African Postharvest Losses Information System – a network for the estimation of cereal weight losses

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Abstract

Soaring food prices during 2007/2008, and the realisation that sporadic food shortages are likely to continue long into the future, has reawakened interest in the benefits of reducing food losses. As a means of making more accurate estimates of how much food is lost, the Joint Research Centre (European Commission) proposed the development of the African Postharvest Losses Information System (APhLIS) (http://www.phlosses.net). APhLIS estimates postharvest losses (PHLs) by cereal crop, by country and by province in East and Southern Africa. The system went live in March 2009 and combines a loss calculator, a free access database of key information, and a network of local experts who contribute the latest data and verify loss estimates. The loss calculator works of loss figures contributed from the literature and by local experts but also takes account of the prevailing climate, scale of farming (small/large), damp weather at harvest, larger grain borer (in the case of maize), proportion of grain held in farm storage or marketed, and multiple harvests. Before the introduction of APhLIS, the origin and justification of PHL estimates were not well founded. Now PHL estimates are available that are

- Transparent in the way they are calculated
- Based on a complete screening of available research and literature
- Contributed (in part) and verified by local experts
- Based on the primary national unit (i.e. province not just country level, so estimates are more relevant)
- Upgradeable as more (reliable) data become available, so that there is the opportunity for increasing accuracy in loss estimation over time.
- Supported by a downloadable loss calculator that can be used to make loss calculations at a geographical scale below primary national unit.

In the future, APhLIS may be expanded in technical scope (crops) and geographical range (countries) and used to help prioritize and justify loss reduction strategies including those for grain storage.

Keywords: Weight loss, Loss calculator, Postharvest operations, Cereal supply

1. Introduction

The grain storage community has had a long standing interest in the assessment of postharvest losses (PHLs), especially since the food crisis of the 1970s. Estimates of PHLs became both a justification, and an objective measure, for the subsequent Prevention of Food Losses (PFL) programme led by FAO (UN Food and Agriculture Organization). The PFL programme continued into the 1990s but drew to a close with declining food prices. Soaring food prices during 2007/2008, and the realisation that sporadic food shortages are likely to continue long into the future, has reawakened interest in the benefits of reducing food losses, especially as these may offer better use of natural resources than equivalent increases in food production.

PHLs have negative impacts on hunger, poverty alleviation, income generation and economic growth. PHLs are crop/product specific and occur at many stages in the supply chain (harvesting, drying, storage, market, transport, etc.). They are evident as loss of weight and loss of quality and are compounded by subsequent losses of market opportunity and lost production resources such as land, water, labour, agricultural inputs and soil fertility. Yet, the magnitude and location of PHLs are poorly understood because PHL figures are still frequently guesstimates, are relatively difficult to trace for both logic and information source, and the sources themselves may not be very reliable. By improving PHL estimates it will be possible to target loss-reduction interventions at the most affected areas (geographically), the most affected links in the postharvest chain or those links that would be most cost effective to address. A further use for PHL figures is in the calculation of the cereal supply/demand balances of developing countries. An estimate of how much grain may be available to consumers emerges when national cereal production/import figures are corrected for PHLs. National cereal supply is usually determined through a food balance sheet, by institutions such as the Ministry of Agriculture or the Statistical Service, while in highly food-insecure countries, so called Crop and Food Supply Assessment Missions (CFSAMs) are often requested by the country and implemented under the supervision of FAO and WFP (UN World Food Programme). Examples of national cereal balance calculations, including the PHL figures applied, can be seen in the CFSAM reports on the website of FAO's Global Information and Early Warning System (GIEWS). These reports will influence food aid policy on the donors' side, so the availability of reliable PHL data is essential for good decision making.

In response to the need for better PHL estimates, the Joint Research Centre and EuropeAID (European Commission) proposed the development of the African Postharvest Losses Information System (APhLIS) (http://www.phlosses.net). APhLIS estimates the cumulative weight losses that occur along the postharvest chain, including harvesting, drying in the field and/or on platforms, threshing and winnowing, transport to store and then farm storage (large or small scale), transport to market and market storage. Excluded are losses due to cereal processing, e.g., milling and consumer wastage. The main features of APhLIS are presented below; a separate scientific publication is planned to describe it more fully in the future.

2. Development of APhLIS

In its first phase of development, APhLIS has included the countries of East and Southern Africa. Estimates of PHLs for each of the major types of cereals are made for the first administrative sub-divisions (e.g. provinces) of these countries. This makes loss estimation more useful than if it was done on a country-wide basis and conforms to the administrative requirements for making cereal supply calculations. APhLIS consists of four components:

1. A PHL calculator that determines a cumulative weight loss from production for a given cereal grain type using loss figures for each link in the postharvest chain (harvest through to market storage). This set of loss figures is called a PHL profile and such profiles are the basis to loss calculation.
2. A database, accessible by the Network, which stores key data.
3. The Network of experts in East and Southern Africa that provide data relevant to the calculation of PHLs and verify PHL estimates.
4. A web site to display the PHL data in the form of tables and interactive maps (Fig. 1).

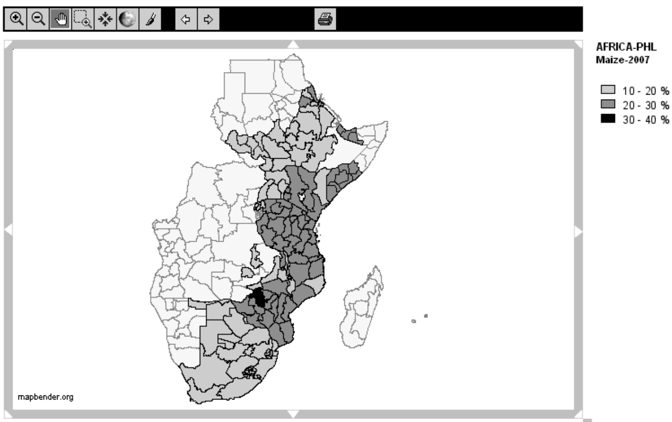

Figure 1 APhLIS interactive map showing maize PHL estimates throughout East and Southern Africa by province, for the year 2007.

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 R.J.Hodges(at)gre.ac.uk.

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Province	2003	2004	2005	2006	2007	2008
Area under National Administration	-	20.5	20.5	20.6	19.7	-
Central Region	-	20	20	20.1	19.3	-
Northern Region	-	20.8	20.9	21	20.6	-
Southern Region	-	20.5	20.5	20.6	19.8	-

Figure 2 APhLIS website - Maize PHL estimates, by year, for the provinces of Malawi. Loss figures may be 'clicked' to reveal tables displaying the data used for their calculation and origin (see Figs 3 to 5).

Calculation matrix documenting the PH loss calculation, quality of data sources and references to sources Country Malawi: Province: Area under National Administration; Climate: Humid subtropical climate (Cwa); Year: 2007; Crop: Maize

Annual production and losses	**Tonne**	**%**
Production	3,444,655	100
Grain remaining	2,767,401	80.3
Lost grain	677,254	19.7

Seasonal production and losses							
Season	**Farm Type**	**Production (t)**	**Remaining (t)**	**Losses (t)**	**Production (%)**	**Remaining (%)**	**Losses (%)**
1	small	2,856,698	2,284,102	572,596	92.9	74.3	18.6
1	large	218,237	191,737	26,500	7.1	6.2	0.9
Seasonal:		3,074,935	2,475,839	599,096	100.0	80.5	19.5
2	small	369,720	291,563	78,157	100.0	78.9	21.1
2	large	0	0	0	0.0	0.0	0.0
Seasonal:		369,720	291,563	78,157	100.0	78.9	21.1
Annual:		3,444,655	2,767,401	677,254	100.0	80.3	19.7

NB Annual averages are a weighted average of the seasons

Figure 3 APhLIS website - Details of production and losses of maize grain for two harvesting seasons of large and small farms in the Area of National Administration in Malawi (follows from Fig. 2 after 'clicking' on the PHL figure for 2007 – 19.7%).

PHL (%) Calculation: Season: 1 Farm Type: small		
Marketed at harvest (%)	20	If data is missing **(no data)** it is assumed that for subsistence farmers all grain is stored but for commercial farmers all grain is marketed. Note: Figures in this table are farm type specific (small or large farms). The value **Marketed at 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 data	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)	no data	Effect of storage duration: 0-3 months % figure for storage is 0 (zero) 4-6 months the % figure of the PHL profile is divided by 2 more then 6 months or in case of missing data (no data) the % figure in the general profile is used

PHL (%) Calculation: Season: 1 Farm Type: small					
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 (%)	
		74.3		18.6	
Stages	PHL profile (adjusted)	Remaining grain	Loss increment	Remaining grain	Loss increment
Harvesting/field drying	6.4	69.5	4.8	17.4	1.2
Platform drying	4	66.8	2.8	16.7	0.7
Shelling	1.2	66	0.8	16.5	0.2
Winnowing	-	66	0	16.5	0
Transport to farm	2.3	64.4	1.5	16.5	0
Farm storage	9	58.6	5.8	16.5	0
Transport to market	1	58.6	0	16.3	0.2
Market storage	4	58.6	0	15.7	0.7
Total		58.6	15.7	15.7	2.9

Figure 4 APhLIS website - Details of the PHL profile and modifying factors used for the maize PHL estimate for 2007 for the Area under National Administration in Malawi (follows from Fig. 3).

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.

References and individual loss figures % for small farms						
			Origin of figure			
Stages	**Loss figure**	**Reference**	**Cereal**	**Climate**	**Farm type**	**Method**
	2.0	Boxall R.A. - 1998	0	0	1	0
	9.9	Grolleaud M. - 1997	1	0	1	0
	5.8	Mvumi B.M. - 1995	1	1	1	0
	9.5	Odogola W.R. - 1991	1	1	1	0
	5.0	Vervroegen D. - 1990	0	1	1	0
Harvesting/field drying	6.4		1	1	1	0

Figure 5 APhLIS website -The data quality display and derivation of the first element of the PHL profile (Harvesting and field drying – 6.4%) for maize produced on small farms in the Area under National Administration in Malawi (follows from Fig. 4). On the actual web page each 'Reference' can be 'clicked' to reveal the full bibliographical details.

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.

3. Loss estimation methodology and assumptions

When APhLIS estimates a PHL for a particular cereal crop, in a particular province, the pre-determined PHL profile is automatically loaded into the PHL Calculator. Examples of PHL profiles are shown in Table 1. A problem faced in seeking to provide PHL profiles is that for most of the many provinces of East and Southern Africa there are no PHL data specific to them. It is therefore inevitable that many different provinces have to share the same data. This sharing was achieved by clustering together the provinces of many countries that are basically similar with respect to the factors that influence PHLs; the most convenient method of clustering was found to be based on climate classification. The climates of East and Southern Africa are classified by the Köppen system (Peel et al., 2007), into one of three basic types, tropical savannah/forest, arid/desert or warm temperate. For each crop there is a PHL profile for each climate type, so with seven crops (maize, sorghum, millet, wheat, barley, rice and teff) there is a total of 21 (3 x 7) profiles.

In establishing PHL profiles it is necessary to create a generalized loss figure for each link in the postharvest chain. The basic data on which these were derived came from two sources, the scientific literature and figures supplied by the PHL Network. These figures were refined by 1) removing ‘outliers’, 2) avoiding the use of ‘questionnaire/guesstimate’ data where there are sufficient measured loss estimates and 3) averaging what data remained. In the case of storage loss figures, where these are taken from the literature, they are standardized to a nine-month storage period. If not already adjusted for farmers consumption patterns, then they are adjusted assuming an even consumption across the entire storage period. The PHL profile alone does not determine the magnitude of the cumulative loss as the loss estimates in the PHL profile are adjusted for:

Table 1 Examples of PHL profiles for three cereal crops, showing % weight loss from production, under different climates and scales of farming.

Climate type **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

1. Whether or not there is wet/damp weather at time of harvest – damp weather increases losses and the % weight loss figure in the profile is set to 16.3% (as this is currently the only measured figure in the literature for this type of loss).
2. The length of the farm-storage period. If the duration is less then 3 months then the % storage loss figure is set to zero. If the duration is 4 to 6 months then the standard % weight loss for storage is divided by 2 (i.e., is only half the annual figure). If grain is stored for 7 or more months then the annual % storage loss figure is used.
3. In the case of maize, whether or not lesser grain borer, *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) is expected to be a significant pest. If a significant pest, then this has the effect of doubling the storage weight loss. From experience in the use of APhLIS it has been found that these factors have a much greater influence on the magnitude of the final PHL estimate than the initial choice of PHL profile for a crop according to climate type. Furthermore, the Calculator takes into account:
4. The proportion of grain that is marketed directly. This affects the proportion of harvest for which farm-storage losses are considered. Furthermore, it is assumed that subsistence farmers eventually

consume all grain that is not marketed so this stock suffers no transport to market or trader-store losses.

5. Whether or not the crop is harvested in one, two or three seasons – each season is a separate calculation and losses are computed as a weighted average.

4. What the website shows

The APhLIS website displays the basic data submitted by the Network used in the estimation of PHLs. This data includes crop production, rainfall, temperature, extreme climatic events, etc., by crop and by year for country and province.

PHL estimates are presented as interactive maps (Fig. 1) or as a series of tables. In the tables, PHLs are first presented by crop, then by country and then by province. PHLs for maize in the four provinces of Malawi are shown in Figure 2. By 'clicking' on one of the provincial PHL figures shown in Figure 2, details of the loss calculation are presented (Figs. 3 and 4).

The PHL profiles is shown in Figures 4 and 5 present details of how specific, to the situation in question, is each of the loss estimates that comprise this particular PHL profile. Each loss figure in the profile is itself derived from a series of estimates from the literature or the experts of the APhLIS Network. The table shows each of these contributed figures and gives it a rating according to whether it is specific to the cereal crop, to the prevailing climate and to the farm type. It also rates the 'Method' by which the estimates were derived, i.e., by actual measurement or from questionnaires/guesstimates. Figures are rated as '1/green' if they are 'specific' or 'measured' or rated as '0/red' if 'not specific' or 'questionnaire/guesstimate'.

Furthermore, a source is quoted for each and every figure. In most cases, some of the estimates applied in a PHL profiles are generalized, i.e., are derived partly or completely of figures that are not specific to the cereal type, climate or farm type in question. In the example of Figure 5, none of the component estimates for the 'Harvesting and field drying' figure were 'measured' estimates, they were all 'questionnaire/guesstimates', consequently, they are all scored as '0/red' for 'Method'.

5. The downloadable PHL calculator

Besides offering PHL estimates on the web site, a downloadable version of the PHL calculator is available, on an Excel spreadsheet. This offers users several advantages. They can substitute the most up-to-date or most relevant data and at a chosen geographical scale within east and southern Africa. To be able to choose the geographical scale is 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. Like the web site, the downloadable PHL calculator also presents ratings of specificity for the figures in the PHL profile. In this way, users can determine the suitability of the PHL estimates for their purposes.

6. Conclusions

There have often been demands for simplified loss figures. This for example has lead 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 Tyler (1982) noted "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." Therefore, it is 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. APhLIS addresses this task.

APhLIS was launched in March 2009 and in its early stages may or may not provide loss estimates that are different from those used previously. If they are different, there will be no solid evidence that they are more accurate. However, APhLIS generates estimates that are

- Transparent in the way they are calculated
- Contributed (in part) and verified by local experts
- Based on the primary national unit (i.e., province not just country level, so estimates are more relevant)
- Upgradeable as more (reliable) data become available, so that there is the opportunity for increasing accuracy in loss estimation over time.
- Supported by a downloadable loss calculator that can be used to make loss calculations at a geographical scale below primary national unit.

APhLIS estimates will be tested during CFSAM missions and compared with estimates derived by other means. In the medium term, APhLIS would benefit greatly from the supply of additional loss figures. To strengthen the ability of target countries to collect relevant data, in the format needed by the system, requires suitable initiatives underpinned by modern rapid approaches to loss assessment.

In the future, the use of the APhLIS is expected to benefit agricultural development and food security by

1. highlighting missing data and helping identify which gaps in our knowledge would be the most cost-effective ones to fill, and
2. acting as a model system to explore loss scenarios so that opportunities for loss reduction can be identified. Furthermore, as climates become increasingly less stable it may be used to suggest how climate change could impact on PHLs.

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