METHODS & TOOLS BRIEFS

Innovating Post-Harvest Losses Measurement: A Modelling Approach to Grain Storage Losses

50x2030
DATA-SMART AGRICULTURE

MAY 2026

Sorghum farmers in Sokoro, Mali. / Photo by Aly Boubacar, via CropTrust

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BACKGROUND

Reliable measurement of post-harvest losses (PHL) remains a major challenge for many national statistical systems, due to the high cost and complexity of traditional data collection methods. This brief draws on a pilot study implemented in Mali under the 50x2030 Initiative, which tested an innovative model-based approach combining targeted physical grain measurements with statistical modelling to generate accurate, cost-effective estimates of storage losses.

KEY POINTS

- **A practical alternative to costly measurement approaches:**

  The hybrid model integrates limited field measurements with statistical modelling to produce reliable PHL estimates while significantly reducing the need for repeated, resource-intensive data collection.

- **Proven feasibility in a national statistical system:**

  Results from the Mali pilot demonstrate that this approach can be successfully embedded within existing agricultural surveys, delivering robust estimates and strengthening national capacity.

- **Improved data for policy and SDG monitoring:**

  By enabling consistent, scalable, and cost-efficient estimation of storage losses, the approach supports better-informed policy decisions and more effective tracking of progress toward SDG Target 12.3.

AROUND THE WORLD, food loss and waste continue to undermine food security, farm incomes, and the sustainability of agri-food systems. While global attention has grown—reflected in Sustainable Development Goal (SDG) Target 12.3, which calls for halving per capita food waste and reducing food losses along supply chains by 2030—many low- and middle-income countries still lack the reliable, regularly updated data needed to measure post-harvest losses (PHL) effectively and to track progress over time.

Generating precise PHL estimates typically requires repeated field visits, physical measurements of stored grain, and laboratory analysis. These operations are expensive and difficult to sustain within national statistical systems. The 50x2030 Initiative to Close the Agricultural Data Gap is addressing this challenge through innovative measurement methods that strengthen data quality while lowering costs. To improve measurement, the Initiative has been developing model-based approaches for estimating post-harvest losses that are analytically sound and operationally feasible for national survey systems.

Family in Mali with their corn harvest. / Photo via Myagro.

FROM MEASUREMENT TO MODELLING: THE INNOVATION

Traditional approaches to estimating PHL rely either on farmers' recall or on comprehensive physical measurements taken in the field. Both methods face clear limitations: recall data are prone to memory error, while direct measurement approaches are costly, complex, and difficult to scale. To overcome these constraints, the 50x2030 research team developed an on-farm storage loss model that integrates:

- Targeted **physical grain measurements** collected through sub-samples embedded in national agricultural surveys
- **Laboratory analysis** of grain damage, moisture content, and weight loss
- **Statistical modelling techniques** to estimate storage losses in survey rounds when no physical measurement is conducted

This hybrid strategy ensures precision while reducing fieldwork costs, allowing national agricultural surveys to maintain high-quality storage loss estimates with far fewer specialized operations.

TESTING THE APPROACH IN MALI

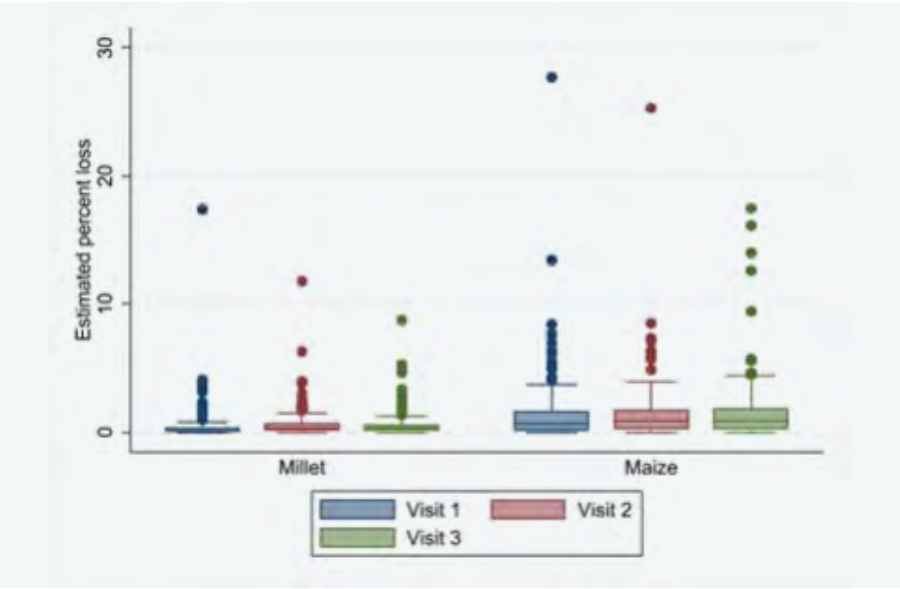
In 2022/23, this modelling approach was piloted in Mali by integrating a dedicated survey on storage losses within the *Enquête Agricole de Conjoncture (EAC)*, implemented by CPS/SDR. The pilot was conducted by CPS/SDR in collaboration with AFRISTAT, INSTAT, and LABOSEM, with financial and technical support from the 50x2030 Initiative, FAO, and the World Bank. The pilot focused on maize and millet—two key staples—and was carried out in the regions of Ségou and Sikasso.

The pilot included:

- **1,290 grain samples** collected across three rounds during farmers' storage period
- **Laboratory analysis** of physical damage, moisture, and weight loss
- Linkage of grain measurements with detailed **survey data on storage practices**
- Integration of **weather and local agro-climatic indicators**

Physical measurements indicated that maize losses ranged from 1.3% to 1.6% on average per survey visit, while millet losses ranged from 0.4% to 0.6% on average across the three collection rounds, with significant variation across households (see Figure 1). These figures, while seemingly modest in percentage terms, translate into meaningful quantities at national scale and underline the importance of consistent, evidence-based measurement.

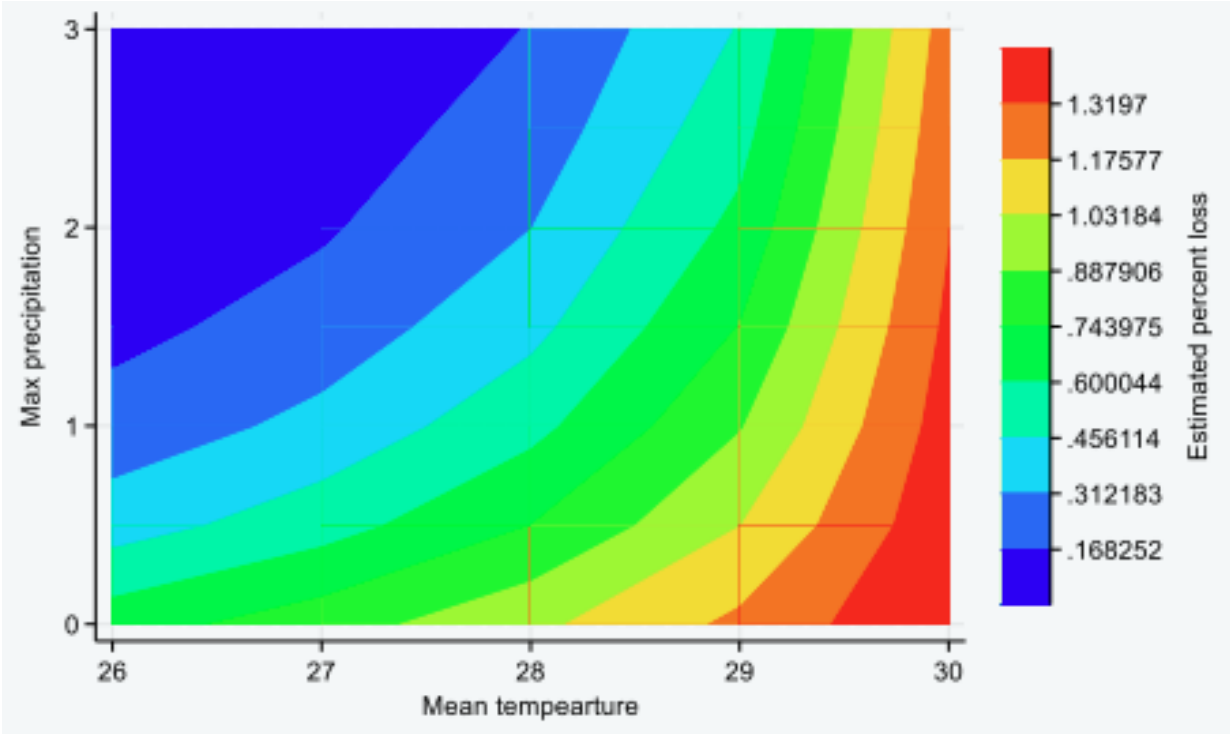
FIGURE 1 – Estimated loss percentage by crop and visit. This figure presents the distribution of estimated grain storage loss rates (%) separately for maize and millet across the three data collection visits conducted during the 2022/23 season in Mali. Each panel shows the spread of observed losses within the sample, illustrating how loss levels and their variability evolved over the storage period. Source: On-Farm Storage Loss Model to Improve National Estimates and Reduce Data Collection Costs



1290
grain samples were collected for this pilot study in Mali

The pilot also showed that **statistical modelling can be used to generalize results beyond the measured sample**, making it possible to update national storage-loss estimates in future survey rounds without repeating costly physical measurements every year.

FIGURE 2 – Weather factors interaction for maize losses. This heatmap illustrates the combined effect of mean temperature and maximum precipitation on estimated maize storage losses. Darker cells indicate higher predicted loss rates, highlighting the conditions—particularly elevated temperatures combined with high rainfall—under which storage losses are most severe. This interaction underscores the importance of incorporating agro-climatic data into loss modelling frameworks. Source: On-Farm Storage Loss Model to Improve National Estimates and Reduce Data Collection Costs



In addition, the study generated empirical evidence on the **main factors associated with storage losses**, including storage infrastructure, drying practices, packaging methods, pest management, and weather conditions. As seen in Figure 2, weather conditions – namely high temperatures and high precipitation – are correlated with higher maize losses.

Mali, Integrated Maize Project (PIM) / Photo via Eucord.

WHY THIS MATTERS FOR POLICY AND NATIONAL STATISTICAL SYSTEMS

The Mali pilot illustrates how **data-smart survey design can produce reliable storage loss estimates at a fraction of the traditional cost**. By shifting from full-scale physical measurement every survey year to periodic calibration rounds supported by statistical modelling, countries can:

- Reduce costs by limiting expensive field operations,
- Improve data quality through rigorous modelling,
- Embed post-harvest loss monitoring into existing survey systems, and
- Generate consistent time series for policy analysis and SDG reporting.

Beyond these efficiency gains, the pilot demonstrated that **this approach is operationally feasible within a real national statistical system**. Successful implementation depends on careful survey planning, close coordination between field teams and laboratory partners, and aligning data collection schedules with crop storage cycles to ensure that measurements capture representative storage conditions.

The experience also meaningfully strengthened national technical capacity in survey operations, laboratory protocols, and the integration of multiple data sources—laying a solid foundation for country ownership and long-term sustainability of PHL monitoring systems.

COMPLEMENTARY WORK UNDER THE 50x2030 METHODS & TOOLS COMPONENT

This work in Mali is part of a broader methodological agenda on PHL measurement.

In parallel, the Initiative conducted analytical research that explored how **machine-learning models, sub-sampling strategies, and farm and household survey data** can be used to estimate storage losses more efficiently.

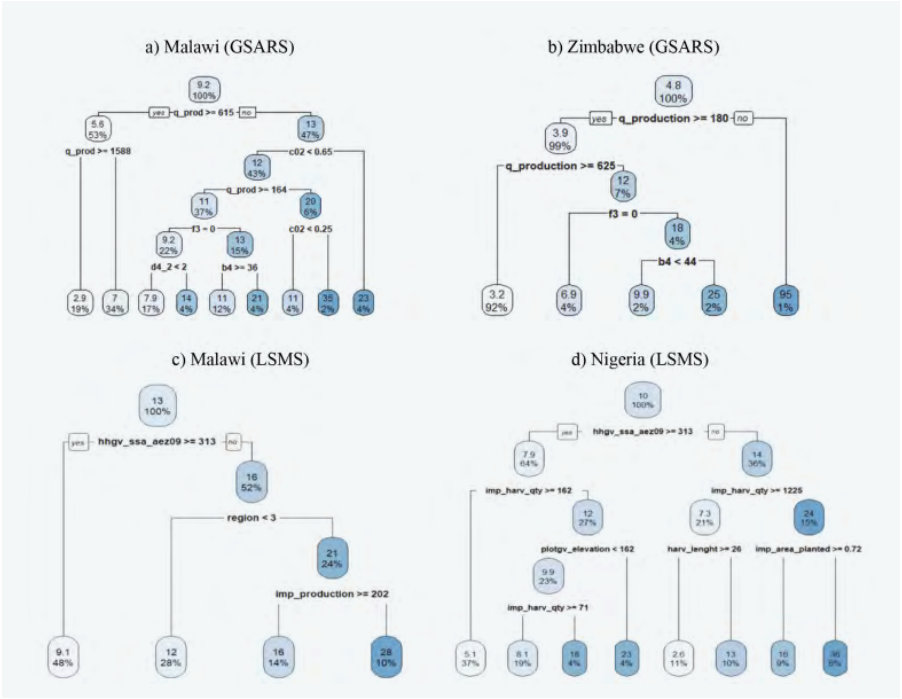
- **Classification and Regression Tree (CART) models** can identify the most relevant predictors of storage loss and map their interactions in an accessible, interpretable way

Data collection costs are significantly reduced, as reliable loss estimates can be produced even when sample sizes are reduced by up to

60%

- Combining survey data with **agro-ecological and weather variables** significantly improves model accuracy and predictive power
- Reliable loss estimates can be produced even when **sample sizes are reduced by 30–60%**, offering substantial savings in data collection costs without a meaningful loss of precision

FIGURE 3 — Regression tree (CART) models for predicting grain storage losses — Malawi, Zimbabwe, and Nigeria. These classification and regression tree diagrams illustrate the hierarchical decision rules identified by the CART models for predicting grain storage losses in three country contexts. Each node represents a key explanatory variable (e.g., storage type, pest management, weather), and the branching structure reveals how combinations of factors jointly determine loss outcomes. The models highlight which variables are most predictive in each setting, supporting the design of targeted, cost-efficient survey instruments. Source: Rühl, S. et al., 2022.



Together, these two research efforts form a coherent and mutually reinforcing package of methodological advances under 50x2030: one provides the analytical and statistical foundation, the other the operational proof of concept within an active national statistical system.

Learn more:

The findings summarized in this brief are drawn from a growing body of rigorous research. For full technical details on survey design, field implementation, modelling specifications, and validation evidence, see the resources below:

On-Farm Storage Loss Model to Improve National Estimates and Reduce Data Collection Costs (50x2030 Working Paper, 2025)

Combining farm and household surveys with modelling approaches to improve post-harvest loss estimates and reduce data collection costs, Statistical Journal of the IAOS (Rühl et al., 2022)

Minimum Losses by Commodity and Region (50x2030 Working Paper, 2021)

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