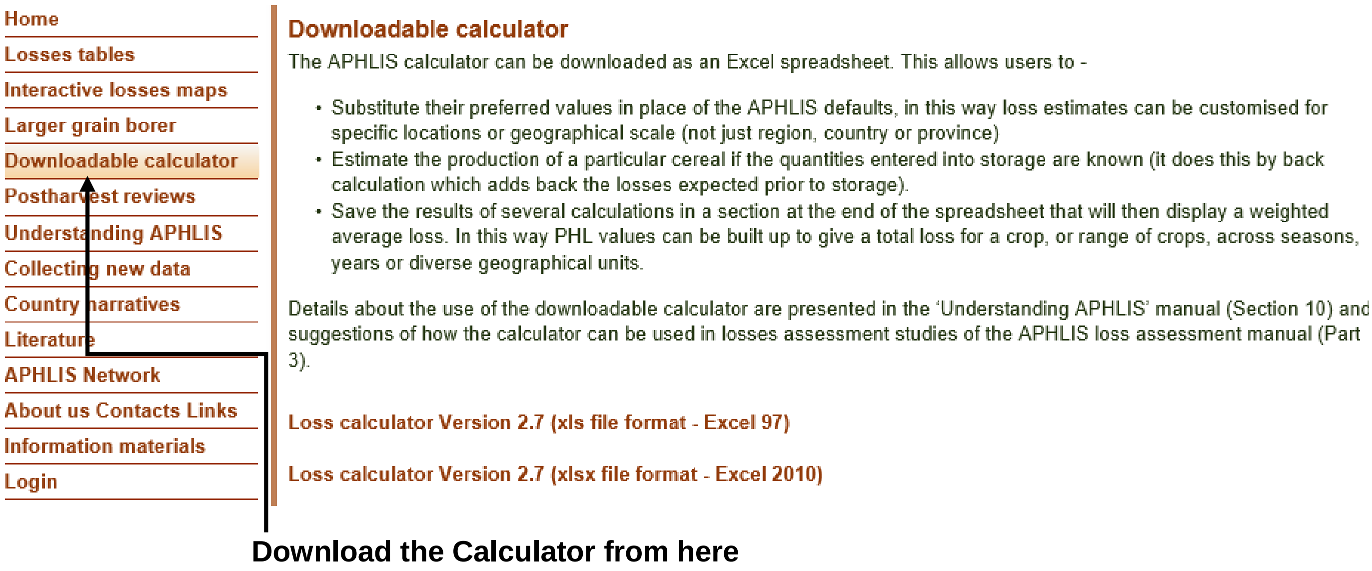
The Country Narratives assemble what is known about losses for individual countries and places that knowledge in the context of the prevailing conditions, both to explain the losses and identify opportunities. To take these opportunities further it will often be necessary refine the loss estimations so that they are specific to particular situations, rather than just rely on very generalised provincial estimates displayed in the APHLIS website. APHLIS facilitates loss estimate at a finer geographical scale by offering a downloadable Calculator that will accept user define loss values in place of the APHLIS defaults. This Calculator is the subject of the next chapter.

7. How to estimate losses using the downloadable PHL Calculator

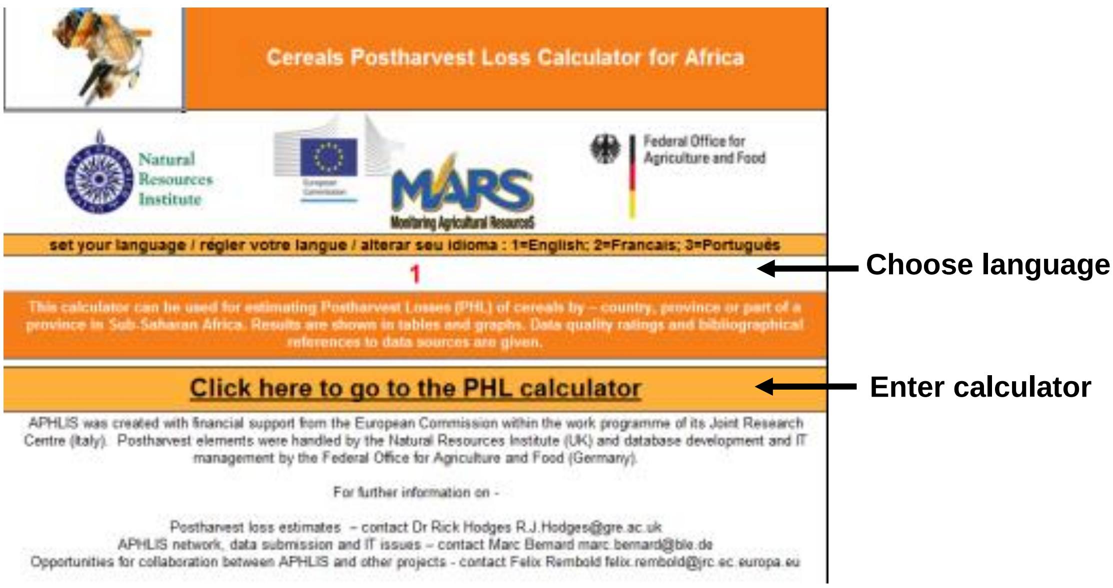
The downloadable PHL Calculator is a spreadsheet that allows users to substitute their own preferred values for APHLIS defaults and to make estimates at whatever geographical scale is appropriate (not just region, country or province). If production data for cereals are not available then it has a 'Production Calculator that can be used to estimate of the production if the weight of grain placed in storage is known. Finally, the PHL estimates can be saved in a section at the end of the spreadsheet so that a series of PHL values can be built up to give a total loss for a crop, or range of crops, across seasons, years or diverse geographical units. The downloadable PHL Calculator can be used for loss estimation in real situations or can be used with hypothetical data in order to model 'what if' scenarios.

7.1 Home page of spreadsheet

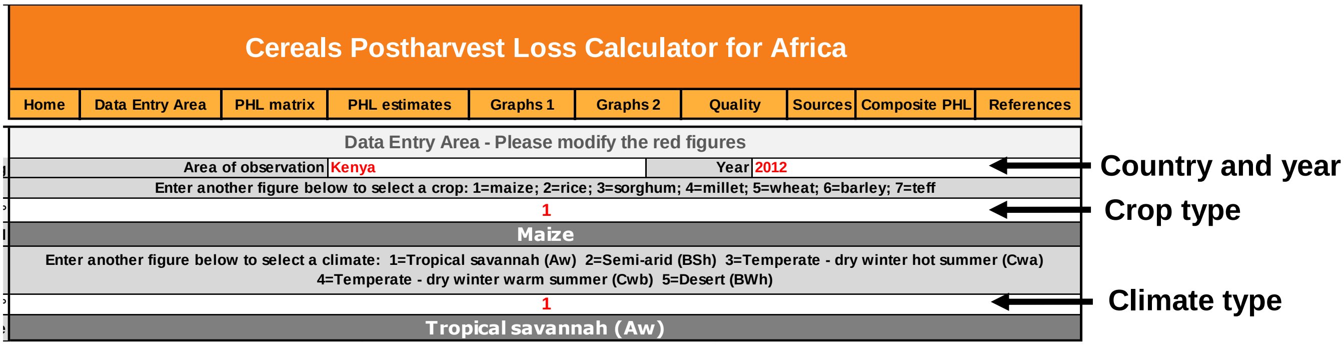
A copy of the Calculator can be downloaded from the website (http://www.aphlis.net), click on the 'Download calculator' button.



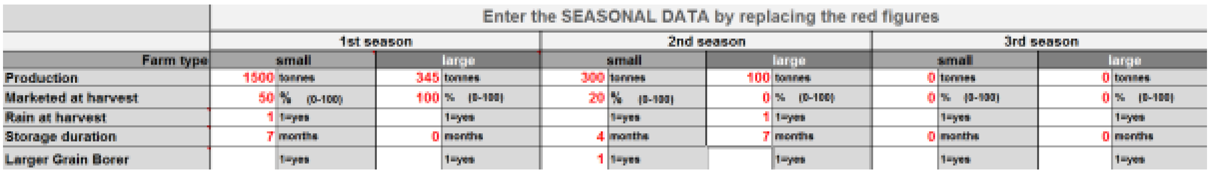
Open the file and front page (below) will appear. Choose your language (English, French or Portuguese) by entering the appropriate number in the first box, then 'click' to enter the Calculator.



Once you have entered the Calculator you will be presented with a series of boxes, where the red figures can be altered by the user (all other elements of the calculation are automatic). The first box allows the user to set geographical data, crop type and climate type relevant to the study. If you are unsure about the climate type, consult the Köppen map on the APHLIS website (from the menu - Losses maps, General, Köppen).



In the next box you should enter the seasonally relevant data for the situation for which you are making the loss estimate. There is an option to enter data for one, two or three seasons. Note that in the case of cereal production data, if there is no data for a particular season then you should enter a zero '0'. You should <u>not</u> leave the cell blank, if you do then a warning message will be displayed.



	Enter the SEASONAL DATA by replacing the red figures											
	1st season				2nd season				3rd season			
Farm type	small		large		small		large		small		large	
Production	1500	tonnes	345	tonnes	300	tonnes	100	tonnes	0	tonnes	0	tonnes
Marketed at harvest	50	% (0-100)	100	% (0-100)	20	% (0-100)	0	% (0-100)	0	% (0-100)	0	% (0-100)
Rain at harvest	1	1=yes		1=yes		1=yes	1	1=yes		1=yes		1=yes
Storage duration	7	months	0	months	4	months	7	months	0	months	0	months
Larger Grain Borer		1=yes		1=yes	1	1=yes		1=yes		1=yes		1=yes

You must enter data on

- Crop production – an estimate of the tonnage of grain produced in the season(s) with which you are concerned (if you have no production estimate then it may be possible to create one, see <u>**Section 7.5**</u>),

The following data are not essential but if added will improve the loss estimate -

- Marketed at harvest – this is the % of grain marketed in the 1st three months after harvest,
- Rain at harvest - if there has been wet/damp cloudy weather at harvest time that makes it difficult to dry the grain then enter '1' into the 'rain at harvest' box.
- Storage duration - the number of months grain will be held in farm storage (**BUT** if you are going to change the default storage loss in the PHL profile to a specific figure that you have measured (see <u>**Section 7.2**</u>), then you <u>**should always**</u> enter here a period of 9 months storage, even if it wasn't, this ensures that APHLIS will not make further adjustments to your storage loss figure)
- Larger Grain Borer – if LGB is a problem during storage of maize then enter '1' into the 'Larger Grain Borer' box (**BUT** if you are going to change the default storage loss in the PHL profile to a specific figure that you have measured then leave this unchecked as any losses due to Larger Grain Borer would already have been included in your own storage loss measurement).

Once you have entered this data then PHL profiles are offered for smallholder and/or larger-scale commercial farming. These profiles include a % weight loss figure for each link in the postharvest chain (except winnowing as this is not relevant to maize).

PHL (%) Calculation: Maize - Kenya - 2012

1st season – Farm type	small: adjusted PHL profile	small: store – remaining grain	small: store – loss increment	small: market – remaining grain	small: market – loss increment	large: adjusted PHL profile	large: store – remaining grain	large: store – loss increment	large: market – remaining grain	large: market – loss increment
Share of production	9					91				
Share		5		4.5					90.9	
Harvesting/field drying	16.3	4	0.7	4	0.7	3.8			87	3.4
Platform drying	4.0	4	0.2	4	0.2	3.5			84	3.1
Threshing and Shelling	1.3	4	0.0	4	0.0	2.3			83	1.9
Winnowing	-									
Transport to farm	2.4	4	0.1	4	0.1	1.9			81	1.6
Farm storage	5.3	3	0.2							
Transport to market	1.7			3	0.1	1.0			80	0.8
Market storage	2.7			3	0.1	2.7			78	2.1
Total		3	[illegible]	3	1.2				78	12.9

2nd season – Farm type	small: adjusted PHL profile	small: store – remaining grain	small: store – loss increment	small: market – remaining grain	small: market – loss increment	large: adjusted PHL profile	large: store – remaining grain	large: store – loss increment	large: market – remaining grain	large: market – loss increment
Share of production	75					25				
Share		60		15.0			25			
Harvesting/field drying	6.4	56	3.9	14	1.0	16.3	21	4.1		
Platform drying	4.0	54	2.2	13	0.6	3.5	20	0.7		
Threshing and Shelling	1.3	53	0.7	13	0.2	2.3	20	0.5		
Winnowing	-									
Transport to farm	2.4	52	1.3	13	0.3	1.9	19	0.4		
Farm storage	5.3	49	2.7			2.3	19	0.4		
Transport to market	1.7			13	0.2	1.0				
Market storage	2.7			12	0.3	2.7				
Total		49	10.8	12	2.6		19	6.1		

3rd season – Farm type	small: adjusted PHL profile	small: store – remaining grain	small: store – loss increment	small: market – remaining grain	small: market – loss increment	large: adjusted PHL profile	large: store – remaining grain	large: store – loss increment	large: market – remaining grain	large: market – loss increment
Harvesting/field drying	6.4					3.8				
Platform drying	4.0					3.5				
Threshing and Shelling	1.3					2.3				
Winnowing	-									
Transport to farm	2.4					1.9				
Farm storage										
Transport to market	1.7					1.0				
Market storage	2.7					2.7				
Total										

Smallholder farmer PHL profile for the Season 1 harvest. Note farm storage loss is 5.3%.

7.2 Changing the default values of the PHL profile

An important feature of the downloadable Calculator is that it is possible to change the default values[4]. At the far right of the spreadsheet there are boxes where your new values can be entered to replace the defaults according to season and by scale of farming (small/large). Enter the postharvest loss values that are relevant to your study or loss figures that you wish to use to generate a 'what if' scenario. In the example below, a 10% loss figure was determine by a project and so this figure has been entered to replace the default value of 5.3% (which you saw in the previous figure).

1st season – Farm type	small: adjusted PHL profile	small: store – remaining grain	small: store – loss increment	small: market – remaining grain	small: market – loss increment	large: adjusted PHL profile	large: store – remaining grain	large: store – loss increment	large: market – remaining grain	large: market – loss increment
Share of production	9					91				
Share		5		4.5					90.9	
Harvesting/field drying	16.3	4	0.7	4	0.7	3.8			87	3.4
Platform drying	4.0	4	0.2	4	0.2	3.5			84	3.1
Threshing and Shelling	1.3	4	0.0	4	0.0	2.3			83	1.9
Winnowing	-									
Transport to farm	2.4	4	0.1	4	0.1	1.9			81	1.6
Farm storage	10.0	3	0.4							
Transport to market	1.7			3	0.1	1.0			80	0.8
Market storage	2.7			3	0.1	2.7			78	2.1
Total		3	[illegible]	3	1.2				78	12.9

Notice that the storage loss of 5.3% has now changed to 10%

This box is at far right of spreadsheet

Personalised profiles – Replace default values	1st season: small	1st season: large	2nd season: small	2nd season: large	3rd season: small	3rd season: large
Harvesting/field drying						
Platform drying						
Threshing and Shelling						
Winnowing						
Transport to farm						
Farm storage	10.0					
Transport to market						
Market storage						

Enter new values in the yellow boxes to customise the PHL profile

Below you will be able to see an estimate of loss for each of the two seasons, these are expressed as % weight loss (relative loss) and the MT lost (absolute loss). This includes transport to market and market storage for the marketed portion of the crop. In the case where you have entered your own storage loss value into the storage loss profile then when making your report on the cumulative loss you should mention the length of the storage period since this will be specific to the storage loss value that you entered into the Calculator.

[4] Warning – when defaults are changed the spreadsheet will take some seconds to recalculate. You must give it time to make the changes, the 'Calculating Cells' display in the bottom left hand corner monitors progress.

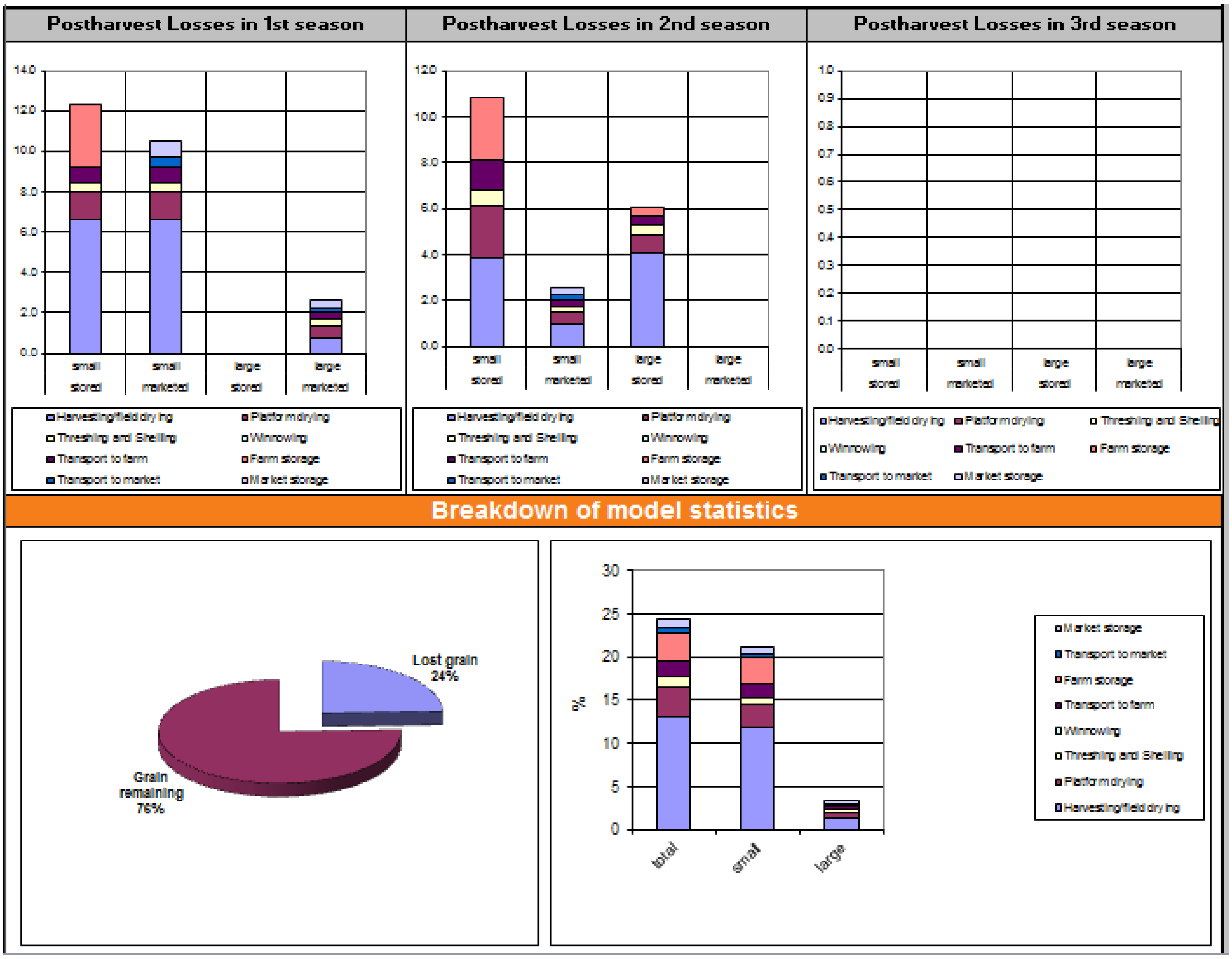
Farm type	small	large	small	large	small	large
Grain remaining	58.5	16.0	61.6	18.9		
Lost grain	22.8	2.7	13.4	6.1		
	1st season		2nd season		3rd season	
Grain remaining	74.5		80.5			
Lost grain	25.5		19.5			
Total remaining	76 %					
Annual loss	**24 %**					

PHL (tonnes) Calculation: Maize - Kenya - 2012						
	1st season		2nd season		3rd season	
Farm type	small	large	small	large	small	large
Production	1,500	345	300	100		
Grain remaining	1,079	296	247	76		
Lost grain	421	49	53	24		
Production	1,845		400			
Grain remaining	1,375		322			
Lost grain	470		78			
Annual production	2,245 tonnes					
Total remaining	1,697 tonnes					
Annual loss	**548 tonnes**					

470 + 78 MT = 548 MT

A loss of 24% (this includes season 1 and season 2) which amounts to 548 MT

Further down in the spreadsheet you will be able to see a graphical representation of the proportion of loss attributable to each link of the postharvest chain.



7.3 Tracing loss values and their quality

The next section of the spreadsheet presents the quality (reliability) of the data sources used to generate each of the figures used in the PHL profile (see Section 3.4). It is from here that you can see whether the loss estimate used for each step in the PHL profile is specific to the crop, climate and scale of farming or is 'other' meaning that the closest applicable figures, but not specific ones, are being used. There is also a record of how the figures were derived under the 'Method' column. Figures are either 'measured' in which case objective techniques have been used to estimate a loss value or they are 'questionnaire/guesstimate' meaning that they are less objective (but not necessarily less accurate). It is anticipated that where specific and 'measured' figures are being used then the estimate is more reliable than when figures are from 'other' or 'questionnaire/guesstimate'. To make visualizing this rating system easy, specific and or measured estimates are marked in green and other or guesstimates are marked in red, see the table below.

Following the data quality record, there is a table presenting the loss profile figures used for smallholder or large-scale farmers against which there are numbers. The first figure (highlighted) has no reference number against it, this is the PHL profile figure derived from the other estimates in the same row. These other estimates are those taken from the literature or submitted to the PHL database, each has a reference number above it that refers to a listing of bibliographical source found at 'References' tab in the top left hand corner of the spreadsheet.

Tracing Loss Values Area

Default PHL profile as defined by this crop and climate

Farm type	Small farms					Large farms				
	%	Origin of figure				%	Origin of figure			
Steps		Cereal	Climate	Farm type	Method		Cereal	Climate	Farm type	Method
Harvesting/field drying	6.4	other	other	small	questionnaire/guesstimate	3.8	other	other	large	questionnaire/guesstimate
Platform drying	4.0	other	other	small	questionnaire/guesstimate	3.5	other	other	large	questionnaire/guesstimate
Threshing and Shelling	1.3	other	other	small	questionnaire/guesstimate	2.3	other	other	large	questionnaire/guesstimate
Winnowing	-	-	-	-	-		-	-	-	-
Transport to farm	2.4	other	other	small	questionnaire/guesstimate	1.9	other	other	large	questionnaire/guesstimate
Farm storage	5.3	Maize	Aw	small	measured estimate	2.3	other	other	large	questionnaire/guesstimate
Transport to market	1.7	Maize	Aw	small	questionnaire/guesstimate	1.0	other	other	other	questionnaire/guesstimate
Market storage	2.7	Maize	Aw	small	questionnaire/guesstimate	2.7	Maize	Aw	large	questionnaire/guesstimate

References and individual loss figures %

Data and references for the PHL profile of small farms

Steps	Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Harvesting/field drying	reference n°		13	33	51	53	71	73	73	73	73	75	-	-	-	-	-	-	-	-	-	-	-
	figure	6.4	2	9.9	5.8	9.5	5	3.2	6.5	6.9	9.9	5.5	-	-	-	-	-	-	-	-	-	-	-
Platform drying	reference n°		45	53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	4.0	3.5	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Threshing and Shelling	reference n°		13	33	51	53	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	1.3	1	0.3	2.5	1	1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winnowing	reference n°		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transport to farm	reference n°		13	53	71	73	73	73	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	2.4	2	1	3	2	2.3	4	2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Farm storage	reference n°		18	18	18	18	26	27	52	67	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	5.3	4.6	5.2	6.2	7.3	3.1	6.1	4.6	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Transport to market	reference n°		53	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	1.7	1	2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Market storage	reference n°		13	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	2.7	4	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Please note that the loss figures of this general profile are adjusted in the loss calculation matrix above (adjusted profile) for 'rain at harvest', 'storage duration' and problems with the 'larger grain borer' according to the data you enter.

Data and references for the PHL profile of large farms

Steps	Number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Harvesting/field drying	reference n°		13	73	73	73	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	3.8	2	2.1	4.1	4.8	5.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platform drying	reference n°		45	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	3.5	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Threshing and Shelling	reference n°		13	53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	2.3	1	3.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Winnowing	reference n°		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transport to farm	reference n°		13	73	73	73	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	1.9	2	0.5	2	2.1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Farm storage	reference n°		73	73	73	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	2.3	1.7	2.5	2.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transport to market	reference n°		53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Market storage	reference n°		13	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	figure	2.7	4	1.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Please note that the loss figures of this general profile are adjusted in the loss calculation matrix above (adjusted profile) for 'rain at harvest', 'storage duration' and problems with the 'larger grain borer' according to the data you enter.

7.4 Calculation of postharvest losses for a country

The spreadsheet has a table where users can record the PHL estimates made for one or more crops in any particular area (region, sub-region, country, province, sub-province etc.). The values entered can be saved each time the Calculator is used and so eventually the table will display the final total loss estimate for the crop (s) and geographical area.

Area of observation	Tanzania		Year	2007	
Cereal	Annual production	Annual loss	Total remaining	Share of total production	Share of total losses
	tonnes	tonnes	tonnes	%	%
Maize	125,378	26,233	99,145	84.2	88.4
Sorghum	23,456	3,456	20,000	15.8	11.6
Total	148,834	29,689	119,145	100	100
Total remaining %			80%		
Annual loss %			20%		

Write the PHL estimate for each cereal into this table. The table helps you to compute the combined PHL estimate for all cereals in the area of observation

7.5 Using the PHL Calculator to help make a production estimate

To calculate a cumulative postharvest loss, the PHL calculator uses an estimate of production as its starting point. If an estimate of production is not available then the Calculator has a facility that can to make one. This is called the 'Cereals Production Calculator' and it can be found on the far right hand side of the PHL Calculator spreadsheet. It is shown in the following illustration.

Cereals Production Calculator								
Farm type	small				large			
Weight of grain in store	200				3000			
Weight of grain marketed and consumed	150				4375			
Rain at harvest (1=yes)	1							
Steps	adjusted PHL profile	store	market	% of production	adjusted PHL profile	store	market	% of production
		Grain weight				Grain weight		
Transport to farm	2.4	205	154	82	1.9	3057	4458	1712
Winnowing	-	205	154	82	-	3057	4458	1712
Threshing and Shelling	1.3	208	156	83	2.3	3126	4558	1750
Platform drying	4.0	216	162	86	3.5	3235	4718	1812
Harvesting/field drying	16.3	251	188	100	3.8	3357	4896	100
Production	439				8253			
Marketed at harvest	43%				59%			
Stored at harvest	57%				41%			

Before you can use the Production Calculator you must have data on both the tonnage of grain being stored and tonnage that has already been removed (sold/consumed). These two figures together represent the total amount of threshed grain from a particular harvest. The weight of grain produced is then estimated by adding back all the expected weight losses that occur between storage and harvesting (i.e. the estimate is made by effectively running the PHL Calculator in reverse).

To use the Production Calculator-

1. Set the PHL Calculator to the correct crop type and climate type (see **Section 7.1**)
2. In the production box add in the weight (MT) of grain in store and the weight of grain already marketed and/or consumed. There are separate entries for either smallholder or larger commercial farmers.
3. The production in each farm type is displayed. Now that you have a production estimate, this can be entered into the PHL Calculator (under 'Seasonal' data) to help obtain a cumulative weight loss estimate.

7.6 Resetting the PHL Calculator to model losses

The Calculator can be used to model different scenarios by changing the default values of the PHL profile. How to change these defaults is explained in **Section 7.2**. The values for 'seasonal' data can also be changed and this is a convenient way of observing their effect on loss estimation. So for example, if it would be of interest to model loss without grain marketing by smallholders then the marketed crop can be removed from the calculation by setting 'Marketed at harvest' to zero, as show below.

Marketed at harvest set to zero

	1st season				2nd season				3rd season			
Farm type	small		large		small		large		small		large	
Production	34.5	tonnes	345	tonnes	300	tonnes	100	tonnes	0	tonnes	0	tonnes
Marketed at harvest	0	% (0-100)	0	% (0-100)	20	% (0-100)	0	% (0-100)	0	% (0-100)	0	% (0-100)
Rain at harvest	1	1=yes		1=yes		1=yes	1	1=yes		1=yes		1=yes
Storage duration	7	months	0	months	4	months	7	months	0	months	0	months
Larger Grain Borer		1=yes		1=yes	1	1=yes		1=yes		1=yes		1=yes

This results in no losses accruing due to transport to market or due to market storage.

Farm type	small					large				
Share of production	9					91				
Destination		store		market			store		market	
Share		9							90.9	
Steps	adjusted PHL profile	remaining grain	loss increment	remaining grain	loss increment	adjusted PHL profile	remaining grain	loss increment	remaining grain	loss increment
Harvesting/field drying	16.3	8	1.5			3.8			87	3.4
Platform drying	4.0	7	0.3			3.5			84	3.1
Threshing and Shelling	1.3	7	0.1			2.3			83	1.9
Winnowing	-									
Transport to farm	2.4	7	0.2			1.9			81	1.6
Farm storage	10.0	6	0.7							
Transport to market	1.7					1.0			80	0.8
Market storage	2.7					2.7			78	2.1
Total		6	2.8						78	12.9

No transport to market or market storage losses are registered

The loss estimate returned has now increased to 26% and 582 MT (see below), since farm storage with a 10% weight loss is much more severe than the losses due to transport and market storage that would have affected the 50% of grain sent to market.

Farm type	small	large	small	large	small	large
Grain remaining	56.7	16.0	61.6	18.9		
Lost grain	24.7	2.7	13.4	6.1		
	1st season		2nd season		3rd season	
Grain remaining	72.7		80.5			
Lost grain	27.3		19.5			
Total remaining	74 %					
Annual loss	26 %					

	PHL (tonnes) Calculation: Maize - Kenya - 2012					
	1st season		2nd season		3rd season	
Farm type	small	large	small	large	small	large
Production	1,500	345	300	100		
Grain remaining	1,045	296	247	76		
Lost grain	455	49	53	24		
Production	1,845		400			
Grain remaining	1,341		322			
Lost grain	504		78			
Annual production	2,245 tonnes					
Total remaining	1,663 tonnes					
Annual loss	582 tonnes					

In this case a higher loss is estimated if no grain is marketed

However, although the % loss is correct the tonnage includes grain that previously was marketed. This may be satisfactory for some purposes but if it should be excluded from the estimate then this can be done by reducing the maize production estimate by 50% (which is the amount of grain that was marketed).

7.7 Using the APHLIS as a component of loss assessment studies

Projects on loss assessment are designed to collect loss data in order to -

i) justify/plan the implementation of loss reduction measures, and/or
ii) to document the impact of loss reduction measures as a component of project monitoring and evaluation (M&E). Such projects typically deliver postharvest training, introduce new postharvest techniques (better stores, drying methods, mechanisation etc.), and/or connect farmers to more quality conscious markets.

In all cases APHLIS is an invaluable tool. General loss estimates for provinces can be obtained from the APHLIS website (they are either displayed or will require data input for them to be displayed). Such figures are a useful benchmark against which to compare the progress of projects that are working at a smaller geographical scale. Most postharvest practitioners work on projects that address losses at a relatively small geographical scale (i.e. not the whole country or a whole province) and generate loss data specifically for a situation at much smaller geographical scale. Such practitioners need to use the downloadable PHL Calculator to obtain a cumulative estimate of postharvest losses that shows the impact of loss reduction on grain availability. It is very unlikely that a project could collect loss data for all links in the postharvest chain but APHLIS can provide these while at the same time the practitioner can enter into the Calculator the figures relating to those links in the postharvest chain that are relevant to the project. The impact of the new data on the postharvest system as a whole can be seen when the Calculator returns an estimate of the cumulative loss of the whole chain. So for example, if losses during storage have been reduced from 10% to 1%, it will now be possible to see what effect this has on the cumulative losses (which would not be a 9% reduction). It will be possible to estimate how much more grain is available and, if farm gate prices are available, then to calculate how much better off farmers might be if they can sell this grain.

In cases where projects have investigated adopters and non-adopters of a technological improvement then for purposes of comparison the groups should be as similar as possible in all respects except for the adoption of the improvement. In the real world they may not be very similar because where an intervention is now well embedded it may have altered the behaviour of the adopters (e.g. they may market more or less grain, store grain for longer or shorter periods or apply or not apply insecticides). In this situation the Calculator maybe used to generate different scenarios, such as the losses of these two groups as actually observed, or their losses could be modelled by inserting the different weight loss values that result from adoption on non-adoption into each other's loss profiles (Table 7.1).

Table 7.1: The various estimates of cumulative loss that can be generated to compare the losses of adopters and non-adopters of a postharvest intervention

Cumulative loss of -	Loss estimated by -
Adopters (A_1)	Entering observed new values for 'seasonal' data and the PHL profile relevant to adoption
Non-Adopters (NA_1)	Entering observed values for 'seasonal' data and the PHL profile relevant to non-adoption
Adopters if they had not adopted (A_2)	Substituting into the 'seasonal' data and PHL profile those values relevant to non-adoption (from NA_1 - this models non-adoption in adopters)
Non-adopters if they had adopted (NA_2)	Substituting into the 'seasonal' data and PHL profile those values relevant to adoption (from A_1 - this models adoption by non-adopters)

The types of advantage of adoption can be expressed in the following ways:

Type 1 - The difference between adopters and non-adopters of the intervention = $NA_1 – A_1$

Type 2 – The advantage to adopters of the intervention (removing other factors that might affect the non-adopters) = $A_2 – A_1$

Type 3 - The potential advantage if non-adopters adopted the intervention = $NA_1 – NA_2$

If the circumstances of adopters and non-adopters are well documented then a narrative can be created to explain the types of advantages (disadvantage) that has been estimated.

An example of the way that the APHLIS downloadable PHL Calculator can be used to assess the potential advantages that accrue from a loss reduction project is presented in Box 7.1.

Box 7.1: Using the downloadable PHL calculator to support a loss reduction project

A grain storage project in Ghana introduced metal silos for smallholder farmers last year. The researchers now want to estimate how much more maize **grain is available** from those farmers who adopted metal silo storage compared with those who did not adopt the new method. To estimate the new grain availability requires a determination of a cumulative loss that takes into account all links in the postharvest chain; this is what the APHLIS Calculator does (not just the change in loss during storage). During 2011, researchers measured the weight losses of maize grain stored in the metal silos of 20 farmers (Group A) using a visual scale (see **Chapter 10**). They also assessed the losses of another (control) group of 20 farmers (Group B) who were still using the usual method of grain storage, which is to keep the maize in jute bags in the house without any insecticide treatment.

Groups A and B both live in the same agro-ecological zone (same climate type) and apart from the difference in storage method had exactly the same postharvest practice (but their behaviour was different with respect to % marketed at harvest and length of storage period). To estimate the actual losses from the two groups, the researchers used the downloadable PHL Calculator. The features of the two groups were as follows:

Group A - 20 maize farmers using metal silos to store their grain

Estimated maize production = 108 MT

Weight losses in storage = 1%

Proportion of grain marketed at harvest (i.e. was stored on farm <3 months) = 10%.

Storage period = 9 months (between harvests)

Group B - 20 maize farmers using jute bags to store their grain

Estimated maize production = 121 MT

Weight losses in storage = 10%

Proportion of grain marketed at harvest (i.e. was stored on farm <3 months) = 20%.

Storage period = 7 months (between harvests)

For the Group A (metal silos), APHLIS returned a loss of 14.6% or 16 MT (see table below) and for the Group B (jute bags) 21.1% or 26 MT (see table below). These are not just storage losses but the expected losses in the postharvest chain from harvesting to market storage. The advantage in terms of the grain availability was that farmers using metal silos storage were able to contribute 6.5% (21.1%-14.6%) more grain than those using jute bags. This difference amounts to 10 MT. The comparison however includes not only different grain stores but also the differences in the % marketed at harvest and the difference in storage period.

Cumulative weight loss or difference	Tonnage loss/difference

Estimate 1 - with marketed grain in the estimate		
Group A	14.6%	16
Group B	21.1%	26
Advantage B-A	6.5%	10
Estimate 2 - marketed grain now excluded from the estimate		
Group A	14.3%	14
Group B	22.1%	21
Advantage B-A	7.8%	7
Estimate 3 - Group B modelled with the storage losses of metal silos		
Group B (bags)	21.1%	26
Group B_1 (silos)	14.9%	18
Advantage B-B_1	6.2%	8

The storage loss can be brought into sharper focus by making the estimates with no marketing entered into APHLIS. To do this the production must be reduced by the amount that is marketed and 'Marketed at harvest' entered as zero. When this is done the % weight loss increased from 6.5% to 7.8% but this now represents a lower tonnage (7 MT – Advantage B-A in the table above)).

It could be argued that the storage period and marketing arrangements are an essential part of the comparison and grain storage cannot be considered in isolation when trying to assess benefits. It may therefore be of interest to estimate the grain losses if Group B adopted silo storage without changing their marketing arrangements and the length of farm storage, i.e. substitute the storage loss value of B with that of A (assuming that for 7 months storage it would still be 1%). The result is a 6.2% reduction in loss which is equivalent to 8 MT of grain (Advantage B-B1 in the table above). The difference is lower than for Group A as the higher proportion marketed at harvest is unaffected by the adoption of metal silos.

Other comparisons are possible and they should be explored depending on the situation and on what features researchers wish to emphasise.

The downloadable PHL Calculator enables practitioners to use postharvest loss estimates to understand the wider implications of loss reduction, in particular the changes in grain availability that result from loss reduction programmes. However, the quality of Calculator outputs depends on the quality of the loss data that are entered into the Calculator. It is essential that these loss data are reliable. Loss data are generated by loss assessment exercises. Part 3 of this manual suggests an approach to loss assessment using rapid methods.

Part 3 – Loss Assessment

8. Loss assessment – planning a losses survey

This is the first of four chapters (**Chapters 8 to 11**) that explain how to undertake loss assessment for cereal grains and submit new loss data to APHLIS. New loss data are essential for monitoring loss reduction activities and for the improvement in the accuracy APHLIS loss estimates. A separate manual dedicated to loss assessment (based on these four chapters) can be downloaded from the APHLIS website at the 'Collecting new data' tab from the main menu.

In this chapter we start by giving a summary of the steps involved in loss assessment and then consider how to plan a survey of losses that involves both a questionnaire survey and some measurement of losses. Chapter 9 deals with the implementation of questionnaire surveys used to collect essential data to explain losses. Chapter 10 describes a rapid approach to measuring losses called 'visual scales'; these are mostly relevant to the estimation of storage losses. Chapter 11 considers measuring losses at links in the postharvest chain other than storage and also presents an example of a loss estimation study complete with data collection sheets.

In the 1970s several techniques were developed for assessing postharvest grain losses which are detailed in Harris and Lindblad (1978) and reviewed in Boxall (1986). They mostly concern grain storage losses and the proposed techniques, although relatively accurate, are very time consuming. They involved taking samples, returning them to a laboratory and then analysing them. From the 1990s onwards researchers shifted from purely lab-based techniques to rapid methods (called visual scales, see **Sections 8.3 & 10.1**) that could be implemented on site and done with the participation of grain owners (Compton *et al*., 1995, 1999). Furthermore, any grain samples extracted remained with its owners. These rapid methods can be linked to questionnaire surveys and designed so that these two methods are complementary in providing the data required by APHLIS for loss estimation.

8.1 Planning loss assessment and the resources needed

The flow of activities required to undertake a loss assessment programme is summarised in Figure 8.1.

The best time to do a loss assessment

Agricultural activities are very seasonal, consequently assessing the loss associated with farmers' postharvest activities has to be implemented taking into account the seasons. The assessment usually has to start at the beginning of a season, i.e. at harvest time or at least close to harvest. Consequently, it is essential to select the sample sites well before harvest, select and train staff, develop and test questionnaires (formal or informal) and visual scales, and carefully plan data collection and sample analysis.

The assessment of losses elsewhere off farm, e.g. in transport to market, in storage at market or warehouse etc., is less constrained by season but also requires careful planning to ensure that the objective of the assessment can be achieved.

Sources of information in support of the assessment

Before starting any kind of loss assessment survey it is important to gather together all available information that can help plan and implement the study. It may be possible to find the information with government services, larger active NGOs or on the internet, which might include -

- Previous reports on loss assessment studies

- Meteorological data
- Production and marketing data
- Maps of the target areas
- Lists of villages with population statistics
- Farmers' calendars

Equipment

Equipment falls into two categories, that needed to actually make the assessment of loss and that needed to facilitate the survey. Equipment to assess losses includes the grain sampling equipment that is need to take samples in the field (**Section 8.4**) and the laboratory equipment needed in the construction of the visual scale (**Chapter 10**, **Box 10.3**). Equipment need to facilitate a survey includes -

- Clip boards, stationery, pens, sample bags, markers/labels, rubber bands etc.
- Folders to store completed data sheets
- Suitable vehicles
- GPS to record the precise location of sample points and enable these to be plotted on maps of the area (e.g. on Google Earth)
- Camera to record people, places and incidents
- Copies of questionnaires

Staffing needs

Staff for the survey are divided between those with experience of planning, implementing, analysing and reporting on field studies and those who will be used for field work to collect raw data.

When choosing staff to undertake studies of postharvest losses two disciplines are especially relevant, postharvest technology and agricultural economics. In addition, for the design of questionnaires the support of staff with skills in socio-economics and/or social anthropology can be very helpful and biometricians/statisticians are required for advice on the design and analysis of quantitative aspects. Surveys are best managed by teams with a range of skills and ideally any team should include at least a postharvest technologist and an economist, with access to advice from other specialists.

The staff involved in data collection (enumerators) need to have relevant skills and should have a sufficiently strong agricultural and educational background (at least secondary school) so that they fully understand how and why the survey is being implemented and can be trained for specific tasks. Those engaged in questioning farmers must have been trained in the use of questionnaires and must have had some supervised practice with the particular questionnaire that will be used. This will ensure that the questions are being asked, and answers recorded, in a standardised way. It is helpful to make local language translations of survey documents before field testing as this will help to reduced variance caused by differential translation of phrases and terms between enumerators. Likewise staff using a visual scale must be trained in its use and in recording the results.

Data management

Most projects involve the collection of substantial quantities of data. Much of the data will probably be collected by enumerators trained to do this job. To ensure quality control of the data and security for its long-term availability, a well-defined system of data management is required (University of Reading, 1998). The main elements of data management involve:

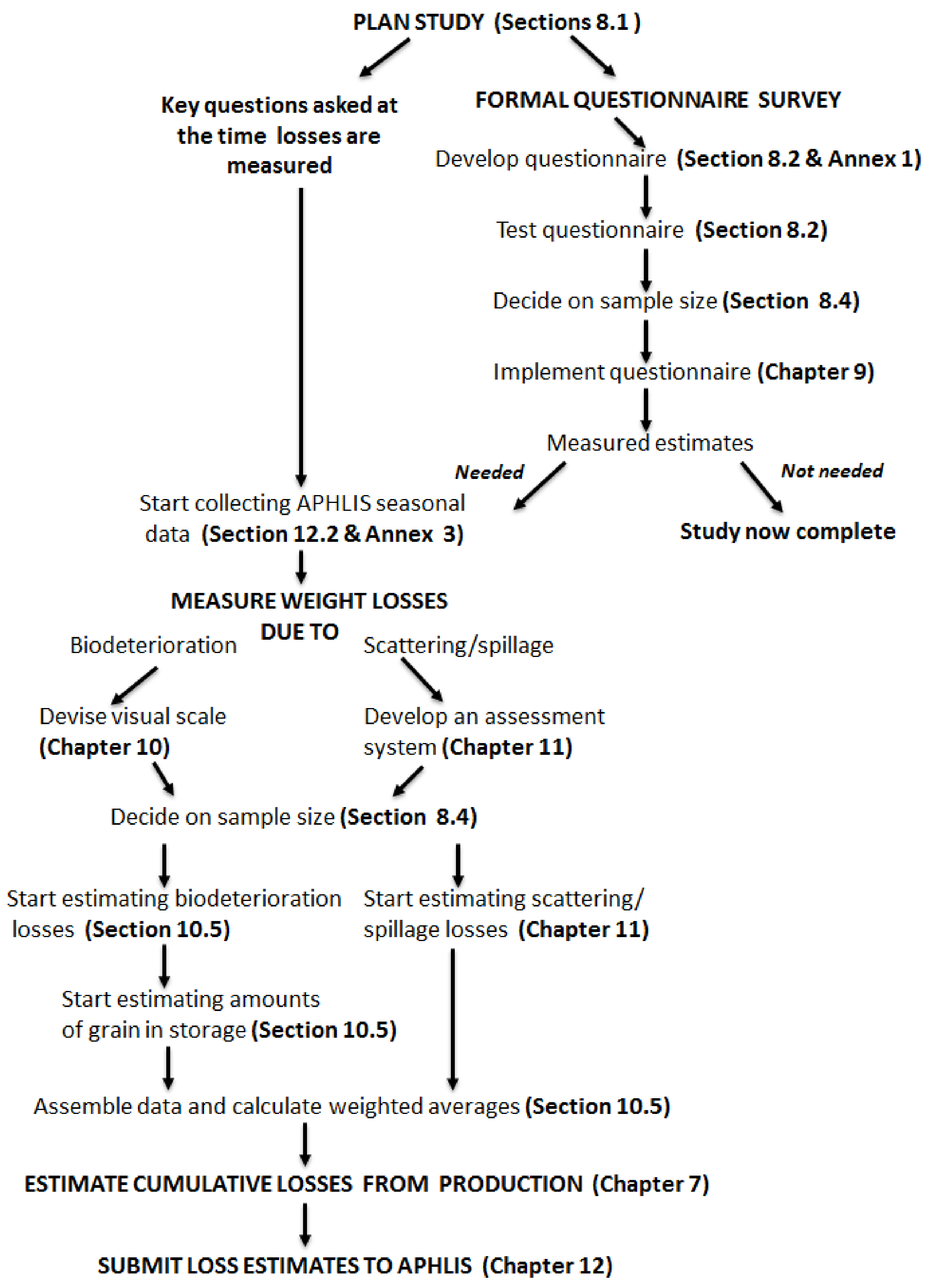


Figure 8.1: Work flow for a loss assessment study

1) Designing and creating a database or spreadsheet for the survey data. Many software packages allow the user to design data entry screens that allow someone to type in data easily and with a minimum of error.
2) During the survey, checking the data sheets to ensure that data are being collected in the required manner and are being properly and legibly recorded.
3) Entering the data into a computer using a database or spreadsheet and creating backup copies in case of loss or damage.
4) Checking that the data have been entered correctly.
5) Organising the data into various forms suitable for analysis.
6) Organising the data so that they remain available throughout the subsequent phases of the project and into the future.

On receiving data, the co-ordinator should check a sample of answers for correctness. If there are any queries the co-ordinator should try to resolve these with the appropriate person. Once the co-ordinator is satisfied then the data should be entered into a computer using suitable software.

Budgeting for an assessment – what to include

Loss assessment exercises require considerable preparation. Initial field visits are required to create the implementation plan, the questionnaire and a visual scale. To actually implement the plan may then require a return to the field several times, possibly as many as five or six times in a season involving transport and accommodation costs. The main budget items are as follows –

1. Searching for supporting information
2. Preparation of a loss assessment proposal
3. Initial field visit to plan implementation
4. Preparation of questionnaire
5. Construction of a visual scale
6. Training enumerators on objectives of the exercise, survey techniques, tools, ethics etc.
7. Testing visual scale in the field
8. Testing questionnaire in the field
9. Field implementation of questionnaire and visual scale over the period of an agricultural season (i.e. several visits)
10. Analysis and report writing

Summary of the main steps in a loss assessment survey

For any particular loss assessment project, the main steps in loss assessment are as follows:

Step to follow	Activities required	See Section
Planning	1) Identify the data that need to be collected to ensure an effective contribution to project objectives and to enable good loss estimation using the PHL Calculator which should include information on: • Grain production (MT) • % grain marketed up to 3 months after harvest • Climatic problems during and just after harvest time that affect grain drying • Period of grain storage on farm (months) • Infestation of maize by the Larger Grain Borer 2) Identify the potential geographical spread, target groups, and optimal sample size for the loss study.	**Chapter 8 and Section 4.8**

	3) Search all available sources for information materials relevant to the study. 4) Estimate requirements for equipment, staff and other resources. 5) Prepare a written proposal including a budget and timetable for the loss assessment. Ensure that the financial resources available match the proposed budget. 6) If necessary secure additional resources or scale the project to fit the available resources.	
Develop a questionnaire survey	Where loss assessment is focussed on farming households then a questionnaire of some form will be needed. 1) Decide on the questions required with reference to the survey objectives, any information your project has already collected, and the data needs for using APHLIS to estimate cumulative losses from production. 2) Draft the questionnaire and if necessary translate it into the local language. 3) Field test the questionnaire to ensure it is understandable and collects the required information. 4) Train field staff in the use of the questionnaire 5) Determine sample size to give a result that will be representative of the target population. 6) Undertake a field visit to determine the variation in household diversity, using well-being ranking. 7) Select households to include in this study based on a representative cross section of well-being ranks.	**Section 8.2** **Section8.4** **Chapter 9**
Develop a visual scale	Where grain biodeterioration is a key element of loss, such as in grain storage, a visual scale should be developed for loss estimation. 1) Collect grain samples that represent the range of grain qualities likely to be encountered. 2) Work with stakeholders to determine the end use of grain at these different qualities. 3) Construct a visual scale with grain in classes with specified degrees of damage, weight loss and contamination. 4) Field test the visual scale to determine whether it can be used reliably with stakeholders. 5) Determine sample size to give a result that will be representative of the target population. Where grain losses are at other links in the postharvest chain, often not related to biodeterioration, then other loss assessment approaches will be needed	**Chapter 10** **Section 8.4** **Chapter 11**
Initiate loss assessment study	1) Make the first visit to the project targets (e.g. households) at the time when loss assessment should start. For farming households this is usually very soon after harvest, but may be before harvest if harvesting is a focus of the study. 2) Implement the questionnaire survey and initiate the loss assessment process. 3) Where storage is being assessed then initiate recording of grain removals to assist in the calculation of a cumulative loss.	**Chapter 9**

	Then make return visits as required to collect sufficient data to enable an accurate assessment of the loss.	
Prepare loss estimates and loss narrative	1) Determine loss for each sample unit (e.g. each household). 2) Calculate a weighted average loss based on the grain production by each sample unit (e.g. household) 3) Substitute the new loss estimate for the default values in the downloadable PHL Calculator to estimate a new cumulative weight loss from production. 4) Prepare a report on the loss assessment that includes, the methods used and relevant observations, photos, maps of sample sites etc., that will provide a narrative explaining the loss or reduction in loss.	**Section 10.6** **Section 10.8** **Section 7.2**
Submit loss data to APHLIS	Present the loss report to APHLIS (info@aphlis.net) so that loss data can be added to the system to upgrade the default loss profiles. This improves the performance of the web-based loss calculator and makes loss figures available to other users.	**Section 4.8**

8.2 The questionnaire as a basis to the loss assessment survey

An interview with the owner of the grain (farmer, co-operative, trader etc.) should complement the actual measurement of losses although the extent of questioning may vary greatly according to the needs of the project. Consequently, a project may have a full formal questionnaire survey in advance of loss measurements and/or abbreviated questioning exercises running parallel to loss measurement. Either way it is essential to put the loss data obtained into the context both of farming and of the household. For most cases certain basic questions are likely to be required in order to give an understanding of the context of the investigation, to ensure the collection of the data required by the PHL Calculator on losses and seasonal factors that affect postharvest losses, and/or to provide a narrative to accompany the losses that the study reveals. Typically, the grain owner would be asked questions relevant to the survey objectives and in the case of households these questions could include -

- the timing of postharvest activities
- the postharvest methods employed,
- the number of bags of grain produced
- the number of bags of grain sold and when sold
- the duration of storage of grain for household consumption,
- their normal grain consumption rate,
- their knowledge of losses and which stages and factors are most problematic,
- how losses vary between harvesting seasons and from year to year, and
- access to extension advice/services.

An example of a formal questionnaire for a postharvest losses survey of householders is given in **Annex 4**. This example is fairly general in nature, so that more specific questions on particular links in the postharvest chain would be added to address the interests of a specific project.

The time available for you to spend with each grain owner answering a questionnaire will always be limited (typically about 1 hour), so engaging in lengthy discussions may not be possible, but at least in the case of farming households a detailed briefing from a local agricultural extensionist could provide much needed background information and help to reduce interview times with households.

Analysis of questionnaire results

It is possible to use questionnaires to quantify key aspects of the postharvest system and in order to do this advice should be sought from a statistician or biometrician on the design, data management and the analysis of the questionnaire. Furthermore, instead of being used to collect new data on losses a questionnaire could also be designed that will validate existing data on losses, i.e. confirm that loss data established elsewhere applies to a different community or geographical area.

During a questionnaire survey it should never be assumed that the answers given by individuals are accurate, they may be given because they are thought to please the questioner or because they are to the advantage of the interviewee. In order to overcome some of these problems the approach taken should involve some degree of 'triangulation' (Pretty *et al*., 1995). This can be achieved by 1) having study teams with members coming from different disciplines so that the topics under study can be viewed from 'different angles', 2) interviewing more than one key informant or group, using the same questions, so that responses can be compared, and 3) use different tools to investigate the same phenomenon, for example questioning farmers about the significance of quality decline or losses at a particular link in the postharvest chain, assessing the losses using rapid techniques, and then comparing the farmer's perceptions with actual loss data.

Field testing and refining the survey questionnaire

When a decision has been made on the questions to be included in the questionnaire then it can be assembled in draft ready for field testing. Field testing is an important step in developing an effective questionnaire. It is a way of checking that:

- questions make sense and are easily understood by respondents,
- questions do actually need to be asked,
- important questions haven't been forgotten
- responses can be analysed by whatever analysis protocol has been selected, and
- the questions can be understood by the enumerators and they can be delivered by them in the vernacular.

Field testing should be done by the questionnaire designers backed up by one or two of the staff who will implement the survey. It should be done at a convenient location with not less than five respondents who will be similar to the targets of your survey. Chapter 9 gives guidelines on how to do the interview with respondents.

After field testing, the survey group should consider the results and refine the questionnaire accordingly.

8.3 Rapid techniques for measuring losses

Losses occur at each step in the postharvest chain. The methods used in their measurement have to vary according to the nature of the loss, typically whether the measurement is of grain biodeterioration or of grain scattering/spillage (see **Chapter 2**). If grain is lost due to biodeterioration, which may occur due to pest attack throughout the postharvest system but especially during storage, then the least time consuming approach to measuring grain weight losses is to use a visual scale. A visual scale can be used to assist loss assessment at any link of the postharvest chain where there has been biodeterioration but the method gives no measure of losses due to scattered or spilt grain or those grains completely removed by rodents, ants etc.. For that other methods would be required. How to construct a visual scale is presented in **Chapter 10** and how to estimate losses using the scale is presented in **Section 10.6**. If grain is scattered/spilt during operations such as harvesting, winnowing, threshing and transport then careful grain recovery is required to determine how much would have been lost. Details of this are given in **Chapter 11**.

8.4 Making representative loss estimates – sample size and sample location

It is essential that the samples you take, whether these are 'households' participating in a questionnaire survey or the' grain stores' for loss measurement, are representative of the 'population' of households or grain stores within the area of the investigation. The principles for determining the number of households to visit during a questionnaire survey are similar to those for determining the numbers of grain samples to take when assessing grain losses. Households and grain samples are both 'sample units' and the principles for determining how many units are needed, and whereabouts you should take them from, are described in this section. This section also deals with the practicalities of sampling grain.

The balance between sample size and accuracy of individual measures

The extent of postharvest losses can vary greatly; in some situations they can be severe in others only minor. The reasons for this variation are diverse. It may have to do with small differences in the time of harvest, the postharvest handling technique employed especially how much attention is given to hygiene, the prevailing climate, or it could be just a matter of chance. A good example of chance is the attack on maize cobs by the Larger Grain Borer (LGB). There are good years and bad years for this pest, but also certain farmers suffer severe infestations while their neighbours may suffer none. This relates to the way that the pest finds its food. Male beetles locate maize purely by chance (it appears they cannot smell maize). Once a male has found some maize it releases a chemical signal (pheromone) that attracts females and also other males (Hodges, 2002). The result is that in some farm stores a large infestation develops but in maize stores close by there may be no infestation at all.

When making an assessment of losses it is important that this variation is taken into account. For example, it would distort the truth if a loss study just reported the losses from sample units that were unlucky enough to have had a severe LGB infestation. Instead it is important to make an assessment of many sample units (farmers/co-operatives etc.), which will be representative of all those in the area in question; for example the group should include those suffering severe infestation, moderate infestation and no infestation. This is known as a representative sample, the average (mean) loss from all units is calculated and this mean represents the population of the area.

If the loss assessment technique employed is time consuming (and/or expensive) then relatively few assessments can be made. The more time consuming methods generally have the advantage of giving more accurate results for individual sample units but have the disadvantage that when smaller numbers of estimates are used to calculate mean loss values for the wider population they have a low accuracy (i.e. are not very representative). Conversely, rapid loss assessment techniques are less accurate than their conventional counterparts but for the same, or a lower cost, they can be applied to many more sample units. In this way they are likely to offer a more representative estimate of loss.

This brings us to the question of how many sample units to include in order to make a good estimate of the loss.

How many sample units to take

It is very difficult to determine the number of samples to take without knowing in advance how variable losses are between sample units (the more variable losses are between units the more units needed to be sampled in order to give a good estimate of the whole population). If you have information on 1) the degree of precision required (i.e. the estimate of the overall mean loss to be within say 1%, 2%, 5% of its true value, and 2) the range of loss values that can be expected (i.e. difference in % between highest and lowest loss), then you can use Table 8.1 to determine the number of samples units (e.g. households, grain samples etc.) that are required to obtain a specified degree of precision.

Table 8.1: Number of samples required to achieve a given degree of precision (Harris and Lindblad, 1978)

Desired precision	**Range of weight losses expected (%)** (difference in % between highest and lowest)								
	100	**80**	**60**	**50**	**40**	**30**	**20**	**10**	**5**
±1%	5625	3600	2025	1406	900	506	225	54	14
±2%	1406	900	507	351	225	126	57	14	4
±5%	225	144	81	56	36	20	9	2	-
±10%	57	36	21	14	9	5	3	-	-

If the predicted number of samples represents a workload that cannot be supported by the funding available then a lower degree of precision would have to be accepted. Normally, we do not know the range of loss values expected, so some guess work is required.

Deciding which households to sample

There are also other things that need to be taken into account when planning the sampling of households. For example, it is important to ask whether the study area has some parts that are different from others, such as farmers with different practices at certain locations, different climates etc.. Even within a village there may be differences, it is common to find that some farmers are much better off than others (referred to as a difference in 'well-being'), it is therefore important that farmers in different well-being categories are included in the study. So in planning the study you must 'stratify' your sampling effort so that at least some samples will be taken from any areas that may be regarded as different.

But this still does not tell you exactly how many samples you should take. If the sample unit is farmers or grain bags then there may be hundreds or even thousands that could be chosen for assessment. In this case the simplest 'rule of thumb' is to take the square root of the number of farming households in the whole area (Table 8.2).

Table 8.2: Number of units (households, bags etc.) to sample

No. of sample units	No. of units to be sampled
Up to 10	Every unit
11 to 100	10 units, selected at random
More than 100	Approximately the square root of the total number of units, selected at random. So for 500 units you would sample 22 units, 2000 units sample 45 units etc.

In other words if there were 2000 farming families in an area then you would visit 45 of them ($\sqrt{2000} = 45$). If 500 of 2000 households were different for some reason, e.g. a different ethnic group, or further up the mountain so subject to a different climate etc., then it would be important that 25% (500/2000), or 11 farmers (0.25 x 45) in the sample of 45 come from this group. You now have two distinct groups to investigate 34 farmers in Group A and 11 in Group B (34+11 = 45).

The next question is how do you decide which households to visit? If Group A farmers were located in 5 villages of more or less equal size then you would choose 6 or 7 households from each village. If Group B were all from a single large village then all 11 samples would be from that village. Within any village you may then have to decide which households to visit. You must avoid visiting only the more well-off farmers who will have more land and more resources to devote to better postharvest practices. You need to work with a group from the area to decide what 'well-being' categories are relevant to farming families. You should then select some families from each well-being category. This is discussed in more detail in **Section 9.1**.

8.5 Using grain spears to take samples

Taking grain samples from stores, whether these stores are grain bags, metal or mud silos, underground pits etc., is most easily done using a grain spear of the appropriate type.

For grain stored in bags

Grain stored in bags can be sampled using a bag spear. These are hollow metal tubes with one pointed end (Fig. 8.2) that can be pushed into a bag of grain. Grain fills the tube which is then removed from the bag, the grain then drains through the handle of the spear into whatever sample receptacle has been provided, tray, plastic sample bag etc.. These spears are relatively cheap, simple and quick to use; two common designs are the cylindrical and tapered types (Fig. 8.2). The tapered sampling spear penetrates bags easily and causes minimal damage to bag material. The cylindrical sampling spear takes a larger and much more even sample. But it is more difficult to push into a bag and tends to leave large holes in the bag material, although the woven bag material can usually be pushed back into place after taking the sample to prevent grains falling out through it.

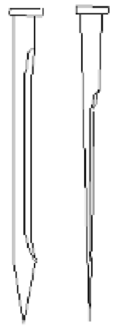


Figure 8.2: Bag sampling spears - cylindrical spear (left), tapered spear (right)

Generally, bag spears with an external diameter of about 12mm are designed for small grains such as sorghum and millet, while 25mm diameter spears are suitable for larger grains such as maize and common beans. For good penetration into a bag, the spear should be 40 to 45cm in length. Shorter spears will be unable to obtain material from deeper inside bags. If grain spears are not available locally then it is normally possible for local metal workers to manufacture them.

The correct way to obtain a sample with a bag spear is to insert the spear with the open side facing downwards and then, when fully inserted, to twist the spear so that the open side faces upwards. If a sampling spear is inserted into a bag with the open side facing upwards, it will be filled with material from the outer few centimetres thus preventing material deeper in the bag from being sampled (Fig. 8.3).

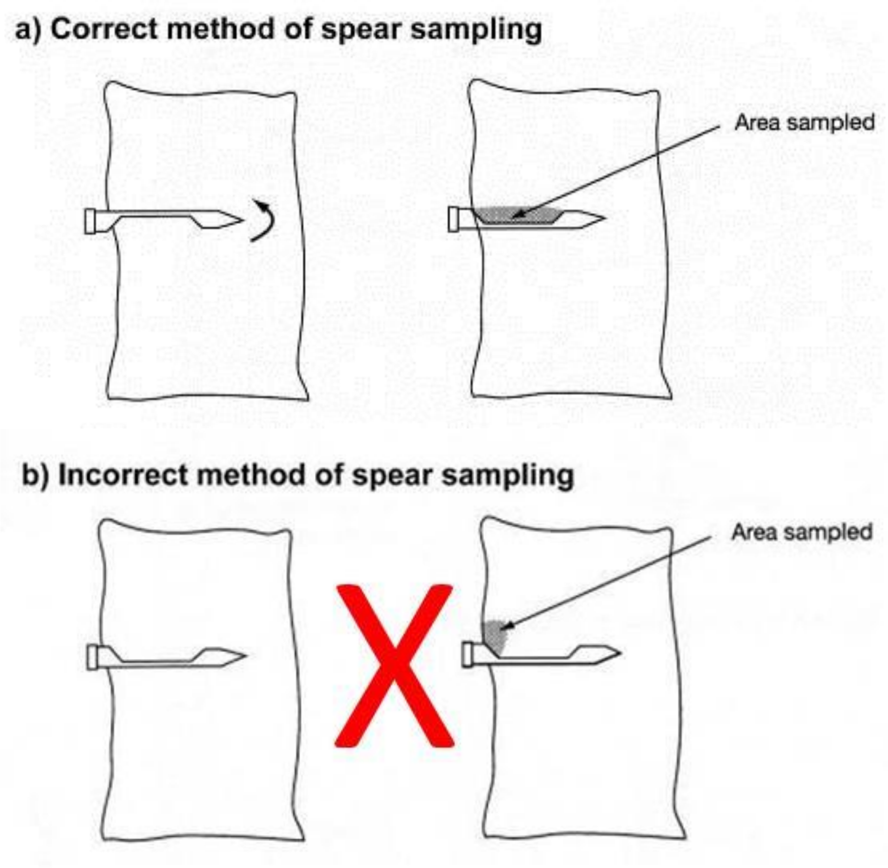


Figure 8.3: The correct and incorrect methods of taking a sample with a bag spear

Important points to remember when using a sampling spear are:

- Normally a sampling spear is inserted once into a 50kg bag to obtain a sample of about 25g of grain and twice into a 100kg bag to obtain 50g of grain. In the case of a 100kg bag, make sure that the two places where the spear is inserted are far apart. When sampling successive bags don't always sample in the same place, take some samples from the middle, some from the top, and some from the bottom of the different bags.
- As spears damage the bag material, they must be used with care. After sampling, the hole made by the spear should be closed by gently pulling the weave of the bag material back together so that grain doesn't keep falling out through it. This may also be achieved by gently tapping the hole with the handle of the sampling spear.

For grain stored in bulk

If instead of sampling grain from bags, the grain is in bulks in metal/mud silos, store compartments etc., then a double-tube spear should be used (Fig. 8.4 & 8.5). These consist of two metal tubes, one fitting closely inside the other and each with several slots corresponding to similar slots in the other tube (Fig. 8.5). The intake apertures are opened or closed by turning the inner tube. Spears of this type may vary in length from 45cm to 3.5 metres, and in width from 12 to 50mm. The multi-compartment spears used for the job should be long enough to reach to near the bottom of the grain mass. Note that the tip of the spear needs to be masked with soft tape if the store is susceptible to puncture. It should also be marked at the top end to indicate the maximum depth of insertion.

Figure 8.4: Using a 2m multi-compartment spear to sample a millet granary in Namibia

Figure 8.5: Multi-compartment sampling spear (160 cm) to sample bulk grain from various depths

Typically, a spear will have from 3 to 6 compartments. There should be a block (cork or other suitable material) between the compartments of the spear to prevent the grain sampled by each compartment mixing with that of another compartment. In this way it will be easy to distinguish the quality of grain from different depth. Very often the grain at the surface and at greater depths is more damaged by insects than grain at intermediate depths.

The spear is inserted into grain with the tubes in the closed position so that no material enters until the sampling position has been reached. Then, the inner tube is turned to open the slots and grain is collected from several positions along the line of penetration. Before withdrawing the spear, the inner tube is turned to close the slots so that none of the sample material is lost as the spear is removed.

After each insertion, lay the spear horizontally and rotate the inner tube so that the grain is released to form several small piles of grain, each corresponding to a certain depth within the grain. The grain from the second insertion can be placed by the side of that from the first insertion and the two mixed to give a larger samples corresponding to each depth (Fig. 8.6).

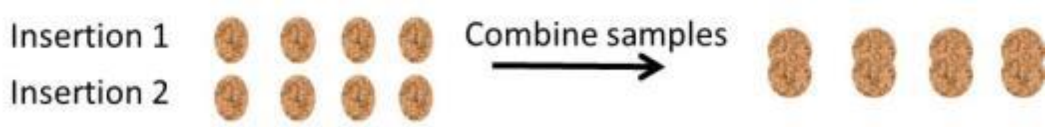


Figure 8.6: Empty the grain spear after each insertion and then combine samples taken from the same depth in the grain

Before proceeding to sample another store, it is a wise precaution to clean the spear to avoid transferring contamination (insects) between stores.

9. Loss assessment – the questionnaire survey

In the previous chapter we discussed the need for asking questions of the relevant stakeholders as part of our postharvest loss assessment and considered the questionnaire as an integral part of this process. We will now consider how to implement a household survey using a questionnaire that has already been developed following the process described in **Section 8.2**; an example of which is shown in **Annex 4**.

9.1 Household diversity as a factor in the design of surveys

Our survey will seek to find out about grain management practices and losses but these will vary both within and between communities according to ethnic/cultural background and access to resources. In effect, there is diversity both between different communities and also between the households that make up those very same communities. We need to know about this diversity in advance of our 'survey' so that we can ensure that our chosen survey respondents reflect this diversity – in other words that they come from the wide range of circumstances that pertain to the communities under study. To help with this a process of well-being ranking is described in the next section; this is used to distinguish the diversity of households according to access to resources and activities. Once households have been identified in this way then a selection from each well-being category can be used to obtain further information.

In our survey work, besides aspects of ethnic/cultural and resource diversity we also need to give special consideration to gender. We must ensure that the gender balance of our sample of respondents closely matches the manner in which postharvest activities are gendered in the community under study. This is essential since there may be a strong gender-bias on postharvest activities and household management.

The next section describes the essential steps in implementing the survey. These are the minimum required and much abbreviated. A more detailed discussion of farmer survey methodology, rather than just questionnaire surveys, can be found in Nabasa *et al.* (1995).

9.2 Implementing households surveys

Step 1: Approach the Extension Service

Approach the extension service to explain the project and ask for help in selection of communities. Help is also needed for an introduction to the communities.

For selection of communities, first ask about ethnic groups in the area (provided this is not a sensitive issue), known differences in agricultural/postharvest practices, accessibility for transport, and general seasonal activities. You should select communities to cover the widest range of the diversity described by the extension agent. In other words, there will be a purposeful choice of communities in order to capture diversity of practice.

Step 2: Visiting the Community Leader

a. Arrange with the Extension Agent to visit the leaders of the chosen communities. Ask the Agent to explain that you wish to talk with the Community Leader and later both the Community Leader as well as senior and respected members of the community, school teachers, pastors etc. (including at least one woman) as a group. It is important to follow any local protocol that is advised by the extension worker.

b. On arrival in the community, explain to the Community Leader the purpose of the project and ask permission to work in the community.

c. Ask a group consisting of the Community Leader and the respected members of the community to describe a range of wellbeing indicators for the communities (e.g. ownership of land, cattle, transport, processing facilities, wages from non-agricultural activities etc.). Alternatively, this might be done with an extension worker who knows the community very well.

d. Ask the group to select symbols (stones, green leaf, dried leaf, bank notes, etc.) to represented each of the well-being indicators (Fig. 9.1) and then group the indicators to help decide how many well-being categories there are in a community.

Figure 9.1: Creating well-being classes by using various symbols to represent indicators of well-being (Ghana)

e. Ask the group to indicate how many of their households there are in each category.

f. You can now calculate how many households you should interview in each category if say the number should not exceed 12, an example is given below.

Category	No. in community	% of community	No. to interview
1	25	12.5	2 (=12x12.5%)
2	50	25	3
3	75	37.5	4
4	50	25	3
Total	200	100	12

g. Ask the Community Leader to provide a listing of twice as many households in each well-being category as required by the study. The required number of respondents can be selected at random from this list by drawing names/numbers from a hat or by using a random number table (**Annex 5**).

h. Ask the Extension Agent to check through the list of households to identify those that may not be available, are inaccessible etc., and select replacements from the list.

i. Arrange a timetable of visits with the Community Leader and Extension Agent and ensure that the households are warned in advance of your coming.

Step 3: Organising and implementing household interviews

Before implementing the survey it is important that the survey staff is briefed on its roles. They should also have had an opportunity to practice the use of the questionnaire. Staff can be grouped in teams of two, since not more than two should interview any one household, although two or three teams might be active in anyone community at the same time. There should be a division of labour in the two-person team, one person can do the talking while the other can listen and write the responses into the questionnaire form.

Organising the interview

- Inform the local Extension Agent of the proposed visit in advance in order to alert respondent households and arrange interview times etc..
- Brief team members on the rationale and format of the visit.
- Designate the interviewer and recorder in advance; if possible the local Extension Agent should also be part of the team.
- No more than 3 people should be present, in addition to household members (and non-participants who might prove to be a distraction are probably best steered away, providing this doesn't place the interviewee under any additional strain).

Just before the interview

- Meet and greet farmer and household – Local Extension Agent could make the initial introductions.
- The interviewer should mention the purpose of the project (i.e. to understand postharvest operations, assess losses, and seek solutions to reduce losses).
- The interviewer should state explicitly -
    - ✓ Who is sponsoring this research
    - ✓ Which organisation is implementing it
    - ✓ That participation is voluntary and that farmers can withdraw at any time
    - ✓ The findings will remain anonymous
    - ✓ The Interviewer should confirm farmer's interest in taking part in the interview, and that s/he is happy to undertake the interview now (or at a later specified time), and
    - ✓ The Interviewer must explain his/her and the reporter's roles, and that of anyone else that may be present.

During the interview

- Deliver the questions carefully and allow the respondent to answer fully without any prompting.
- Once the questionnaire is completed, ask respondent if there are any questions s/he would like to ask.
- With permission, take pictures of the farmer in front of his/her house so that construction and roof details are shown and any other interesting assets (e.g. ox cart, oxen, stores). Take pictures of postharvest equipment and stores whenever possible. Well cited pictures can capture aspects of wealth or poverty.
- Wind-up the interview; offer thanks and indicate the probable return dates if applicable.

You now have some ideas about implementing a questionnaire survey as part of the loss assessment exercise. Suggestions have been given concerning the questionnaire, the approach to testing it for suitability, and how to implement the survey. During the questionnaire interview or subsequently, you may initiate the process of making an actual assessment of losses. This may be done using a visual scale. How to construct a visual scale is the subject of the next section.

10. Loss assessment – rapid measurement of storage losses

Visual scales are a relatively quick and easy way to estimate the grain weight losses due to insect pest attack and also to assess grain quality. However, they give no measure of losses due to scattered or spilt grain or those grains completely removed by rodents, ants etc. For assistance with these see **Chapter 11**.

A visual scale consists of several grain samples, with different degrees of pest damage and other types of quality decline, arranged into a sequence from best to worst. Each sample represents a particular class of weight loss/quality loss. Samples of grain can then be assessed for weight loss and quality by comparison with the visual scale. There are some other methods that can be used to estimate weight losses (Boxall, 1998) which are more accurate but all are much more time consuming. The advantages of visual scales are that they:

- Avoid the need to return samples to the laboratory, as the assessment is done at the place where samples are taken
- Avoid time consuming laboratory analyses, they are a rapid technique
- Increase the number and geographical spread of samples because they can be done quickly
- Avoid taking grain away from farmers, so compensation is not required
- Involve grain owner in the assessment so improving the relationship between the researcher and the grain owner, and
- Link the assessment to both weight and quality (value) loss

Visual scales are usually prepared for threshed cereals but in the case of maize they can also be prepared for cobs. This Chapter describes how to prepare them and how to estimate losses from visual scale scores.

10.1 The principles of a visual scale

The best way to understand a visual scale is to see one. The example in Figure 10.1 was constructed for the loss assessment of millet in traditional farm stores. The first four classes are fit for human consumption and have associated weight loss values. In the case of Class 5, the grain is no longer fit for human consumption and has an associated weight loss of 11% but as it is outside the human food chain it may therefore be regarded at 100% weight loss, despite the fact that it could be fed to animals and so retains some residual value.

The scale is prepared in four basic steps:

Step A- a set of grain samples of widely differing qualities, from best to worst is obtained from farmers and traders.
Step B – stakeholders are consulted on the end-uses of different grain qualities.
Step C – in the laboratory several samples of grain representing each distinct quality ('Class') with distinct end-uses are prepared. The weight loss associated with each Class is determined using the 'count and weigh' technique (Box 10.2), and a description of grain quality prepared for each class.
Step D - each sample is a 'Class' and is placed transparent plastic container (plastic bag, Petri dish etc.). They are presented to stakeholders to confirm that they relate to the identified end-uses and that they can be used easily to assess samples taken from stakeholders grain stocks.

The loss assessment is made by comparing a sample taken at the relevant link in the postharvest chain with the set of pre-prepared grain classes.

Class	% insect damage (% weight loss*)	Contamination	End use	Sample photo
1	0 (0)	None	Suitable for sale to Namib mills or a local commercial miller (ABC)	
2	15 (2.12)	1.5% frass/sand, almost no moth webbing	For household consumption, sales to local people and possibly ABC millers	
3	30 (4.25)	3% frass/sand, moth webbing frequent small portions, occasional rodent pellets	For household consumption, sales to local people	
4	60 (8.5)	Large amounts of moth webbing, frequent rodent pellets, mud from basket plastering	To be hand-picked, infested material fed to animals, the rest used as human food	
5	80 (11)	Vast amounts of moth webbing, frequent rodent pellets, straw and , mud	To be fed to animals	

Figure 10.1: Visual scale for loss assessment of millet in Namibia

*determined by the count and weight methods (Box 10.2)

10.2 Constructing a visual scale for threshed grain

To establish a visual scale, it is usually necessary to prepare four or five different grain classes. These are made using high quality grain (Class 1), the other classes are derived by mixing in different proportions of grain that are insect damaged, broken, mouldy or discoloured and foreign matter such as dockage, sand, insect frass etc.. Each class is assessed for its implied weight loss by analysis using the 'count and weight method' and its degree of contamination described to show its quality loss. It is intended that each class will be assigned to an end-use; this makes the scale intuitively easier for stakeholders to understand and may allow it to be associated with a market value, so that in more advanced studies a quality loss could be given a financial value. The relationship between quality and value is often complex, for a discussion of this see **Section 1.5**. After consultation with stakeholders, the classes might be arranged like this:

Class 1 – highly valued in a formal market (something like grade 1 in a formal grain standard)

Class 2 – acceptable in a formal market (something like grade 2 in a formal grain standard)

Class 3 – not likely to enter a formal market without some conditioning to make it equivalent to Class 2 but acceptable on a local, informal market

Class 4 – acceptable for home consumption and sale or exchange to neighbours especially if subject to some conditioning

Class 5 – not generally fit for human consumption but would be fed to livestock

These different end-uses are established by showing samples of the pre-prepared classes to the relevant stakeholders (farmers, traders etc.) to gain their feedback on what the classes mean to them. The classes of a visual scale may be presented in the form of photographs and/or grain in containers such as plastic bags or Petri dishes and the user can assign a grain sample to a class or place it between two classes. Following stakeholder feedback, the classes may have to be 'redesigned', i.e. classes added or combined or redescribed. During an assessment of millet losses in Namibia, stakeholders were asked to assess the visual scale samples presented in saucers (Fig. 10.2). It was observed that they required almost no explanation on what to do and were extremely quick to assign end-uses. They recognized issues of grain contamination and of grain damage and assessed both when making a decision about the class of a sample.

Figure 10.2: Members of a local co-operative assigning the end-uses of the five millet classes of a visual scale (Namibia)

A visual scale is simple to use. It is just a matter of taking samples of the grain under test and assessing which of the classes they resemble most closely. Samples can even be positioned between two classes, where the grain damage or contaminations values are taken as mid-way between the two classes (i.e. 2.5 is between Class 2 and Class 3). It is possible to rate samples according to insect damage (which also gives a measure of weight loss) and their quality. They may often have the same rating on both measures but may sometimes differ.

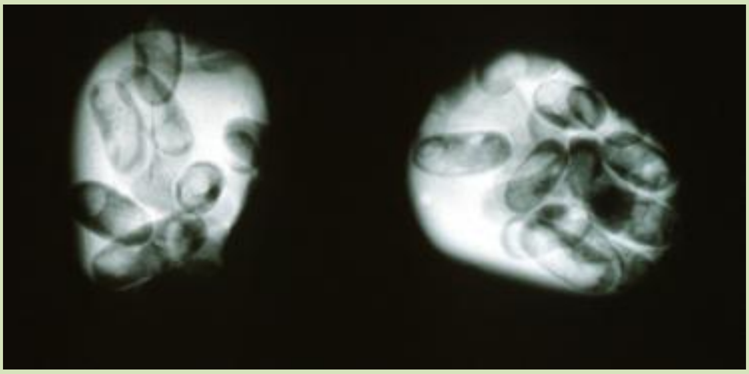
The following steps should be followed to create a visual scale for threshed/shelled grain.

A. Obtain grain samples

1. Obtain grain samples (about 1kg of each) with widely differing degrees of insect damage/contamination of the grain type and variety that is the subject of study.
2. These samples should vary from completely undamaged/uncontaminated grain through to the most damaged and contaminated grain that is likely to be encountered.
3. Obtain the samples by visiting various stakeholders, i.e. farmers, traders, market stalls etc., at various times in the postharvest season (early, middle, late)
4. All samples should be treated to avoid any further deterioration. If they have a moisture content of more than 13.5% then they should be dried in the sun or in an oven if available. When fully dried they should be disinfested (of insects) either by placing in a freezer (-18°C) for at least one week or subject to a phosphine fumigation. Box 10.1 explains how to do these methods of disinfestation

Box 10.1: How to disinfest grain samples

Grain samples will continue to be eaten by insects if care is not taken to disinfest them and then keep them in insect-proof containers. This is important because time and effort is required to prepare the samples of a visual scale and their loss would be a considerable waste of effort. The immature stages of insects that infest grain can be completely hidden within the grain and then emerge later as adults to lay eggs that will result in more insects and more grain damage. It is important not to assume that sound looking grain is uninfested, such grain must still be treated to ensure that any hidden infestation is destroyed.



An X-ray of insect infestation hidden within maize grains that have a sound external appearance

Disinfestation by freezing
Place 1-2 kg of grain to be disinfested in a plastic bag and close tightly. Put the bag in a freezer (at -18°C) and leave there for a minimum of 7 days. Remove the bag from the freezer and allow the grain to warm to room temperature before opening the bag. Opening the bag whilst the grain is still cold could result in moisture condensation and consequently an increase in grain moisture content. This might lead to mould growth.

Disinfestation by phosphine fumigation
Instead of freezing, insects could be destroyed by fumigation with phosphine gas. Place the grain samples in an open weave sack, paper bag or other container that is easily permeable to air. Place the grain into a plastic or metal drum or other container (up to 0.5 m^3 capacity) that can be sealed easily to make it airtight. Place one 3g tablet of aluminium phosphide in a lightly sealed paper envelope and put this in the drum. Seal the drum and leave for a minimum of 5 days. During this time the drum should be in a well-ventilated place away from human habitation. This is important as phosphine gas can be lethal to humans. At the end of the fumigation period, open the top of the drum in an open-air, fully ventilated location. Remove the grain samples and leave them in the open air to ventilate for a minimum of two hours. Dispose of the phosphide residues in the envelope by burying at 50cm in the ground at a location at least 25m from human habitation or water source.

B. Establish the scale classes

5. When collecting the samples from stakeholders discuss with them what the different end-uses and values of the samples represent. This will help in the initial establishment of the scale.

C. Preparing the visual scale

6. Undertake the following analysis of those samples that most closely represent the end-uses and values identified by the stakeholders. For each sample:
    a. Record the total weight of each sample (you will need weigh scales that read to 2 decimal places)

b. Select out the good grain, each category of damaged grain and foreign matter, this will typically be
    - Good quality grain
    - Broken grain
    - Pest (insects, rodents) damaged grain
    - Mouldy and discoloured grain
    - Foreign matter
c. Record the weight of each of these fractions and calculate this weight as a percentage of the sample weight.
d. Undertake a 'count and weigh' loss assessment of the pest damaged grain (Box 10.2) so that the weight loss associated with each class of the scale is known.

> **Box 10.2: Count and weigh loss assessment**
>
> The pest damaged and undamaged grain from the sample are first counted and then weighed. The % weight loss can then be calculated using the following equation
>
> $$\text{Weight loss \%} = \frac{NdWu - WdNu}{(Nd + Nu) \times Wu} \times 100$$
>
> Where
>
> Nd = Number of damaged grains in the sample
>
> Nu = Number of undamaged grains in the sample
>
> Wd = Weight of damaged grains in sample
>
> Wu = Weight of undamaged grains in the sample

7. Take pictures of each class of grain so that assessment can be done using pictures; have the class number showing in each picture (as in Fig. 10.1). Once prepared each picture should be enlarged so that two pictures will fit on an A4 page. Place the pages in clear plastic envelopes to keep them dry and clean. Sufficient sets of these photographs need to be prepared to distribute to each loss assessment team.
8. Place the grain samples representing each class in clear plastic bags that are labelled with the class number and tightly closed, or in clear plastic Petri dishes sealed at their edges with tape. These grain samples and the pictures (see 7. above) should both be available when the visual scale is to be used.

D. Validating the scale classes

9. Now that the visual scale has been prepared it is time to practice its use. Visit a sample of stakeholders that are representative of the range to be included in the loss assessment exercise; include two or three of each category, e.g. two or three small holder farmers, market traders etc.. Take with you the visual scale (as photographs and/or a set of grain samples representing each class), some grain samples to be assessed and equipment for taking grain samples. Explain to the stakeholders the use of the scale. Ask them to make a visual scale assessment of the grain samples you have brought with you, you could ask for a class value according to both the grain damage and quality (contamination). Then take a sample of the stakeholders' own grain and ask them to assess that. Record the results for both the samples you provided and the one belonging to the stakeholder. Repeat with other stakeholders.

10. Now assess how well the stakeholders managed to make the assessment and also how consistent the results were between the same stakeholders and different stakeholders. From this you should be able to conclude whether or not adjustments need to be made to the scale to make it more meaningful in terms of end-use or to make it easier to apply.

A list of the equipment needed for the construction of a visual scale is given in Box 10.3.

Box 10.3: Equipment needed for the preparation of a visual scale

Sampling spear – to take grain samples for the construction of the visual scale
Forceps – for handling grain
Metal trays – for handling grain
Sample divider – to separate samples in a representative manner
Sieves (appropriate sizes relevant to the grades used locally)
Balance (weighing to at least 2 decimal places) – for weight loss estimates
Plastic sample bags – for collection and transport of samples and to display them
Plastic Petri dishes – to display samples of each class of the visual scale
Sellotape – to seal Petri dishes
Access to freezer/ phosphine fumigation – to disinfest grain samples
Camera – to take pictures of visual scale samples
Colour printer (laser or inkjet) – to print out the visual scales (alternatively photographs could be glued to paper)

Now we will consider the practical details of creating a visual scale for maize cobs.

10.3 Constructing a visual scale for maize cobs

Making visual scales for maize cobs is similar in principle to that for shelled grain but differs in that - a) a sample of cobs is taken and from this sample the cobs are sorted into damage categories, and b) in preparing the scale the count and weigh technique can be refined to take into account grain that are missing from the cob (Compton *et al*., 1998). Use the following procedure:

A. Obtain a large sample of maize cobs

Find a location where it is possible to obtain a large sample of maize cobs that have varying degrees of damage. Sort these maize cobs into several distinct categories according to their degree of damage; typically four, five or six categories, with about 50 cobs in each category.

B. Establish the scale classes

Work with farmers to define the end uses of the damage categories that have been identified, in a similar way to that described for shelled grain.

C. Preparing the visual scale

Determine the weight loss associated with each damage class by selecting about 30 cobs from each class. Shell these cobs and bulk the grain from each damage class. Undertake a modified 'count and weigh' analysis on each sample (see Box 10.4) to determine its damage coefficient.

Box 10.4: Modified count and weigh for maize cobs

1. Shell about 30 maize cobs from 'one class'. Record the number of missing and destroyed* grains in each cob. These are then summed over all cobs in the sample to give the total number of destroyed and missing grains (TND).
2. Sift the shelled grain from each cob through a standard nested sieve set (e.g. 3.35/2.0/0.85 mm).
3. The sifted grains from all the cobs are then pooled. The pooled sample is weighed and the weight recorded to the nearest gram. This is the final weight (FW).
4. A box divider (riffle divider) is used to sub-divide the pooled sample several times to obtain two sub-samples containing about 400-600 grains each. The number of grains should be increased if there is a high proportion of damaged grains. There should be a minimum number of 50 undamaged grains in the sub-sample.
5. The grains in each sub-sample are separated into two groups, damaged and undamaged.
6. For each sub-sample the groups of damaged and undamaged grains are counted and weighed as in the conventional method.
7. The following formula is used to calculate the weight loss.

$$\text{Weight loss \%} = 100 \times \frac{TND(Wd - Wu)Wu + FW(NdWu - NuWd)}{TND(Wd + Wu)Wu + FW(Nd + Nu)Wu}$$

The weight loss is calculated separately for sub-samples 1 and 2, and the average of these two values is taken as the estimated weight loss of the cob sample.

FW = Final weight

Nd = Number of damaged grains in the sample

Nu = Number of undamaged grains in the sample

TND = Total number of damaged and missing grain

Wd = Weight of damaged grains in sample

Wu = Weight of undamaged grains in the sample

*Destroyed grains are those that are crushed during shelling into fragments smaller than one third of a grain or pass through a 3.35mm sieve in step 3.

Take pictures of maize cobs from each damage class including examples of the best and the worst cobs from each class (Fig. 10.3). Also keep examples of cobs from each damage class in tough transparent plastic bags, which should be disinfested using one of the methods described in Box 10.1. Use the pictures and examples of cobs during field assessments.

Class 1 - Undamaged

Class 2 – light damage

Class 3 – medium/high damage

Class 4 – severe damage

Figure 10.3: Example of a visual damage scale for maize

10.4 Simple calibrations to convert observed grain damage to weight loss

It is possible to determine grain weight loss by reference to the percentage of damaged grain observed in a sample. In the past 'rule of thumb' conversion factors have been used to convert grain damage into weight loss (Table 10.1). Put simply, it is possible to work with an average figure for the proportion of grain that is removed by insects; in the case of maize grain insect damage is expected to remove about 1/8th of the weight of each infested grain, so if the proportion of grain with insect damage is known then dividing this by 8 will give an estimate of the weight loss due to infestation.

Table 10.1: Conversion factors between grain damage and grain weight loss (Adams and Schulten, 1978)

Crop	Conversion factors (divide % damage grain by this factor to obtain % weight loss)
Maize (stored as shelled grain or a cobs without husk)	8
Maize (stored as cobs with husk)	4.5
Wheat	2
Sorghum	4
Paddy	2

If you plot the relationship between damaged grain and weight loss on a graph then this typically follows a simple straight line at levels of grain damage up to about 50% but thereafter weight losses tends to increase more quickly so if conversions of grain damage above 50% are required then a carefully constructed curve rather than the simple rule of thumb will significantly improve accuracy. The collection of a range of samples of widely differing levels of damage and their assessment for weight loss using the count and weigh technique (Box 10.2) will provide data from which such a graph can be constructed.

To determine grain weight losses take sample consisting of several hundred grain. Count the numbers of grains that are damaged and then apply the appropriate conversion factor.

The next section describes how to undertake loss assessment exercise using the visual scale, how to estimate the loss and adjust it in a way that can be used in the APHLIS system.

10.5 How to estimate storage losses using a visual scale

For some years visual scales have been used to estimate losses in grain storage although at least in theory they might be used at other links in the postharvest chain. Sampling a store to give a representative sample is an important part of the process and has been dealt with in **Section 8.4**. The current section addresses five important questions when using a visual scale a) when to do the sampling, b) how to determine the quantity of grain present at each sampling interval (to assist in estimating a cumulative loss for the whole storage period), c) how to use the visual loss data to estimate weight loss at each sampling interval, d) how to estimate the cumulative loss, and finally e) how could the visual scale be used to estimate qualitative losses.

When to take the samples

In the case of **farm stores**, samples need to be taken early in the storage season and again at intervals so the progress of loss over time is recorded. How this is done depends on the household plan for storage. If the grain will be removed by the household for sale, consumption etc. during the storage period then more frequent visits are required than if the grain will remain untouched for the entire duration of storage. The reason for this is that if grain is being removed then the loss associated with the weight of grain removed at each interval must be recorded in order to compute a cumulative loss (explained in **Section 10.8**). On the other hand, if the grain is untouched during storage then the same loss value applies to all the grain and no cumulative loss calculation is required. Likewise it is important to know if grain is actually added during the storage period as this would make a loss computation very difficult.

Whatever the circumstances, a visit to the farmers early in the storage season is essential to gather data on which to base the sampling plan and record the grain weights held in storage; this is usually the time when a questionnaire survey is done (see **Chapter 9**). If grain will be removed there need to be several visits at intervals of four to six weeks over the duration of storage. Experience has shown that losses are minimal in the first three months; they begin to rise in the fourth to sixth month and may then proceed more rapidly after the seventh month (Fig. 5.3). So a sampling plan commencing 6 weeks after the start of storage then at six to eight week intervals to the end of storage is likely to be adequate (giving a maximum of about 7 visits across the season). However, to obtain the most accurate baseline of grain damage, i.e. to know precisely the condition of grain entering storage, it would be best to be present at the time grain is put into store. If the storage techniques that have been adopted result in minimal storage losses then the frequency of visit can be reduced (giving three or four visits across the season).

Determining how much grain is in store

Under most circumstance it is important to know how much grain is present in a store at the time of sampling. This is even more important if a cumulative loss over several sampling intervals is to be calculated. To determine the weight of grain lost during storage and to make cumulative loss estimations it is essential to know how much grain is present at the start of the loss assessment study, how much is removed from store during the study and finally how much remains at the end. For grain stored in bags or in parallel sided containers, estimating the amount at these intervals is relatively easy and described below. If stores are of other shapes then special arrangements will be needed and these depend on the shape (an example of estimating the grain weight in a spherical granary is presented in **Annex 6**).

Grain bags

It is relatively easy to determine how much grain is held in a store when grain bags are in use. All that is required is to observe how many bags are present, the capacities of these bags (e.g. 50kg, 90kg 100kg), and by recording how full they are, i.e. full, half or quarter.

Parallel side stores

For stores with parallel sides, the volume of grain in cubic meters (m^3) is calculated very simply by multiplying the length by the width of the store by the depth of grain in it. For examples if a store is 1.80m long, 1.0m wide and is filled to a depth of 2.10m with sorghum grain, then the volume of grain is -

$$1.8\text{m} \times 1.0\text{m} \times 2.1\text{m} = 3.78\text{m}^3$$

The weight of grain is then determined by multiplying this volume by the bulk density of sorghum. Examples of various bulk densities are shown in Table 10.2 but may vary according to how the grain is stored (bag or bulk), by grain variety, by plumpness (how well grain is filled during growth) and by moisture content. For the store in our example, the weight of the sorghum grain would be -

$$3.78 \times 730 = 2759\text{kg}$$

Table 10.2: The bulk density of some common cereal grains (Golob *et al.,* 2002)

Crop	Bulk density (kg/m^3)
Barley (bulk)	605-703
Maize (shelled, bagged)	613
Maize shelled (bulk)	718-745
Millet (bagged)	640
Millet (bulk)	853
Paddy rice (bagged)	526
Paddy rice (bulk)	576
Rice (bagged)	690
Rice (bulk)	579-864
Sorghum (bulk)	730
Wheat (bagged)	680
Wheat (bulk)	768-805

10.6 Making the visual assessment in farm stores

Bags

First assess how many bags should be sampled by reference to the required number of bags Table 8.2. In many farm stores it will be possible to sample most if not all the bags present in the store. Every effort should be made to sample as many bags as possible. A typical farm store holds 1-2 MT which would be 20-40 bags of 50kg or 10 to 20 bags of 100kg. Some bags of grain may be inaccessible; these may have to be left unsampled.

Sample each of the selected bags with a sampling spear (see **Section 8.4**), placing each sample in a separate plastic bag ready for visual assessment. Once the samples have been taken, work together with the householder to assess each sample for its class for insect damage and class for quality. Record the results on a data sheet that includes details of the household and quantity of grain present in store. If time is short then it is possible to combine all the samples taken in one household and assess that single sample as representative of all of them. However, if possible the assessment should be done on each individual sample as this will show the degree of variation within one household.

Grain Bulks

In some cases the household will be storing its grain in bulk. The bulk could be contained in a silo or grain store compartment or be loose as a pile on a drying floor or heap of grain in a house. In all these situations it may be possible to use a multi-compartment spear (see **Section 8.4**) to take the samples. The sampling spear chosen for the job should be able to reach to near the bottom of the grain mass. Typically the spear will have 3 to 6 compartments. If the spear has say 5 compartments each extracting about 25g then each insertion take a total of about 125g which is equivalent to sampling five 50kg bags. If a store holds 1 tonne of grain (i.e. holds the equivalent of twenty 50kg bags) then the spear should be inserted 4 times so that in effect twenty bags (5 bags x 4) have been sampled. The four insertions should be as far from each other as possible. In shallow, loose bulks, a scoop (such as a long handled spoon) could be substituted for a sampling spear. When sampling from bulks using the multi-compartment sampling spear each compartment will represent a different sample from a particular depth within the store. Grain quality is likely to vary according to depth. Once the samples have been taken, work together with the householder to assess each sample for its class for insect damage and class for quality according to depth.

Maize cobs stores

Maize cobs could be sampled in the field, from a drying floor, or from a drying crib. They need to be selected at random from as many locations as possible. When sampling cobs, take a minimum of 30 cobs, but preferably 50 to 100 cobs, with the cobs taken from as many locations in the bulk as possible. If necessary remove the sheathing leaves from the cobs and then sort them into the damage categories (whatever number of categories you have defined).

10.7 Sampling to make a visual assessment of grain in a large bag store

When working in the bag store of a large trader the situation is different as many of the bags cannot be accessed because they are inside a big bag stack. A true representative sample can only be taken from a large bag stack when it is being built or being taken down, so that all the bags in the stack have an equal chance of being sampled. It may not be practical to sample the bags during bag movements so instead it has to be assumed that the bags in the stack have been placed randomly and that those on the outside represent the quality of those on the inside (which would normally be the case). It is important that samples are taken from each of the sides and the top of the stack, i.e. the sampling operation is stratified by the sides and top of the stack. The number of samples taken from any side or the top should be in proportion to the numbers of bags present, i.e. if for example the top has twice as many bags as any of the sides then twice as many samples should be taken from the top. This stratification is important as insects are not likely to be evenly distributed on the surface of a bag stack. So when the number of bags to be sampled has been determined (Table 10.2) then these should be divided according to the numbers of bags available for sampling on each of the five surfaces. The bags on each surface should be selected at random for sampling. The bags to be sampled can be selected by drawing names/numbers from a hat or by using a random number table (Annex 5).

10.8 Calculating weight losses from visual scale assessments

Visual losses from threshed grain

The data collected will represent a number of visual scale estimates for a particular farming household. It might appear as follows (Table 10.3) when ten bags of equal size (e.g. 50kg) have been sampled:

Table 10.3: Class values and weight loss of ten 50kg bags of grain showing a visual weight loss calculation

Sample no.	Bag weight	Class	% weight loss	Comment
1	50kg	1	0	
2	50kg	2	2.12	
3	50kg	2.5	3.31	Between class 2 and 3
4	50kg	3	4.5	
5	50kg	1	0	
6	50kg	3	4.5	
7	50kg	2	2.12	
8	50kg	3.5	6.5	Between class 3 and 4
9	50kg	4	8.5	
10	50kg	1	0	
		Mean % weight loss	**3.2**	

The weight loss is calculated by taking the simple arithmetic mean of the weight losses (=3.2%). However, if the samples taken were representatives of different weights, for example if there was a mixture of bags and some were 100kg and others 50kg then it would be necessary to calculate a weighted average as shown in Table 10.4.

Table 10.4: Class values and weight loss of five 50kg bags and five 100kg bags of grain showing the calculation of a weighted average visual loss

Sample no.	Bag weight (a)	Class	% weight loss (b)	Weight loss proportion (a x b)	Comment
1	50	1	0	0	
2	50	2	2.12	106	
3	50	2.5	3.31	165.5	Between class 2 and 3
4	50	3	4.5	225	
5	50	1	0	0	
6	100	3	4.5	450	
7	100	2	2.12	212	
8	100	3.5	6.5	350	Between class 3 and 4
9	100	4	8.5	850	
10	100	1	0	0	
Totals	750			2658.5	
Weighted mean % weight loss 2658.5/750 =				**3.54**	

The weighted average calculation applies to any situation where one or more samples represent a greater quantity of grain than others. This might happen in a spherical grain store (Fig. 10.3) where a sample taken from a 20cm layer near the top and one taken from a 20cm layer near the middle would represent layers of the same height but quite different widths (the middle section of a sphere is much wider than the top or bottom sections).

Figure 10.3: A spherical grain store where the width of the area sampled is much wider close to the middle of the store than towards the top or bottom of the store

Having obtained a weight loss estimate for a particular situation, say the weight loss of grain in one particular household at a certain time after harvest, then it will be necessary to put this together with the loss estimates for other households to give a representative estimate of weight losses for the 'population' that is the research target, e.g. a particular village, harvest season, province etc.. In most postharvest surveys the weight loss estimates for each household are combined to give a mean value without any regard to the amount of grain held by each household (i.e. it is assumed that they all produce similar quantities). However, where they are big differences between households then again a weighted average loss, taking into account the total weight of grain held by each household would be more accurate.

Visual loss from damage cobs

During the sampling exercise the enumerators will have recorded the number of maize cobs in each damage class. Using this data, the following equation is employed to calculate the visual weight loss in the sample -

$$\text{Visual weight loss} = \frac{aN1 + bN2 + cN3 + dN4 + eN5}{NT}$$

$N_1 - N_5$ = Number of cobs in classes 1 to 5 in sample
N_T = Total number of cobs in sample
a-e are damage coefficients (i.e. % weight loss associated with each class).

10.9 Computing a loss value that takes grain removals into account

From any situation where a storage loss value is being estimated, if grain removal has occurred during the storage period then the loss should be expressed as a cumulative loss.
In this situation determining the cumulative loss requires knowledge of -

1) The quantity of grain in store at the start of the loss monitoring exercise
2) The quantities removed from store at specified intervals (this could be taken as monthly if more precise data not available). It is also important to know if any grain has been added as this may affect any loss estimation.
3) A weight loss value that can be attributed to each quantity removed from store, this is estimated using the grain remaining in the store at that time
4) The weight and loss associated with the grain that remains at the end of the storage period.

The example shown in Table 10.5 illustrates the data that might be collected in a losses study.

Table 10.5: An example of data collected in a loss assessment study of grain storage where grain is removed by the household at intervals, a loss value is assigned to the grain removed by assessing the grain removed in the store at roughly the same intervals as the removals

	Sampling Date	Quantity of grain removed/ left at end of storage	% weight loss by visual scale of grain in store
Start	2nd Feb	Store filled with 900kg of grain	0%
	2 March	70kg removed	0%
	2 April	90kg removed	0.25%
	2 May	150kg removed	0.75%
	2 June	130kg removed	1.8%
	2 July	190kg removed	2.6%
	2 Aug	60kg removed	5.2%
	2 Sept	72kg removed	9.7%
	2 Oct	55kg removed	15.0%
End	2 Nov	Grain remaining 47kg	20.0%

A cumulative loss is then computed using the method shown in Table 10.6.

Table 10.6: The calculation of a cumulative loss based on field data gathered at monthly intervals

Total quantity stored = 900 kg on 2 Feb										
Date	**02-Mar**	**02-Apr**	**02-May**	**02-Jun**	**02-Jul**	**02-Aug**	**02-Sep**	**02-Oct**	**02-Nov**	**Total**
Observed quantity removed (kg) (a)	70	90	150	130	190	60	72	55	47	864.0
% of grain removed (a/900) =(b)	7.8%	10.0%	16.7%	14.4%	21.1%	6.7%	8.0%	6.1%	5.2%	
Observed weight loss at each interval (c)	0.00%	0.25%	0.75%	1.80%	2.60%	5.20%	9.70%	15.00%	20.00%	
Weight loss as % of total stored (b*c)	0.00%	0.03%	0.13%	0.26%	0.55%	0.35%	0.78%	0.92%	1.04%	
Cumulative % weight loss	0.00%	0.03%	0.15%	0.41%	0.96%	1.31%	2.08%	3.00%	4.04%	
Total lost = 4.04% of 900kg = 900*0.404 = 36kg										

It may not always be possible to gather complete field data and it may be necessary to make assumptions about certain variables. For example, the data concerning grain removals may be incomplete so the researcher may have to assume a certain pattern of removals based on what farmers say is their own normal experience. So taking the example above, it might be assumed that the consumption pattern was even between the months. This would give the cumulative loss shown in Table 10.7. The loss here is greater because more grain is left until later in the storage season which is a time when losses are higher.

Table 10.7: The calculation of a cumulative loss based on field data but with an assumed consumption pattern

Total quantity stored = 900 kg on 2 Feb										
Date	**02-Mar**	**02-Apr**	**02-May**	**02-Jun**	**02-Jul**	**02-Aug**	**02-Sep**	**02-Oct**	**02-Nov**	**Total**
Assumed quantity removed (kg) (a)	100	100	100	100	100	100	100	100	54.0	854.0
% of grain removed (a/900) =(b)	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	6.0%	
Observed weight loss at each interval (c)	0.00%	0.25%	0.75%	1.80%	2.60%	5.20%	9.70%	15.00%	20.00%	
Weight loss as % of total stored (b*c)	0.00%	0.03%	0.08%	0.20%	0.29%	0.58%	1.08%	1.67%	1.20%	
Cumulative % weight loss	0.00%	0.03%	0.11%	0.31%	0.60%	1.18%	2.26%	3.92%	5.12%	
Total lost = 5.12% of 900kg = 900*0.0512 = 46kg										

The situation could be even more difficult. For example if only the beginning and end of storage are observed then it might be known what quantity entered storage (900kg) and what loss was observed at this time (0%) and then the store was visited again at only the end of storage when the quality remaining and loss have been observed. In this situation then the removal pattern would again be assumed on the same basis as before and a general rule of thumb applied to the rate at which insect infestation increases in store which would be that the first 3 month period suffers 15% of the losses, the second 3 month period 30% of the losses, and the final three months 55% of losses. Table 10.8 demonstrates the losses that are estimates in this case.

Table 10.8: The calculation of a cumulative loss based on field data but with an assumed consumption pattern and assumed pattern of loss based on the final % weight loss value

Total quantity stored = 900 kg on 2 Feb										
Date	02-Mar	02-Apr	02-May	02-Jun	02-Jul	02-Aug	02-Sep	02-Oct	02-Nov	Total
Assumed quantity removed (kg) (a)	100	100	100	100	100	100	100	100	37	837
% of grain removed (a/900) =(b)	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	4.1%	
Assumed/observed weight loss at each interval (c)	1.0%	2.0%	3.0%	5.0%	7.0%	9.0%	12.7%	16.3%	20.0%	
Weight loss as % of total stored (b*c)	0.1%	0.2%	0.3%	0.6%	0.8%	1.0%	1.4%	1.8%	0.8%	
Cumulative % weight loss	0.1%	0.3%	0.7%	1.2%	2.0%	3.0%	4.4%	6.2%	7.0%	
Total lost = 7.0% of 900kg = 900*0.069 = 63kg										

The losses are again somewhat higher due both to the assumed removal pattern and due to the fact that the loss values for the first three months are higher than actually observed in the field. However, the overall range of losses are not great 4.0 – 7.0% (in this example) and likely to fall within the range of individual household variation. When loss data like this are combined into a cumulative loss value for the postharvest chain the difference has only a relatively modest impact. Clearly it is better to work with a full data set from the household but estimation of this type is likely to provide a much better understanding of the true situation than just guessing, i.e. the loss value is not being taken as 20% which would have been wildly inaccurate.

The visual scale can be used to assess losses in storage and some other situations, but other techniques are required when dealing with most grain held elsewhere (see **Chapter 11**).

10.10 Estimating quality losses with the visual scale

The visual scale offers a means of determining quality loss, especially if the class values reference directly to a formal grading system, e.g. class 1 = grade 1, class 2 = grade 2, class 3 = grades 3 and 4. The method for determining the class value is the same as for determining the weight loss as described in **Section 10.6**. The weighted average class value must then be expressed in terms of its equivalent formal grade (if the visual scale has been constructed so that this can be done).

Once the classes of grain held by farmers or farmers' groups have been identified then a market value, or loss of market value, can be assigned to the grain. The time chosen for grain sales does not necessarily coincide with maximum grain prices but varies considerably according to farmers' cash needs, storage capacity and the shelf-life of the grain (a function of initial quality and storage method). Nevertheless assessment of economic loss is possible and an approach to this has been described by Adams and Harman (1977). A copy of this report can be downloaded from the NRI Postharvest Loss Reduction website (http://www.postharvest.nri.org), see the 'Text books and Reports' tab.

This chapter has focused on how to assess grain losses during storage. The next chapter deals with losses at other links in the postharvest chain.

11. Loss assessment - measurements at other links of the chain

In the literature describing postharvest losses of cereal grains, the majority of loss estimates are figures for storage losses (Fig. 5.1). Figures for losses at other links of the chain are relatively scarce. There are two reasons for this. The first is that loss assessment has generally been undertaken when there is a project to actually improve an aspect of the postharvest system and links other than storage have rarely been the subject of such improvement projects. The second reason concerns the difficulty of making the estimates. As farm stores are protected, discrete entities, assessing the losses associated with them is relatively easy, but nevertheless it is still a time-consuming and expensive job.

Accounts of approaches to loss assessment for other links in the postharvest chain are given below. These are general guidelines rather than precise recipes of what to do. This allows researchers to at least propose a general plan for loss assessment while a fully detailed procedure will have to be developed when the nature of the situation is fully understood.

To show how a loss assessment study might be designed, an example of a plan is given in the **Section 11.7**.

11.1 Harvesting and field drying

Harvesting by smallholders in Africa is almost always done by hand (Fig. 11.1). Losses at the time of harvest arise from two sources, 1) the scattering of grain (or shattering if the grain falls from the seed head) due to a combination of the method of harvest, the type and variety of crop and its maturity, and 2) the grain that is not harvested, i.e. remains on the plant. Crops harvested too late suffer much greater scattering losses, they may also suffer losses due to bird attack and this can be estimated separately by estimating the weight of grains missing from panicles or heads at time of harvest. To allow further drying, the crops may also be stacked or 'stooked' in the field and further losses may occur due to more scattering and consumption by pests (insects, rodents and birds).

Figure 11.1: Harvesting the crop

Loss assessment at harvesting is potentially a very time consuming process. The basic approach is to measure the potential yield of the crop. There are two ways to do this.

1) To harvest a test area very carefully, avoiding scattering losses and grain remaining on the plant, or

2) To collect up (glean) the grain that has fallen on the ground and the grain that is still attached to the plant then add these back into the actual yield of threshed grain to give the potential yield.

The advantages and disadvantages of each approach are discussed by Boxall (1986); both present difficulties. It is also important in any study to make it quite clear on what basis the loss is being expressed. First, is the loss being calculated as a percentage of the potential or of the actual yield? Boxall (1986) considers that it is more appropriate to express the loss as a % of the food available at harvest, so loss as a percentage of the actual yield is probably justified. Also, is the harvesting loss only grain scattered at the time of harvest or does it also include sound and mature grain left on the mature plant during the harvesting operation? Have other losses, such as grain removed by birds or termites been included (although it is often difficult to distinguish between bird losses and those resulting from shattering).

The losses that happen during the stooking and stacking of grain in the field should be included as part of the harvesting operation. Hence in APHLIS the first category of postharvest loss is 'Harvesting and Field Drying'. A simple approach to determining the extent of these losses is to place a plastic sheet under the stacks or stooks and weigh the grain that collects on the sheet. However, there may also be some biodeterioration were a visual scale could be used to estimate losses. One special category of biodeterioration, rotting grain, is a particular problem when the harvest is close to a wet season that commences before harvesting is completed. The damp cloudy weather prevents the harvested crop, or even the crop still on the plant, from drying. Consequently, the grain suffers mould attack that renders it unfit for human or even animal consumption. This may be an increasing problem as climates become more variable as a result of climate change. Determining losses in this case can be done relatively easily. Farmers need to be encouraged to place their damaged seed heads in sacks (these need to be provided by the loss assessment project) and from this the proportion of damaged grain can be easily estimated (see example of loss assessment **Section 11.7**).

11.2 Platform drying

Prior to threshing, grain may be subject to further drying in and around the homestead. The seed heads may be hung on racks, placed on specially constructed platforms or in drying cribs (Fig. 11.2).

Figure 11.2: A improved drying crib

These are effectively grain storage situations and loss could be determined by the use of visual scales to estimate losses due to biodeterioration, while sheets and gleaning can be used to collect scattered/spilt grain.

11.3 Threshing/shelling and winnowing

Losses at threshing (Fig. 11.3) may arise because the threshing is incomplete (i.e. some grain remains on the seed head), the grain is scattered and spilled, or the grain becomes damaged in the process. In the case of winnowing the loss arises from scattering.

Figure 11.3: Grain threshing/shelling

Assessing grain that remains on the seed head (cob, panicle) can be done fairly easily by sampling heads at random after threshing/shelling and counting and weighing the remaining grain. Then for comparison, a sample of the same number and size of heads can then be carefully threshed so that the weight of grain after complete threshing is known. It may be necessary to take the moisture content of the two samples and adjust them to a standard moisture content (normally 14%, see Table 11.1) if there is likely to be a difference in moisture content between them. The weight loss is expressed as the weight of the sample remaining after threshing as a percentage of the weight of completely threshed grain.

To estimate grain scattered during threshing a large plastic sheet can be spread in the area to catch such grain, which can then be collected and weighed. The loss should be expressed as the weight of scattered grain as a percentage of the weight of grain successfully threshed plus the scattered grain.

11.4 Drying

Smallholders in Africa normally only use sun drying for their cereal crops (Fig. 11.4). To measure physical losses of grain during drying, the amount of grain entering and leaving this part of the system could be measured. For example, grain may be weighed before and after sun drying and the difference would be the loss due to spillage, scattering, removal by birds, wind etc.. It is important to remember that drying losses do not include changes in moisture content, so the grain weights before and after drying should be adjusted to standard moisture content (14%, see Table 11.1). It is therefore important to have access to a good moisture meter to check on moisture content.

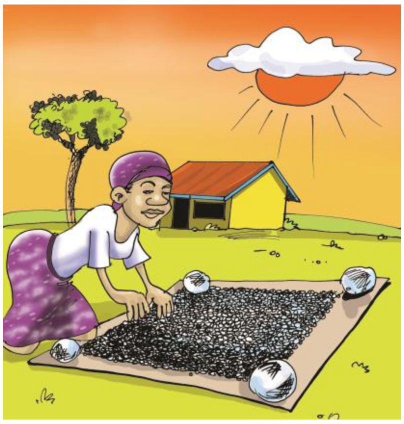


Figure 11.4: Sun drying the crop

Drying losses of paddy grain need separate consideration since grain damage at drying can result in a significant increase in broken grains, which has a negative impact on the value of rice. For more details of loss assessment of rice during drying consult Boxall (1986).

Table 11.1: Conversion factors to obtain grain weights at 14% moisture content*

% Moisture content	Multiply by - 0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
8	1.0698	1.0686	1.0674	1.0663	1.0651	1.0640	1.0628	1.0616	1.0605	1.0593
9	1.0581	1.0570	1.0558	1.0547	1.0535	1.0523	1.0512	1.0500	1.0488	1.0477
10	1.0465	1.0453	1.0442	1.0430	1.0419	1.0407	1.0395	1.0384	1.0372	1.0361
11	1.0349	1.0337	1.0326	1.0314	1.0302	1.0291	1.0279	1.0267	1.0256	1.0244
12	1.0233	1.0221	1.0209	1.0198	1.0186	1.0174	1.0163	1.0151	1.0140	1.0128
13	1.0116	1.0105	1.0093	1.0081	1.0070	1.0058	1.0047	1.0034	1.0023	1.0012
14	1.0000	0.9988	0.9977	0.9965	0.9953	0.9942	0.9930	0.9919	0.9907	0.9895
15	0.9884	0.9872	0.9860	0.9849	0.9837	0.9826	0.9814	0.9802	0.9791	0.9779
16	0.9767	0.9756	0.9744	0.9733	0.9721	0.9709	0.9698	0.9686	0.9674	0.9663
17	0.9651	0.9641	0.9628	0.9616	0.9605	0.9593	0.9581	0.9569	0.9558	0.9547
18	0.9535	0.9523	0.9512	0.9500	0.9488	0.9477	0.9464	0.9452	0.9442	0.9430
19	0.9419	0.9408	0.9395	0.9384	0.9372	0.9360	0.9349	0.9337	0.9326	0.9314
20	0.9302	0.9291	0.9279	0.9267	0.9256	0.9244	0.9233	0.9221	0.9209	0.9198
21	0.9189	0.9174	0.9163	0.9151	0.9140	0.9118	0.9116	0.9105	0.9093	0.9081
22	0.9070	0.9058	0.9047	0.9035	0.9023	0.9012	0.9000	0.8988	0.8977	0.8965
23	0.8953	0.8942	0.8930	0.8919	0.8907	0.8895	0.8884	0.8872	0.8860	0.8849
24	0.8837	0.8826	0.8814	0.8802	0.8791	0.8779	0.8767	0.8766	0.8744	0.8733
25	0.8721	0.8709	0.8698	0.8686	0.8674	0.8663	0.8651	0.8640	0.8626	0.8616
26	0.8605	0.8593	0.8581	0.8570	0.8558	0.8547	0.8535	0.8523	0.8512	0.8500
27	0.8488	0.8477	0.8465	0.8453	0.8442	0.8430	0.8414	0.8407	0.8395	0.8384
28	0.8372	0.8360	0.8349	0.8337	0.8326	0.8314	0.8302	0.8291	0.8279	0.8267
29	0.8256	0.8244	0.8233	0.8221	0.8209	0.8198	0.8186	0.8174	0.8163	0.8151
30	0.8140	0.8128	0.8116	0.8105	0.8093	0.8081	0.8070	0.8058	0.8047	0.8035
31	0.8023	0.8012	0.8000	0.7988	0.7977	0.7665	0.7953	0.7942	0.7930	0.7919
32	0.7903	0.7895	0.7884	0.7872	0.7860	0.7849	0.7837	0.7826	0.7814	0.7802

Source: Toquero 1981 * For example if there is 10 MT of grain at 16.3% moisture content then at 14% mc the weight of the grain would be 9.733 MT (10 MT x 0.9733 = 9.733 MT)

11.5 Transport

A variety of means of transport are used to move grain from the field to farm and farm to market (Fig. 11.5). The measurement of losses during transport requires careful collection of scattered grain or weighing of grain bags at the two geographical ends of the transport process. Weighing at start and finish is likely to be the easier option provided accurate scales and labour are available. If transport is relatively rapid, e.g. done within a 24h period, then no adjustments for moisture content change are likely to be needed. Otherwise, weights before and after transport should be adjusted to standard moisture content (14%, see Table 11.1).

Figure 11.5: Various means of transport from field to farm, from farm to market

11.6 Collection point, market and large-scale storage

Assessing the grain losses at sites where Farmers' Groups and Co-operative etc. aggregate their grain, in market stores and in large-scale stores, can be challenging. The sources of loss are usually two-fold, grain discarded due to sorting/conditioning, and grain loss due to biodeterioration from insects, water leakage into the store etc..

Figure 11.6: A collection point store, the first aggregation point for farm produce

Grain sorting and conditioning is undertaken in order to raise grain quality to a standard at which it can be marketed; usually in order to comply with a specified grade in a formal trading standard. This can result in a considerable loss, since the grain that is removed in this process is often not fit for human consumption. Although, the damage to this grain will have accrued at earlier stages in the postharvest chain the actual weight loss is realized at this stage. The loss can be measured by following grain in the system and first measuring the gross weights of grain entering the system and then measuring the weight of good grain that comes out. For example, this could be done by following specific bags of grain submitted to the system by a particular farmer and observing how much remains after conditioning. Additional grain drying is often part of the conditioning process so correction of weights to a standard moisture content (14%) is important (see Table 11.1).To obtain a measure of loss due to biodeterioration, it is necessary to make an assessment of the grain soon after arrival at the store. If possible, samples should be taken from grain bags as they enter the store. The sample should be taken with a grain spear (see **Section 8.4**). Decide on the number of samples to take by reference to **Section 8.4**. The condition of the grain can be determined using a visual scale **(Chapter 10)**. The grain will be sampled again at appropriate intervals (not more than monthly) and samples taken at random from the accessible outer layers of bags. Weight loss and in quality loss are monitored using the visual scale, but these will not be the only losses. A careful watch has to be kept on the grain that is discarded. This may be the sweeping of spilt grain (which in a well-run store would be carefully reconditioned and returned to a sack set aside for the purpose) or grain that has been damage for one reason or another, especially water leaking from the roof. These other sources of loss are likely to be small compared with the general change in grain quality over time.

11.7 Example - determining maize losses due to damp weather at harvest

In this particular example, a project wanted to help Farmers' Groups to supply traders with more and better quality maize grain. The significant postharvest loss points were expected to be:

1) At harvest time when some of the crop is exposed to damp weather making drying difficult. This leads to damp cobs, grain damaged by mould, and insect infestation.
2) Grain breakage at time of shelling due to poor shelling technique.
3) Once shelled, grain is still not sufficiently dried and held in farm stores at high moisture content (15-16%) for delivery to traders or eventually for self-consumption.
4) The traders receiving poor quality grain, sieve out and/or handpick to remove poor grain to make the quality acceptable to clients. The removals are a grain loss (even if fed to chickens).

Item 1) must be monitored since any losses due to discarded maize cobs will not be reflected elsewhere in the system. Item 2 (broken grain) and item 3 (high moisture grain) can monitored by observations of grain in farm stores over the storage season and item 4 can be assessed at the traders warehouses.

Data on losses were to be collected by individual farmers under instruction of lead famers who had excelled in previous training activities. In each participating Farmers' Group, three members who have been trained were selected to help gather data. This data should be from their own farms and from two other 'average' farmers.

<u>Data to be gathered</u>

1st July to 31st August– Harvesting pattern and damage at harvest (see Data Sheet 1)

a. Note prevailing weather conditions daily – dry sunny, dry cloudy, wet cloudy, each day for the whole period.
b. When harvesting cobs, remove husk cover and use the usual method to sort cobs into good and bad. Place those cobs that are too damaged for human consumption in polypropylene bags provided. Count the number of bags of bad cobs and record for each day. Keep the bags of bad cobs for verification by the supervisor[5] and check on grain moisture content. Continue in the same way until the harvest is complete (records will show harvesting pattern).
c. After shelling good cobs, count the number of bags of grain produced and record daily.

[5] Supervisor will convert the number of bags of damaged cobs into the equivalent number of bags of grain (and grain weight at 14% moisture content), so that the % lost grain can be calculated. For the loss calculation it will be assumed that the size of damaged cobs and size of good cobs is the same.

d. Record the pattern of grain bags marketed. For example bags of grain sent to traders.

1st July to 31st October – weight loss incurred at traders warehouse in order to achieve required quality (see Data Sheet 2)

e. At the traders' warehouses, monitor grain cleaning to meet quality requirements. Weigh a bag of grain before processing and recorded grain moisture content. Complete the processing procedure (sieving/hand picking) then place the good grain back in the bag, weigh it and record moisture content. If possible, do this for at least two bags from each farmer. Record some information about what will happen to the poor quality grain that is removed (its end use).

1st July to 31st March – weight loss in farm storage (see Data Sheet 3)

f. At each visit record the amount of grain that has been consumed by the household since the previous visit.

g. Record the change in grain weight loss and quality in farm store at monthly intervals. Do this using a visual-scale for up to 5 bags in each household. Where possible sample and assess grain from the same bags on each visit. Assess the condition of the grain by rating it on the visual scale giving a class value for both weight loss and grain quality.

The data sheets constructed for the collection and recording of the data are shown on the following pages.

Data sheet 1 – Harvesting, shelling and marketing of maize grain

Month: July Farmer: ....
Trader: ....

Date	**Weather** Wet = W Cloudy =C Dry = D Sunny = S	**No. bags damaged cobs**	**No. bags of good shelled grain**	**Bags of grain marketed to traders etc.**
1 July				
2 July				
3 July				
4 July				
5 July				
6 July				
7 July				
8 July				
9 July				
10 July				
11 July				
12 July				
13 July				
14 July				
15 July				
16 July				
17 July				
18 July				
19 July				
20 July				
21 July				
22 July				
23 July				
24 July				
25 July				
26 July				
27 July				
28 July				
29 July				
30 July				
31 July				

Data sheet 2 - Loss of grain during processing at the traders warehouse

Trader: ....
Province: ....

Date	Name of farmer	Wt of grain in bag before processing (kg) and grain moisture content		Wt of grain in bag after processing (kg) and grain moisture content		Weight of grain lost corrected to 14% moisture content	% weight loss at 14% moisture content
End-use for discarded grain =							
End-use for discarded grain =							
End-use for discarded grain =							
End-use for discarded grain =							
End-use for discarded grain =							
End-use for discarded grain =							
End-use for discarded grain =							
End-use for discarded grain =							

*End-use is the purpose to which the discarded grain will be put, e.g. animal feed, destroyed (burnt/buried), brewing etc.

Data sheet 3 - Household grain storage and consumption pattern
(Monitoring up to 5 bags using visual-scale, farmers to be encouraged to consume/market these five bags last)

Record card for one household

Farmers' group:	Swedru									
Household name	: Kambale									
Province: Eastern										
No. members in household = 5										
No. bags of grain reserved for HH consumption at harvest = 12										
Date of visit	**Grain consumed per month (kg)**	**Visual scale assessment of grain weight and quality loss**								
		Bag 1		**Bag 2**		**Bag 3**		**Bag 4**		**Bag 5**
		Vis. scale classes Wt loss : Quality	Bag wt (kg)	Vis. scale classes Wt loss : Quality	Bag wt (kg)	Vis. scale classes Wt loss : Quality	Bag wt (kg)	Vis. scale classes Wt loss : Quality	Bag wt (kg)	Vis. scale classes Wt loss : Quality
Start	0	Class 1: Class 1.5	50	Class 1: Class 1	50	Class 1: Class 1	50	Class 1.5: Class 1	50	Class 1: Class 1
Month 1	50kg	Class 1: Class 1.5	50	Class 1: Class 1	50	Class 1: Class 1.5	50	Class 1.5: Class 1	50	Class 1: Class 1
Month 2	75kg	Class 1: Class 2.0	50	Class 1: Class 1	50	Class 1: Class 2	50	Class 1.5: Class 2	50	Class 1: Class 1.5
Month 3										
Month 4										
Month 5										
Month 6										
Month 7										
Month 8										
Month 9										

Date of visit	Bag 5 Bag wt (kg)
Start	100
Month 1	100
Month 2	100
Month 3	
Month 4	
Month 5	
Month 6	
Month 7	
Month 8	
Month 9	

Resource implications

The project would face a number of costs to implement the loss assessment exercise.

Field team costs

Field team staff fees and transport costs were a major expense. Their time inputs were as follows -

Date	Activity	Time required
May	Visit 8 Farmers' Groups, identify lead farmers (3/Group) and agree their participation	4 days
June	Train lead farmers, 3 from each group	8 days
July	2 monitoring visits to each Farmers' Group and to traders stores (mid-month, end-month)	8 days
August	ditto	8 days
September	ditto	8 days
October	1 monitoring visit to each Farmers' Group (mid-month, end-month)	4 days
November	ditto	4 days
December	ditto	4 days

Incentive payments to lead farmers

Incentive payments to the lead farmers were considered necessary to ensure their assistance. Advice was taken from the field team on the level of payment and its frequency. It proved a better incentive to offer a small interim payment followed by a final lump sum than say to pay a monthly retainer. There were 24 lead farmers each was paid US$10/month, for the 6 month loss assessment exercise (July – Dec) this gave a total to US$1,440. The individual farmer could be paid an interim of 25% in September (US$15) and the rest in December (US$45). However, it should be noted that in some countries there is a policy not to pay farmers cash for this type of service as it may create unrealistic expectations on the part of farmers offered involvement in future projects.

Polypropylene bags

About 360 polypropylene bags were supplied to farmers for them to store rotten cobs at harvest time. Costs were US$1.5 per bag when purchased second hand from the local market.

Part 4 - For the Future

12. Future developments – moving to APHLISplus

Reducing postharvest losses across and along value chains can have a huge impact on incomes, food availability, nutrition, health (through food safety) and the environment (through more efficient resource use). To achieve this aim requires that postharvest management of smallholder agriculture is optimised. APHLIS can be a major contributor if developed into a communication hub that informs, motivates and co-ordinates efforts to reduce postharvest losses. APHLIS could provide practitioners with

- comprehensive data on losses as well as the prediction of certain postharvest problems,
- systematic approaches to the analysis of loss reduction opportunities,
- the facilities for country-level narratives that express the nature of loss problems and how these can be resolved, and
- the implementation of information exchange between relevant value chain networks and networks of smallholders to generate a bottom-up Community of Practice.

The food crisis of the 1970s prompted the creation of a largely donor-driven Community of Practice called the Group for Assistance on Systems Relating to Grain After Harvest (GASGA). This was later expanded to become The Global Postharvest Forum (P*h*Action) by including a wider remit of food crops. Following the food crisis, food prices fell in real terms throughout the 1980s and 1990s. As a result the international community lost interest in agricultural development and in the early 2000s P*h*Action fell into abeyance. However, interest has been rekindled with the advent of the 2006/08 food crisis (see **Section 1.2**). A new vision of APHLIS, that we call APHLISplus, could offer a bottom up Community of Practice when connected to appropriate means of information exchange (Fig. 12.1). This chapter describes some elements of the new vision.

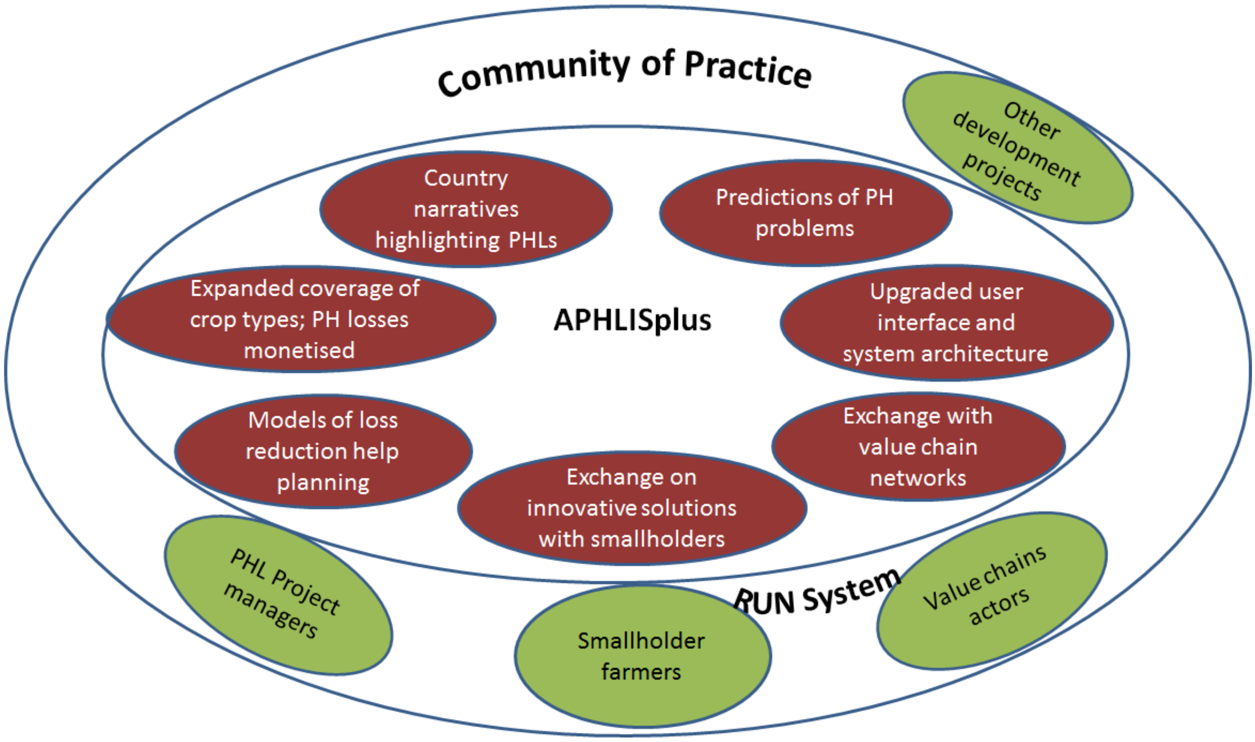


Figure 12.1: APHLISplus - a vision of an expanded APHLIS that becomes the medium for the creation of a new bottom-up Community of Practice focused in postharvest loss reduction

12.1 Broadening the scope from cereals to other food crops

APHLIS is currently operational for the delivery of weight losses estimates for cereals. It could include other food crops based on either the same approach as currently used for cereals or by the development of new approaches. A decision on feasibility and how this should be tackled is required on a case by case basis following careful consideration by crop experts. It is suggested that the initial priorities should be pulses (common bean, groundnut, cowpea and soya), these have similar postharvest characteristics to cereals and, roots and tubers (cassava, yam and sweet potato), these are more perishable and would present a new and interesting challenge.

12.2 Monetising loss estimates

APHLIS currently focuses on cereal weight losses that are not expressed as a value loss (monetary value). If weight loss and quality losses could also be monetized then there would be a common denominator for both types of loss (see **Section 1.6** **&** **1.7**). They could then be summed to express an overall postharvest loss. In the few studies that have compared the monetary value of weight losses with those of quality losses, quality loss value has exceeded that of weight losses (Adams and Harman, 1977; Compton *et al*. 1998). Thus there remains a considerable opportunity to display the true significance of postharvest losses and assess both their financial and economic impacts.

To proceed with the inclusion of value loss in APHLISplus requires careful consideration of the feasibility of determining both the value of weight loss and of quality loss; suitable methodologies are required. To make estimations of monetary loss due to weight loss is fairly simple once there is agreement on the price of the lost grain. One approach to this could be to adopt a range of grain prices reflecting different marketing options at a chosen time of year, and then to quote a range of potential monetary loss values. The availability of such price data would be limited, but the conversion of weight loss into monetary loss could be undertaken on a demonstration basis, at least until such data are more readily available. Much more complex would be to ascribe a monetary value to quality changes. To do this it would be necessary to be able to determine the amount of grain that declines from say grade 1 to grade 2, and then to be able to put a price on the two grades. Currently we have no way of knowing about the decline in grades, furthermore grades generally do not have fixed prices. Indeed grade 2 late in the season may be selling for higher prices than grade 1 soon after harvest.

12.3 Improving the quality and availability of data

APHLIS relies heavily on 'seasonal' data (see **Section 3.5**) that contribute to loss calculations. Variations in these data give the intra- and inter-annual variations in the calculation of losses (since the loss profiles remained fixed over relatively long periods). Currently all data is submitted by APHLIS Network members. However, there could be considerable improvements in efficiency and accuracy of data gathering. In particular, APHLISplus could -

1) download weather data (rainfall, cloud cover, humidity and temperature) from automatic collection sources. Since there is no extensive, high-quality network of weather stations in Africa, exploring the potential of downscaling analytical data sets like the ECMWF re-analysis or high resolution precipitation reconstructions are of interest. A sufficiently calibrated data set would allow coverage of large areas of land going back multiple decades.
2) pilot use of data collected in secondary administrative units (districts) rather than at the centralised level of the Province. This could be collected using the RUN System (see **Section 12.7**)

12.4 Predicting postharvest problems using new data

Besides improving the quality and rate of supply of seasonal data, automatically downloaded weather data could be used as the basis for predicting certain postharvest problems, especially those associated with crop drying, crop drought stress, Larger Grain Borer, and climate change.

12.4.1 Drying problems, drought stress and mycotoxin contamination

Automatic supply of detailed weather data combined with a knowledge of the timing of cereal harvests could be used to highlight those areas of Sub-Saharan Africa that are experiencing difficulty in sun drying. This would indicate those areas where losses would be elevated and also where growth of the fungus *Aspergillus flavus* may be leading to the production of aflatoxin; there may indeed by other fungi and other mycotoxins (see **Section 2.2**). APHLIS may then be able to offer warning maps of areas where conditions would favour fungal infection. These outputs could be linked into current projects on mycotoxin reduction such as PACA[6] (Partnership for Aflatoxin Control in Africa).

Drought stress during the growth phase of crops is also well known to favour infection by *A. flavus* and consequent aflatoxin contamination. This contamination passes along the food chain and would usually only become apparent at the time of postharvest testing. There are advantages in knowing the likelihood of the occurrence of contamination. In the case of maize and groundnuts the conditions that result in plant drought stress and subsequent formation of aflatoxin are reasonably well known (Chauhan *et al.*, 2008). For APHLISplus there is an opportunity to use monitoring systems such as ASIS (Agricultural stress index) developed by FAO and JRC[7] to model the occurrence of aflatoxin risk due to drought stress and to provide maps and alerts. These would be complementary to the risk warning based on the identification of locations where there are problems in drying.

12.4.2 Larger grain borer attack

Automatically weather data downloads may be used to predict those years where the Larger Grain Borer (*Prostephanus truncatus)* is a severe problem. This beetle is a very significant pest of farm stored maize (see **Section 2.2 and 5.3**) and an existing rule-based climate model of its flight behaviour (Hodges *et al*., 2003) could be used to predict locations likely to be experiencing LGB outbreaks. These predictions can be used to support the seasonal data currently submitted by APHLIS Network members, to advise current projects focusing of smallholder grain storage, and to formulate plans for new loss reduction initiatives.

12.4.3 The impacts of climate change

Automatically weather data downloads can contribution to an understanding of the impacts of climate change. Future climates are likely to become more variable and this implies greater difficulty in planning agricultural activities, including crop drying. Data would be available to show changes over time and the scale of the problem, such as comparison maps between seasons and years. This would contribute to projects dealing with climate change adaption for smallholder farmers.

12.5 Filling some gaps in postharvest loss profile data

The PHL profiles on which the APHLIS Calculator operates are derived from a relatively small set of data (see **Chapter 5**). New loss data that broaden the base of loss calculation are welcomed for inclusion in APHLIS provided they are generated using reliable methodologies. Priorities for the generation of any new loss data

[6] http://www.aflatoxinpartnership.org/

[7] http://www.fao.org/giews/earthobservation/asis/index_1.jsp?lang=en

should reflect the fact that there is variation in the degree of impact that different links in the postharvest chain have on loss values; some links result in greater losses that others.

One especially important postharvest link is harvesting and field drying; this can be very badly affected by damp weather. Poor weather at harvest leads to drying problems that result in losses at harvest and at subsequently links. For maize losses due to rain at harvest, APHLIS currently relies on a single study that was undertaken in Swaziland in 1982 and 1983. Further studies are required to confirm the applicability of Swaziland data to other locations in SSA and to offer a range of loss values depending on the extent of poor weather. These studies could be undertaken during field validation of the prediction of the areas affect by rain at harvest and potential mycotoxin contamination (see **Section 12.4.1**). The type of loss assessment approach required for this study is described in **Section 11.7**.

12.6 Develop information tools to assist loss reduction planning

The expansion of APHLIS to become an information hub on postharvest losses can be achieved by the development and addition of features that can be accessed through the APHLIS website. Two areas are suggested. First the development of systematic approaches to the analysis of loss reduction opportunities that connect loss values, technology efficiency and adoption potential. Some moves in this direction have already been made. A preliminary model is available on the website of the 'Postharvest Loss reduction centre at NRI'[8]. Second, the improvement of the template and methodology for Country Narratives (see **Chapter 6**) is required to make them easier to create and more comprehensive to reflect the higher profile of APHLIS in loss reduction. These narratives would become the voice of the APHLIS Network in highlighting losses and suggesting how these could be reduced.

12.7 Information exchange within the Community of Practice

To support a bottom up Community of Practice, APHLIS must create a two-way flow of information with those people working at all levels in the value chains for the commodities covered by APHLIS (assuming these will be expanded beyond cereals). Broadly there would be two groups, smallholder farmers and their associations at the base and then other value chain actors such as trader, millers, input suppliers and those within government responsible for regulation.

Reaching out to these groups requires direct personal contact and should be a two-way exchange. On one hand the opportunities for loss reduction need to be disseminated, on the other the success of these initiatives and measures of loss reduction achieved are required. These measures can be accumulated in APHLIS and displayed as evidence. Ultimately this evidence would be used to co-ordinate further efforts to improve the efficiency of postharvest management as they spread through the Community of Practice. Finally, APHLIS requires data to make its own loss estimation and the rich data sources at secondary level (i.e. in districts rather than at provincial level) should be tapped.

A novel means of implementing the two-way information flow described above is by the use of the RUN-system[9]. This trains young professionals (YPs) in Africa to deliver specific services for the collection of certain data or for the dissemination of information upon the request of an actor in the innovation system. On the completion of tasks the YPs receive a voucher that is redeemable for cash. The system has many advantages. These include accomplishing tasks at relatively low cost, using local people to solve local problems, and it offers employment to suitably qualified young people who are otherwise unemployed or under-employed.

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[8] http://postharvest.nri.org/losses-information/analysing-losses

[9] http://www.erails.net/FARA/erails2/erails2/the-run-system/

The expansion of APHLIS to APHLISplus will bring modern ICT to bear on the problem of postharvest loss reduction, it will provide a cost-effective means to collect data and disseminate results, and with scaling out will have significant impacts on postharvest management and the livelihoods of smallholder farmers.

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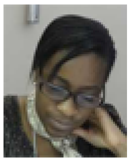
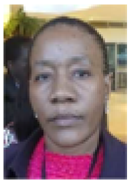
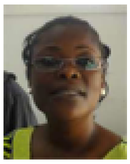
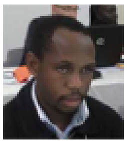
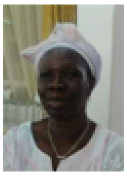
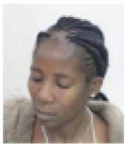
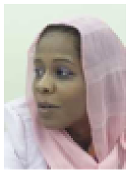
Annex 1 – The APHLIS Network members

APHLIS phase 3: National Contact Persons of the Network					
#	Country	Name	Institute	Acronym	
1	Angola	Elsa Hermina GASPAR	Ministério da Agricultura, do Desenvolvimento Rural e das Pescas	MINADER	
2	Benin	Patrice Ygué ADEGBOLA	Institut National des Recherches Agricoles du Bénin	INRAB	
3	Botswana	Rebecca HANGE	Ministry of Agriculture		
4	Burkina Faso	Djibril YONLI	Institute of Environmental and Agricultural Research	INERA	
5	Burundi	Cyrille HICINTUKA	Institut des Sciences Agronomiques du Burundi	ISABU	
6	Cameroon	Alfred Bekwake NWEGUHE	Institute of Agricultural Research for Development	IRAD	
7	Chad	Dastre ALLARANGAYE	Institut Tchadien de Recherche Agronomique pour le Developpement	ITRAD	
8	Côte d'Ivoire	Adjoua Solange N'GUESSAN ÉPOUSE KOUAMÉ	Université de Bouaké		

9	**DRC**	Jean Pierre Jos MULAMBA	Institut National pour l'Etude et la Recherche Agronomiques	INERA	
10	**Eritrea**	Solome HAILE8 (to be confired)			
11	**Ethiopia**	Solomon TSEGA ASSEFA	Ethiopian Institute of Agricultural Research	EIAR	
12	**Gambia**	Ansumana K. JARJU	National Agricultural Research Institute		
13	**Ghana**	Amatus DEYANG	Ministry of Food and Agriculture	MFA	
	Germany	Marc BERNARD	Federal Office for Agriculture and Food	BLE	
14	**Guinea**	Mamy KEITA	Système d'Information sur les Produits Agricoles en Guinée	SIPAG	
15	**Guinea-Bissau**	Ildo Afonso LOPES	Ministry of Agriculture and Rural Development	MADR	
16	**Kenya**	Kimondo MUTAMBUKI	Kenya Agricultural Research Institute	KARI	
	Kenya	Felix REMBOLD	Joint Research Centre	JRC-EU	

17	**Lesotho**	Thabo PITSO	Disaster Management Authority	DMA	
18	**Liberia**	David KOLLEH	Central Agricultural Research Institute	CARI	
19	**Madagascar**	Francine RASOLOFONIRINA	Ministère de l'Agriculture	Minagri	
20	**Malawi**	Charles SINGANO	Department of Agricultural Research Services		
21	**Mali**	Oumou TRAORÉ	Institut d'Economie Rurale	IER	
22	**Mauritania**	Mamoudou KANÉ	Ministère du Développement Rural	MDR	
23	**Mosambique**	Isabel MONJANE	Instituto de Investigação Agrária de Moçambique	IIAM	
24	**Namibia**	Magdelena HANGULA	Ministry of Agriculture, Water and Forestry		
25	**Niger**	Maman GARBA	Institut National de la Recherche Agronomique du Niger	INRAN	

25	**Niger**	Maman GARBA	Institut National de la Recherche Agronomique du Niger	INRAN	
26	**Nigeria**	Patricia Onoghoete PESSU	Nigerian Stored Products Research Institute	NSPRI	
27	**Rwanda**	Epiphanie KAREKEZI	Ministry of Agriculture and Animal Resources		
28	**Senegal**	Cheikh THIAW	Institut Sénégalais de Recherches Agricoles	ISRA	
29	**Sierra Leone**	Ahmed NANOH	The Sierra Leone Chamber for Agribusiness Development	SLeCAD	
30	**Somalia**	Kamau WANJOHI	FAO	FFSNAU	
31	**South Africa**	Wiltrud DURAND	Department of Agriculture, Forestry and Fisheries	DAFF	
32	**Sudan**	Hala ELAMEIN	Agricultural Research Corporation	ARC	

34	**Swaziland**	Sunshine, Monduzi GAMEDZE	Ministry of Toursim and Environmental Affairs		
35	**Tanzania**	Moses L. BAYINGA	Ministry of Agriculture Food Security and Cooperatives	MAFC	
36	**Togo**	Samou SIDI-TOURÉ	Institut Togolaise de Recherche Agronomique	ITRA/Cacaveli	
37	**Uganda**	Eria BWANA-SIMBA	National Agricultural Research Organisation	NARO	
	United Kingdom	Rick HODGES	Natural Resouces Institute	NRI	
38	**Zambia**	Michael ISIMWAA	Ministry Agriculture and Livestock	MAL	
39	**Zimbabwe**	Brighton MVUMI	University of Zimbabwe		

Annex 2 – Farm store types with different degrees of ventilation

Traditional stores	Modern stores


High ventilation


Restricted airflow


Airtight stores

Annex 3 - Interview form for the collection of APHLIS seasonal data

This form is the basis for an interview with experienced individuals to gather data about agricultural factors that vary from season to season. These factors affect the weight losses calculations of APHLIS.

The interview is expected to last about 40 minutes and may either be 'face to face' or done over the phone. Before proceeding with the interview, the interviewer should establish that the interviewee has sufficient experience to be able to answer the questions with a reasonable degree of accuracy. If not an alternative interviewee should be sought.

Year of observation:

A. Interviewee details

Name: ....

Length of time working in this area: ....

Description of position in organisation: ....

Main area of expertise: ....

Name of interviewer: ....

Date of interview ..../......../.......

B. Context

1. Which area are we covering in this interview? (circle then add names below)

Agric. extension unit, District (s) Province Other

___________________ _________________ __________________ _______________

2. Year of observation:___________________

3. Which crops are important and for which you could give us information? (tick)

Maize		Rice		Sorghum		Millet	
Wheat		Barley		Teff		other	

4. What proportion of farmers cultivate each of the crops in the area you are considering? (insert % of farmers for each crop)

Maize		Rice		Sorghum		Millet	
Wheat		Barley		Teff		other	

5. How many harvests are there each year for each of the important cereal crops and in which month is the harvest?

Crop	**Number of harvests**	**Month of harvest 1**	**Month of harvest 2**	**Month of harvest 3**
Maize				
Rice				
Sorghum				
Millet				
Wheat				
Barley				
Teff				
Other				

6. Are there smallholder and/or large scale farmers in your area? ('Y' or 'N')

Crop	**Smallholder**	**Large scale**
Maize		
Rice		
Sorghum		
Millet		
Wheat		
Barley		
Teff		
Other		

C. Seasonal factors

Rain at harvest

1. Do farmers experience rainfall or damp cloudy conditions at harvest? (mark 'Y' or 'N')

Crop/harvest number	**Smallholder/ season**			**Large scale/ season**		
	1	2	3	1	2	3
Maize						
Rice						
Sorghum						
Millet						
Wheat						
Barley						
Teff						
Other						

1b) Was this year (season) different from previous years (seasons) and if so what was the difference? Record any details.

2. If there was rainfall or damp cloudy conditions at harvest then did farmers experience problems in drying their grain? (mark 'Y' or 'N')

Crop	**Smallholder**			**Large scale**		
	season			**season**		
	1	**2**	**3**	**1**	**2**	**3**
Maize						
Rice						
Sorghum						

Millet						
Wheat						
Barley						
Teff						
Other						

3. If farmers had drying problems in any of the seasons then what % of farmers are believed to have experienced this problem? (mark %)

Crop	**Smallholder**			**Large scale / Season**		
	Season			**Season**		
	1	**2**	**3**	**1**	**2**	**3**
Maize						
Rice						
Sorghum						
Millet						
Wheat						
Barley						
Teff						
Other						

Grain marketed

1. **How much grain do farmers produce?** (record number of bags or MT, stating bag size, or MT)

Crop	**Smallholder**			**Large scale**		
	season			**Season**		
	1	**2**	**3**	**1**	**2**	**3**
Maize Bag size						
Rice Bag size						
Sorghum Bag size						
Millet Bag size						
Wheat Bag size						
Barley Bag size						
Teff Bag size						
Other Bag size						

2. Do farmers sell any of their grain? (mark 'Y' or 'N')

Crop	**Smallholder**			**Large scale**		
	season			**season**		
	1	**2**	**3**	**1**	**2**	**3**
Maize						
Rice						
Sorghum						
Millet						
Wheat						
Barley						
Teff						
Other						

3. If yes, then how many bags/MT of their harvest do they sell? (mark bags/MT)

Crop/harvest number	**Smallholder/ season**			**Large scale/ season**		
	1	2	3	1	2	3
Maize						
Rice						
Sorghum						
Millet						
Wheat						
Barley						
Teff						
Other						

4. How many bags/MT of their grain do they sell within the first three months after harvest? (mark bags/MT)

Crop/harvest number	**Smallholder/ season**			**Large scale/ season**		
	1	2	3	1	2	3
Maize						
Rice						
Sorghum						
Millet						
Wheat						
Barley						
Teff						
Other						

Length of farm storage period

1. In which month do farmers finish consuming all the grain from the first (or only) harvest, 2nd harvest, 3rd harvest? (record month)

Crop/ harvest number	**Smallholder/ season**			**Large scale/ season**		
	1	2	3	1	2	3
Maize						
Rice						
Sorghum						
Millet						
Wheat						
Barley						
Teff						
Other						

Larger grain borer infestation

1. **Do you know LGB? If yes then describe it?** (indicate 'Y'/'N' below, if yes proceed to 2)

Y / N

2. **Does LGB occur on maize grain in your area?** (If yes, then indicate where and which years).

Y / N

Where	Years

3. **Did farmers complain about LGB on maize in your area this season?** (indicate 'Y' or 'N' and provide any additional details)

Y / N

Annex 4 - Example of a postharvest questionnaire

The following questionnaire would need to be customised to the needs of your specific postharvest project. In particular, if you are involved in a postharvest loss reduction project then it must contain questions that relate specifically to improvements that you are trying to introduce.

Year ↘ ↘ Season ↘ Crop ↘ Province ↘ District ↘ Qu'aire No.

Questionnaire number – 2013-A [ ][-][ ][-][ ][ ][-][ ][ ][ ][ ]

Postharvest Questionnaire

(*Suggested greeting*) We are representing (*insert the relevant organisation*) and are doing a survey in order to learn more about postharvest losses that effect farming households. The point of this work is to get an accurate understanding of the size of losses so that we can support farmers to improve their postharvest practices and thus reduce these losses.

We ask that you answer the questions as accurately and honestly as possible so that our understanding and future activities are then based on addressing the real postharvest situation and problems faced by farmers like yourself.

This interview should not take very long. Are you happy to participate?

A. QUESTIONNAIRE IDENTIFICATION (to be filled in prior to interview)	
Date of interview *(dd/mm/yyyy)*	***__ __ / __ __ /2013***
Cropping season	
Enumerator code	[__ __]
B. LOCATION, CROP, FARM SCALE, HEAD OF HOUSEHOLD GENDER (to be filled in by enumerator)	
Province:	
District:	
Village:	
GPS co-ordinates:	
Focal crop of the survey:	
C. FARMER DETAILS (Farmer to answer)	
Total land area farmed by this household:	[__ __] Ha
Female headed household (Yes/ No):	[__]
Child headed household (Yes/ No):	[__]
Who in your household is responsible for this crop's postharvest management? *(Note: interview this person):*	
Name of the person responsible for postharvest management of this crop: Sex (M/ F):	 [__]
Number of household members over 16 years old?	[__ __]

D. FARMER'S CROP POSTHARVEST ACTIVITIES (Farmer to answer – note: answers must be specific to the focal crop)	
1. Do you harvest this crop from just one piece of land or several (if several, how many)?	[__ __] pieces
a) Total area of this crop harvested (state the unit e.g. ha or paces)	[__ __] Ha OR [__ __ x__ __] Paces
2. How long is your experience of cultivating this crop?	[__ __] years
3. What varieties of this crop did you grow in this season?	
4. Did you sell some of this crop harvested in this season? Yes/ No a) If yes, then what markets did you access: b) How did you transport the crop to market:	[__]
5. When was this crop harvested?	[__ __] weeks
6. How many bags of grain of this crop were harvested in this season? (if necessary convert unthreshed in to threshed grain equivalent) a) What is the typical weight of one bag of this grain?	[__ __ __] bags [__ __] kgs
7. What type of structure is used for grain storage	

8. How many bags of this grain were sold soon after harvest (within 3 months)?	[__ __ __] bags
9. How many more bags were/will be sold? (after 3 months)	[__ __ __] bags
10. How many bags of this grain will be kept for the household to eat?	[__ __ __] bags
11. How many weeks will this household food grain last for? *(Calculate how many weeks from harvest until it has all been consumed)*	[__ __] weeks
12. Was there rainfall or damp cloudy weather at harvest time so that this grain was difficult to dry? Y/N a) Any other details about the weather at harvest time?	[__]
13. How do you dry your grain of this crop? *(Probe by asking them to describe: the structure they dry it on, how long they dry it for, where it is dried, and who does it)?*	
14. What method do you use to shell/ thresh this crop? (*Probe by asking them exactly how they do it, what they use, who does it, when, where and over what period of time*)	
15. How do your store your grain of this crop? (*Probe by asking about the storage structure, storage location, form the crop is stored in (cob/grains etc), who manages it, how long is it stored for?*) a) Grain stored for household consumption b) Grain stored for later sale	

16. What kinds of pests attack your stored grain?	
17. Do you add anything to your stored shelled/unshelled grain to protect it against insect pests: Yes / No a) If yes, then what do you add? *(Probe by asking about <u>what</u> they add, <u>when</u> they add it, <u>how</u> they add it, <u>how much</u> of it they add, <u>who</u> adds it, <u>whether it works</u>?)*	[__]
E. FARMER'S PERCEPTIONS OF CROP POSTHARVEST LOSSES *(This section could be expanded into several questions, depending on the aims of the survey)* **(Farmer to answer)**	
18. At which postharvest stages (harvesting, transporting, drying, shelling/threshing, storing, milling, marketing, consuming) do you have the most constraints (or losses)? <u>What</u> are these constraints?	

Do you have any questions you would like to ask us?

THANK YOU FOR YOUR TIME.

NOTES (if responses to any of the questions are too long for the space provided, please continue to record the response on the back of this sheet, make sure you state the question number).

Supervisor to confirm that the data has been collected correctly and/or entered into the computer correctly by signing the relevant boxes below.

F. QUALITY CONTROL	***Supervisor name***	***Date (dd/mm/yyyy)***	***Signature***
Information collected correctly?		__ __/__ __/__ __ __ __	
Information entered into computer correctly?		__ __/__ __/__ __ __ __	

Comments

Annex 5 - Using a random number table to select grain bags for sampling

Tables of random numbers are composed of numbers produced in a completely random manner by computer and from a definite range of numbers. Table 1 contains one thousand randomised numbers in the range from 1 to 100. [Note that the numbers 1 to 9 are printed as 01 to 09, and that 100 is indicated by 00 to maintain a two-digit configuration, and is intended to facilitate reading of the table]. Numbers are presented in blocks of twenty-five pairs of digits for the same reason.

There is some degree of flexibility in the way a table of random numbers can be read provided that two basic rules are observed:

a) you must adhere to the method decided upon at least until all possible number combinations obtainable from it have been exhausted;

b) you must never start at a point in the table which has been used as a starting point before.

Selecting bags for sampling from consignments of 11 to 100 bags

We know that ten bags should be selected at random from consignments of 11 to 100 bags. The example below illustrates how this is done using a table of random numbers.

Example 1

Ten bags have to be selected from a consignment of 53 bags. Using the random numbers in Table 1, read the numbers horizontally from left to right starting at the beginning of the top line (from 73). The first ten numbers within the range 01 to 53 are: 47, 50, 37, 33, 23, 41, 17, 52, 13, and 12. These numbers are re-arranged in their proper order and, as the consignment passes the sampling station, the sampler extracts the 12th 13th 17th 23rd 33rd 37th 41st 47th 50th and 52nd bags. The number 12 in the table should be marked to indicate that it was the last number used, and that the next number (22) is the next starting point.

Alternatively a simple lottery system might be used to make a random selection of bags for sampling. The example below shows how this is done.

Example 2

Ten bags have to be selected from a consignment of 98 bags. Prepare 98 slips of paper or card and number them from 1 to 98. Place the numbered slips in a container, mix them up and draw out 10. The numbers on these slips when re-arranged in their proper order, represent the bags to be sampled.

The numbers on the slips drawn at random were: 14, 9, 23, 31, 73, 39, 17, 61, 46, and 97. These are re-arranged in their proper order and as the consignment is moved, the sampler selects the 9th 14th 17th 23rd 31st 39th 46th 61st 73rd and 97th bags.

Table 1: Numbers 1 to 100 randomised

73 47 50 81 37 99 33 23 41 87 70 17 91 52 73 13 64 12 22 56 42 11 09 87 67
72 74 49 15 76 86 71 97 12 78 48 35 68 27 51 56 05 67 82 93 17 47 14 17 82
97 30 18 66 35 62 67 99 63 47 30 40 36 18 58 47 26 24 62 24 38 26 91 18 69
09 62 27 30 42 72 76 36 81 49 65 19 64 42 45 64 87 61 34 25 73 19 38 97 06
61 56 92 94 75 90 21 60 17 69 94 09 77 34 41 27 31 15 18 87 85 44 58 77 56

40 45 21 69 38 44 71 05 95 02 55 47 69 97 63 29 87 40 30 06 75 72 12 97 93
71 36 67 15 74 76 81 87 44 65 75 04 26 75 91 18 25 39 18 34 62 33 76 55 70
81 47 31 22 32 62 42 02 56 80 08 25 20 55 93 34 22 07 78 36 88 72 10 64 50
07 50 66 70 98 34 56 86 53 66 48 94 00 92 67 12 09 98 83 48 36 91 35 41 83
14 80 26 50 50 19 18 26 21 08 95 60 74 72 97 02 21 14 81 04 54 86 28 52 62

17 90 57 54 48 30 65 15 13 17 70 81 78 93 72 59 21 93 32 87 96 46 87 52 06
06 60 60 48 97 18 65 64 46 96 55 85 73 77 02 07 87 59 33 71 88 47 70 13 81
46 66 98 62 98 84 90 60 64 74 86 00 11 53 63 44 61 93 35 83 70 83 36 54 14
22 39 12 36 78 64 76 18 44 56 61 86 31 84 24 56 18 95 42 28 42 78 46 25 74
62 40 81 48 31 29 41 23 37 67 60 29 27 70 77 99 07 71 78 13 60 02 82 85 12

63 23 85 13 53 93 93 76 82 45 29 39 67 50 13 85 08 61 22 48 71 83 89 27 39
28 38 93 22 61 67 66 54 53 58 71 95 55 82 72 28 34 94 87 16 62 76 58 96 34
31 69 03 31 27 33 68 54 84 48 82 50 75 05 28 09 06 27 21 76 36 95 11 89 82
92 17 82 54 42 66 84 27 52 68 48 25 35 92 25 19 45 11 86 96 70 15 67 03 71
72 23 78 50 85 84 19 57 98 57 27 27 18 37 11 81 29 93 12 36 35 95 66 87 59

33 90 61 20 23 01 73 37 75 91 39 78 16 86 66 69 60 21 77 56 32 33 36 11 19
77 20 63 33 26 38 19 94 69 65 84 24 08 88 50 21 31 41 64 53 30 85 55 62 99
44 41 90 90 34 36 46 14 15 51 61 45 87 72 01 31 54 00 42 57 16 74 68 43 22
23 30 15 89 06 63 33 88 49 96 29 34 71 00 32 93 77 02 97 84 63 08 36 86 50
87 11 78 24 39 77 14 29 71 38 85 11 82 35 46 46 00 74 48 79 26 03 46 70 70

76 82 02 80 57 35 98 02 63 11 35 98 02 63 11 79 20 15 38 19 06 00 41 38 50
39 87 83 58 72 35 75 75 81 55 48 80 73 84 95 52 52 37 06 22 78 76 03 26 92
33 38 10 49 42 28 12 27 13 75 30 29 96 17 96 06 46 75 75 21 08 87 87 85 07
24 64 16 87 72 15 91 76 71 83 21 13 66 51 64 06 78 19 88 96 64 78 27 21 16
13 77 53 95 17 14 96 12 68 55 21 30 57 97 71 09 23 57 55 04 77 26 52 07 53

24 84 24 46 77 11 83 83 19 27 22 38 50 63 67 04 15 12 34 01 95 14 72 48 26
62 08 91 79 38 69 21 23 90 93 13 27 34 58 64 14 45 29 02 53 06 57 92 57 71
51 02 66 99 85 20 43 65 67 69 82 06 04 96 37 94 80 67 70 58 65 15 87 21 70
55 63 95 22 96 24 10 25 73 19 52 84 04 51 89 32 15 55 45 76 62 20 14 14 34
84 36 50 90 24 30 54 77 92 84 36 50 04 87 00 62 85 18 41 09 46 98 64 00 04

72 53 85 61 90 20 90 49 02 34 62 44 65 84 78 79 50 31 92 09 24 69 27 12 90
98 46 89 72 14 97 23 66 64 20 15 03 79 37 82 46 60 11 19 37 33 21 70 66 22
06 24 34 88 30 15 45 54 17 35 00 36 54 73 00 35 51 22 67 90 23 24 44 41 35
58 04 12 76 64 86 67 89 49 16 42 68 37 98 71 24 43 90 05 76 73 23 95 33 18
41 84 53 49 74 89 35 92 48 41 43 22 75 96 75 47 41 00 81 92 34 86 03 32 65

(Note: Numbers 1-9 are represented by 01–09 and 100 is represented by 00)

Selecting bags for sampling from consignments of 101 to 10,000 bags

For a consignment of more than 100 bags, ISO recommends that the number of bags to be sampled should be approximately equal to the square root of the total number bags in the consignment.

The square root (symbol √) is a number which when multiplied by itself gives a particular value.

How to find the square root of a number using a pocket calculator
To find the square root of 225.
First enter the figure 225, then press the square root (√) key.
The number displayed is the square root.
(If the figure is not a whole number then round it up to the next whole number).

If you don't have a calculator, Table 2 will help you to find how many bags to select from consignments containing from 101 to 10,000 bags.

Referring to Table 2 you will see, for example, that the square root of 144 is 12 (12x12 =144) and the square root of 400 is 20 (20x20 = 400)

Table 2: Approximate square roots

N	n	N	n	N	n
101 ... 121	**11**	1601 ... 1681	**41**	4901 ... 5041	**71**
122 ... 144	**12**	1682 ... 1764	**42**	5042 ... 5184	**72**
145 ... 169	**13**	1765 ... 1849	**43**	5185 ... 5329	**73**
170 ... 196	**14**	1850 ... 1936	**44**	5330 ... 5476	**74**
197 ... 225	**15**	1937 ... 2025	**45**	5477 ... 5625	**75**
226 ... 256	**16**	1026 ... 2116	**46**	5626 ... 5776	**76**
257 ... 289	**17**	2117 ... 2209	**47**	5777 ... 5929	**77**
290 ... 324	**18**	2210 ... 2304	**48**	5930 ... 6084	**78**
325 ... 361	**19**	2305 ... 2401	**49**	6085 ... 6085	**79**
362 ... 400	**20**	2402 ... 2500	**50**	6242 ... 6400	**80**
401 ... 441	**21**	2501 ... 2601	**51**	6401 ... 6561	**81**
442 ... 484	**22**	2602 ... 2704	**52**	6562 ... 6724	**82**
485 ... 529	**23**	2705 ... 2809	**53**	6725 ... 6889	**83**
530 ... 576	**24**	2810 ... 2916	**54**	6890 ... 7056	**84**
577 ... 625	**25**	2917 ... 3025	**55**	7057 ... 7225	**85**
626 ... 676	**26**	3026 ... 3136	**56**	7226 ... 7396	**86**
677 ... 729	**27**	3137 ... 3249	**57**	7397 ... 7569	**87**
730 ... 784	**28**	3250 ... 3364	**58**	7570 ... 7744	**88**
785 ... 841	**29**	3365 ... 3481	**59**	7745 ... 7921	**89**
842 ... 900	**30**	3482 ... 3600	**60**	7922 ... 8100	**90**
901 ... 961	**31**	3601 ... 3721	**61**	8101 ... 8281	**91**
962 ... 1024	**32**	3722 ... 3844	**62**	8282 ... 8464	**92**
1025 ... 1089	**33**	3845 ... 3969	**63**	8465 ... 8649	**93**
1090 ... 1156	**34**	3970 ... 4096	**64**	8650 ... 8836	**94**
1157 ... 1225	**35**	4097 ... 4225	**65**	8837 ... 9026	**95**
1226 ... 1296	**36**	4226 ... 4356	**66**	9026 ... 9216	**96**
1297 ... 1369	**37**	4357 ... 4489	**67**	9217 ... 9409	**97**
1370 ... 1444	**38**	4490 ... 4624	**68**	9410 ... 9604	**98**
1445 ... 1521	**39**	4625 ... 4761	**69**	9605 ... 9801	**99**
1522 ... 1600	**40**	4762 ... 4900	**70**	9802 ...10000	**100**

N = the total number of bags in the consignment
n = the approximate square root.

Procedure

The bags to be sampled are selected according to the following procedure:
First divide the consignment into *n* groups of bags (where *n* = the approximate square root of the number bags in the consignment). Any remaining bags will constitute a separate group. Select one bag for sampling at random from each group. The examples below illustrate how this is done.

Example 3 - A consignment of 200 bags

According to Table 2, the approximate square root (*n*) of 200 is 15.

This means that we can have 15 groups of 13 bags and one group of 5 bags.

One bag from each group must be sampled. Select a number at random in the range 1-13 and use this to identify the bag within a group to be sampled. (If the number selected was 7, then sample the 7th bag in each of the first 13 groups) From the remaining group of five bags, select one bag at random.

> **Example 4 - A consignment of 2,000 bags**
>
> According to Table 2, the approximate square root (*n*) of 2,000 is 45.
>
> This means that we can have 44 groups of 45 bags and one group of 20 bags.
>
> One bag from each group must be sampled. Select a number at random in the range 1-45 and use this to identify the bag within a group to be sampled. (If the number 28 was selected, then sample the 28^{th} bag in each group of 45 bags) From the remaining group of 20 bags, select one bag at random.

This system can be rather laborious and a simpler and more convenient procedure is to take the approximate square root *n* and then sample every n^{th} bag. For example, if the square root is 16, select every 16^{th} bag. Usually, when following this procedure a few bags will remain, and one of these bags must be selected at random.

> **Example 5 - A consignment of 186 bags**
>
> The approximate square root of 186 is 14. If every 14^{th} bag is sampled, this can be done 13 times (14 x 13 = 182) and then there will be four bags left over. Take a sample from one of these bags as well.

[Instead of using the square root of the number of bags, some people prefer to sample 10% of the bags by selecting every tenth bag as a consignment is received or issued. Although this does not strictly conform to the principles of representative sampling it may be acceptable, since more bags are selected for sampling than are really necessary, and the unloading or loading of bags is usually carried out in non-uniform manner.]

Annex 6 – Measuring a spherical store to estimate capacity and grain weight

Estimation of weight losses requires that we have estimates of the amounts of grain present in the stores we are studying. Traditional millet stores in Namibia are about spherical in shape so their volumes may be estimated assuming they are spheres. Some stores also have an additional cylinder below the sphere (Fig. A); the capacities of cylinders have to be estimated separately.

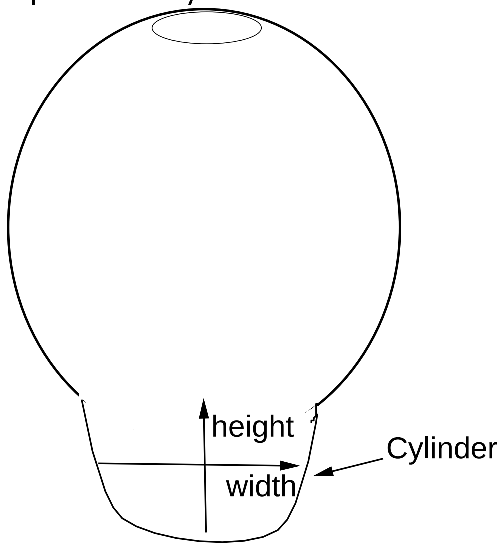


Figure A: Spherical millet store with a cylinder at its base

The volume of a sphere is calculated using the formula

$$4/3\ \pi r^3$$

The only figure that you need to obtain to use this formula is the radius (r); this is half the diameter of the store. Neither the radius nor diameter of traditional stores can be measured easily when they have grain in them. However, the circumference of the store can be measured easily with a tape measure (Fig. B) and the diameter calculated using the equation

$$\text{Diameter} = \frac{\text{Circumference}}{\pi}$$

$\pi = 3.141$

So for example, a store with a circumference of 4.5 m would have a diameter of

$$\text{Diameter} = \frac{4.5}{3.14} = 1.43\text{m}$$

The radius of this store would be 1.43/2 = 0.716 m

The volume of this store would be

$$\text{Volume} = 4/3 \times 3.141 \times 0.716^3$$

that is

$$1.33 \times 3.141 \times (0.716 \times 0.716 \times 0.716) = 1.536\text{m}^3$$

Figure B: Measuring the circumference of a traditional millet granary

If the store has a cylinder at its base then to calculate how much is present, measure the height and width (diameter) of the cylinder. You may determine the width (diameter) directly or by measurement of the circumference. The formula for estimating the volume is

Volume = πr2h

So, for example, if there was a cylinder at the bottom of a store with diameter of 0.5 m and a height of 0.8 m then the volume would be

Volume = 3.141 x (0.25 x 0.25) x 0.8 = 0.1571m^3

The total volume of the store is therefore the volume of the sphere plus the volume of the cylinder

Total volume = 1.5355 + 0.1571 = 1.6931m^3

Before you can calculate how many MT of millet would fit into a store with a volume of 1.6931 m^3, you need to know the weight of millet that occupies 1m^3, this is called the bulk density and an average value for millet is 853 (853kg in every m^3). If the store is full then it would contain

1.6926 x 853 = 1443kg or 1.443 MT

If the store is not full then you will have to reduce this amount. To determine how many MT there are in a partially filled store we will use the formula for calculating the volume of a partially filled sphere which is as follows -

πh2(R-h/3)

where h=height of grain in store and r = radius of store (half the diameter calculated from the measurement of the circumference). To determine the height of grain, measure the space between the store opening and the grain surface using a rigid tape measure. Then subtract this value from the diameter of the store. If for example the store diameter is 1.43m and the grain surface is now 48cm below the opening then the grain height is 0.95m. The calculation would then be as follows -

3.141 x (0.95x 0.95) x (0.71 – 0.95/3) = 1.112m^3

and so the weight of grain in the spherical part of the store is now -

1.112 m^3 x 853 = 948.5kg or 0.949 MT

The weight of grain in the cylinder is -

0.1571 m^3 x 853 = 134

added to the weight of grain in the sphere give a total of

948.5 + 134 = **1.083 MT**

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Abstract

APHLIS provides estimates of the postharvest weight losses (PHLs) of cereal grains for Sub-Saharan Africa. These loss estimates support -

- agricultural policy formulation
- identification of opportunities to improve value chains
- improvement in food security (by improving the accuracy of cereal supply estimates), and
- monitoring of loss reduction activities

APHLIS is based on a network of local experts (see Annex 1). Each country supplies and quality controls its own data that are stored in an exclusive area of a shared database. The APHLIS website displays the loss estimates as maps and tables. The APHLIS Network members also have the opportunity to post a 'Country Narrative' that gives a commentary on these postharvest losses in the context of the postharvest systems and projects of their countries.

The loss estimates are generated by an algorithm (the PHL Calculator) that works on two data sets, the postharvest loss (PHL) profiles and the seasonal data. Each PHL profile is itself a set of figures, one for each link in the postharvest chain. These figures are derived from a very detailed search of the scientific literature followed by screening for suitability. They remain more or less constant between years. The seasonal data are contributed by the APHLIS Network and address several factors that are taken into account in the loss calculation. They may vary significantly from season to season and year to year.

APHLIS estimates are not intended to be 'statistics' although they are computed using the best available evidence; they give an understanding of the scale of postharvest losses using a 'transparent' method of calculation. The estimates are assigned by primary administative unit (province) and may be aggregated to country or to region. Provinces are usually large geographical units and may include several agro-climatic zones, consequently the loss figures are generalisations, i.e. may be at variance from those experienced in particular situations. APHLIS recognises this limitation and offers a downloadable PHL Calculator that enables practitioners to change the default values to those that are specific to the situation of interest and to obtain loss estimates at a chosen geographical scale. The PHL Calculator can also be used with hypothetical data inorder to model 'what if' scenarios.

APHLIS offers a robust system for the estimation of PHLs, is transparent in operation and can capture improvements in loss estimation over time by the accumulation of new and more accurate data. It encourages the collection of new data and offers advice on modern approaches to loss asssessment. For the future, APHLIS is envisaged as a much broader communcition hub that informs, motivates and coordinates efforts to optimise postharvest mangement.

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