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POST-HARVEST HANDLING AND STORAGE (PHHS) PROJECT

FINAL REPORT

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This final report was produced for review by the United States Agency for International Development. It was prepared by Nathan Van Dusen and Kristin Beyard for CARANA Corporation. The authors' views expressed in this report do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

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Introduction

Agriculture drives the Rwandan economy, accounting for 80% of employment, 36% of GDP, and 63% of foreign exchange earnings.[1] The agricultural sector has seen rapid growth in recent years with large increases in production achieved by smallholder farmers, 95% of whom have farms that are less than two hectares in size.[2] This fragmented production base leads to serious challenges in getting product to market efficiently and integrating farmers into commercial marketing channels that allow for differentiation. Among the impacts of fragmentation, small farmers lack the capital and know-how to efficiently harvest, store and market their surplus yields. MINAGRI estimates between 15% and 22% post-harvest losses in cereals as a result. Losses impact producers and consumers, reducing farmer incomes and raising consumer prices as a result of diminished supply.

As part of the U.S. Global Food Security Response and Feed the Future Initiatives, USAID's Post-Harvest Handling and Storage (PHHS) Project set out to integrate farmers into commercial marketing channels as a way of driving investment in post-harvest technology and process improvements for staple crops, particularly maize, beans, and rice. The project took an integrated public-private approach to reducing post-harvest losses and improving food security. CARANA piloted new approaches and innovations to engage policy makers, banks, civil society, cooperatives and smallholder farmers. These pilots contributed to developing a market system in Rwanda that encouraged farmers to supply higher quality grain, and built the capacity of local stakeholders (both private and public) to adopt and sustain these pilots, contributing to a more efficient staple crops value chain. The PHHS project's implementation model allowed it to be responsive to government priorities and enabled Rwandan policy makers to incorporate lessons and realities from the private sector into their post-harvest policy framework.

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[1] World Bank, *Project Appraisal Document on a Proposed Grant to the Republic of Rwanda for a Rwanda Second Rural Sector Support Project in the Second Phase of the Rural Sector Support Program*, World Bank, June 2008.
[2] Morel-Seytoux, Sylvie H. Lalonde. *Gender Assessment and Action Plan for USAID Rwanda*, WIDTech, Washington, District of Columbia, March 2002.

This report summarizes the evolution of the PHHS project in terms of objectives, activities and achievements in addition to presenting lessons learned for future programs with similar objectives. The report covers the period of the original project (September 2009 through March 2012), in addition to the 18-month extension through August 2013.

Methodology and Objectives

Project activities, sectors and objectives were identified in the first two quarters of the project. PHHS carried out an opportunity mapping of sector and activity level priorities in Rwanda's commodity value chains, and as a result, developed an *Inception Report* in April 2010. The report examined the current situation in Rwanda with respect to market linkages, post-harvest investment promotion, and post-harvest management for the six targeted staple crops (maize, rice, wheat, beans/soybeans, cassava and Irish potato). Meetings were held with the major buyers/processors of staple crops, which revealed that with the exception of cassava and Irish potato, the supplies of staple crops did not meet market requirements with respect to necessary volumes and required standards. In the development of this report, meetings were held with umbrella organizations and private sector entities working with farmers' cooperatives to learn what sort of assistance is being provided to producers, as well as what constraints farmers encounter from production to marketing. Information was gathered on the regions which have the largest volumes of surpluses for each of the six targeted crops, and an assessment was made of existing post-harvest infrastructure. Trips were also made to the field to visit farmers in several districts of Rwanda, which revealed that farmers needed capacity building with respect to improved harvest and post-harvest handling practices.

Project Objectives

The inception report prioritized maize, beans and rice as the commodities that domestic producers were most likely to be able to market successfully through commercial channels. As a result, PHHS objectives have been defined as follows:

- Mobilizing *private investment and bank finance* to develop businesses that require storage infrastructure;
- Improving *management and handling* of staple crops by farmers, in partnership with agribusiness firms and Rwandan business development service providers through a market-driven approach;
- Developing more robust *linkages* between farmers and the market by connecting producers to premium markets through intensive training by the Sell More for More Training team and other innovations including an online GPS map of producer cooperatives and Market Information System pilots;
- Assisting farmer associations/cooperatives to *expand their own warehouse infrastructure and availability of working capital* through business plan development and finance training courses to attract private bank finance;
- Increasing *MINAGRI's capacity to widen its medium-term strategy* for the development of Rwandan staple crops through improved marketing and post-harvest activities; and
- Identifying specific *market-led interventions* that can be adopted by individual players within the value chain to reduce post-harvest losses in staple crops, including investments by buyers in supply chain constraints.

Budget	$8.3 million
Duration	4 years : September 2009 through August 2013
Components	1. Market Linkages and Business Development 2. Investment Finance 3. Post-Harvest Management 4. Post- Harvest Policy
Targeted Staple Crops	Maize, Beans and Rice
Geographic Coverage	Throughout Rwanda with a focus on Northern and Southern Provinces

Project Component Areas

The scope of work for the PHHS project is comprised of four key components:

1) **Market Linkages** with firms that will result in strategic partnerships to develop business ventures and invest in post-harvest handling and storage;

2) **Investment Finance** that will result in strengthening supply and incomes within the maize and bean value chains;

3) **Post-Harvest Management** that will lead to better handling practices for farmers seeking higher prices for better quality commodities; and

4) **Post-Harvest Policy** support to the Government of Rwanda with the intent to improve the business environment for the private sector.

Project Achievements

During the 3.5 years of the project, PHHS has achieved the following results:

- 83,676 farmers are now using storage centers through PHHS Assistance.
- 104 storage centers were constructed or rehabilitated.
- $1.6 million USD of new investment was made in private agribusiness, particularly cooperatives, aggregators, processors and millers.
- BDS support was provided to 59 SMEs and direct assistance to 358 private enterprises.
- Over 60,000 farmers were trained in post-harvest handling and storage best practices.
- 3 policy strategies focused on improving the enabling environment at the post-harvest and marketing levels were drafted; one of these strategies, the post-harvest strategy was adopted by government.

Furthermore, the project piloted new innovations and activities that have shown impact and sustainability within Rwanda, including new financial products, capacity building methodologies, policy frameworks, and market information systems, to name a few. Many of these pilots are now being adopted by local entities to expand and scale. Additionally, the co-investment grant activities have enabled SMEs with new business ideas to access financing to pilot business practices and investments that have led to increased returns and additional financing from commercial banks and private sector investors.

Private Sector Strategy

In developing the PHHS project's private sector strategy, CARANA collaborated with strategic buyers including the WFP and large private sector millers and aggregators to identify their needs and opportunities for improving smallholder integration into their supply chains. The PHHS project then addressed value chain constraints to the maize, beans and rice sectors by entering into partnerships with these strategic buyers and linking them to cooperatives capable of aggregating enough product to fulfill commercial contracts. The Project was successful in facilitating these linkages by supporting cooperative managers and members with business and post-harvest technical assistance, co-investment grants that were used to upgrade their post-harvest systems, and credit products that addressed working capital constraints among farmer cooperatives.

As a result of this market/demand driven approach, PHHS identified *four key private sector intervention points:*

- Partnerships with strategic buyers;
- Storage and postharvest system investments;
- Partnerships with banks to address working capital financing constraints; and
- Post-harvest and cooperative management technical assistance.

Component 1: Market Linkages Support

The PHHS project mobilized resources to address post-harvest inefficiencies upstream in the supply chain, in part, by connecting smallholder farmers more directly to formal buyers via effective aggregators (typically cooperatives and Small and Medium Enterprises (SMEs)). This approach helped project beneficiaries move away from spot selling to itinerant traders. More direct relationships with more formal buyers (usually through organized cooperatives) also served as a foundation for credit provision and improved market information, which resulted in the production of a higher quality product that can be sold at a premium price.

This shift from selling small quantities into an undifferentiated commodity market to selling a high-value, differentiated product to larger-scale buyers represented a fundamental change in the staples marketing system. Via aggregators, farmers linked to PHHS' strategic buyers are now selling a product that is in demand in the marketplace, giving them newfound bargaining power when entering transactions. The PHHS project helped farmers, cooperatives and buyers build these relationships by acting as a facilitator to stimulate direct contracting with more sophisticated buyers. The PHHS project has sought to build more direct market linkages by serving as an honest broker and connecting cooperatives and buyers to opportunities on the demand and supply side.

World Food Programme Partnership

WFP's P4P program was an important alliance for PHHS, linking smallholder farmers to a premium market for better quality maize and beans. With a target purchasing power of around 20,000 metric tons per year, WFP and its partner trading companies offer a significant opportunity for cooperatives that seek a stable buyer for large quantities. Most importantly, WFP is willing to pay a premium for grain that meets their standard, unlocking value at the cooperative level for improvements in post-harvest infrastructure.

WFP was an important leverage point for the PHHS project as it sought to generate a shift in the market toward product and price differentiation. WFP was willing to source from cooperatives benefiting from PHHS trainings and credit facilitation services, which may otherwise have been viewed as too risky or not economically viable for private sector buyers. The WFP contracts also acted as a catalyst for bank financing of cooperatives. In addition to securing a market, credit and higher prices for PHHS-trained cooperatives, the WFP provided training in warehouse management to the cooperatives that it sources from. Perhaps most importantly, private sector buyers like ProDev/Minimex are following WFP's lead and starting to buy from reliable cooperatives that have supplied WFP in prior seasons, pushing WFP to move on to marginal suppliers.

WFP's relationship has been transformational for involved cooperatives. These cooperatives have improved their post-harvest infrastructure, gained access to credit and developed their capacity to supply a differentiated product that captures a premium in the marketplace.

Towards the end of the project, PHHS began working with other buyers interested in paying a premium for quality. The Rwandan Grain and Cereal Corporation (RGCC), which is targeting 20,000-30,000MT per year, has

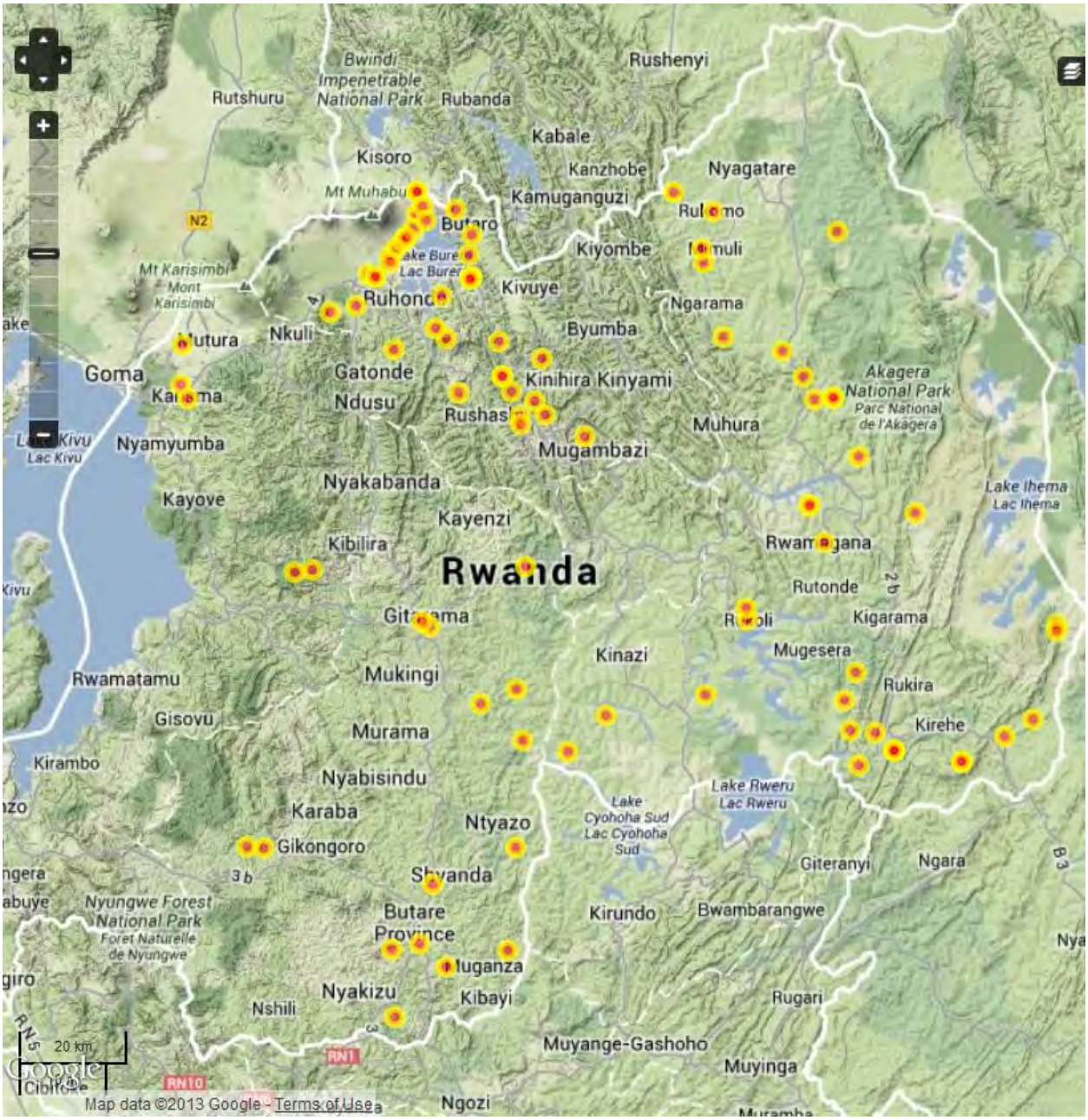
evolved its purchase scheme to mirror the WFP model, offering premium prices for higher quality supplies. Rwanda's Strategic Grain Reserve will also buy according to quality standards.

Market Information Systems

As a way of improving linkages between buyers and producers, PHHS piloted new MIS "e" innovations during the life of the project. PHHS developed a website linked to GPS coordinates of cooperatives supported by the project, and included information on their membership size and the type of product produced. Throughout the project, the business development and communications teams continued to build on the information offered through the PHHS website via discussions with PHHS technical staff and the public/private sector in Rwanda. The PHHS website was used as a virtual business development center and the project has been providing continual updates, including re-verification of GPS coordinates for PHHS-supported cooperatives, redesign of PHHS web pages and development of PHHS Yellow Pages (e-directory) that advertise PHHS stakeholders interested in buying, selling and/or processing beans and maize within Rwanda. These web-based tools have been transferred to the Eastern African Grains Council (EAGC) and the East Africa Commodity Exchange; both organizations are currently building their website content and services.

PHHS also spearheaded the development of an SMS trading pilot system that linked 96 PHHS-trained cooperatives (selling maize and beans) to 53 buyers in Rwanda. Through this platform, buyers are able to share information with cooperatives on quantities demanded and prices, and sellers are able to push information on crops available for purchase. The objective of this pilot system was to address the need for real-time price information on crops, to reduce market information inefficiencies between sellers and buyers, and link PHHS-trained cooperatives with buyers in real time as a way of building on the PHHS GIS tool. One Acre Fund Market Agents are interested in integrating their own cooperatives into the platform, as they have also received quality trainings. Since the project is coming to a close, PHHS is currently transferring this system to the Eastern Africa Grain Council (EAGC).

Figure 1 – GPS coordinates of PHHS-assisted cooperatives.



Through the innovation grants facility, the project worked with a Rwandan, women-run firm—M-Awhiii—to develop a new Market Information System (MIS) model and an SMS based pilot. M-Awhiii designed a survey to assess farmers' needs, identifying preferred and affordable technologies, and rolled out a plan for its MIS platform. The data collected from the survey informed the design of the roll out plan and the platform is expected to improve access to information and facilitate linkages between farmers,

traders and processors. Following the grant, M-Ahwiii will engage with different actors, register them on the platform, and train them on how to use the system. The grantee is also discussing a partnership with the Rwanda Agricultural Board (RAB) to engage their extension workers. M-Ahwiii's MIS product would provide RAB with an interface to connect extension workers with farmers, and provide virtual assistance and information to supported farmers and cooperatives.

Value Chain Analyses and Targeted BDS& Market Linkages Support

On an ongoing basis, through the work of both the Market Linkages Advisor, and later, the BDC Advisor, the project carried out and facilitated ongoing discussions, buyer visits and workshops with private sector actors in Rwanda and within the region. Project staff traveled to Uganda to facilitate deals with beans buyers, worked with other donor projects in Kenya to link buyers and processors with Rwandan producers, helped organize agricultural fairs and workshops for Rwandan stakeholders, and identified value chain stakeholders interested in investing in PHHS priority sectors.

The project carried out a bean value chain study and as an outcome of this study, developed a list of actors used to identify areas of collaboration in training, market linkages, and market information. This assessment led to a feasibility study of the bean value chain, paying particular attention to bean processing constraints and opportunities. The case study analyzed Rwanda Agribusiness Industries (Rabi Ltd), a company involved in processing and packaging pre-cooked beans. As a result, a training program on beans was developed using the SMFM model.

Additionally, through the grants and post-harvest training activities (described in greater detail in the next two sections), the PHHS project provided ongoing market linkages advisory services to project beneficiaries and business development support to firms applying for grants and bank financing. In total, 59 agri-business firms were supported through direct technical assistance.

Transport Study

A team of CARANA consultants undertook a study of the transport and logistics process in Rwanda to understand how inefficiencies in the transport and logistics sector relate to post-harvest loss rates and the overall costs and competitiveness of the maize and beans value chains. The interviews conducted for the study covered all the relevant actors (producers, distributors, transporters, wholesalers and consumers) along the maize and bean logistics chains, as well as production sites, collection centers, wholesale and retail markets, and selected consumption areas across Rwanda. In combination with stakeholders, PHHS identified interventions for MINAGRI and the private sector to address the most glaring inefficiencies, and generated a list of the highest priority road infrastructure and market logistics investments. The study also looked for business opportunities to facilitate the creation of new public-private partnerships for investment in maize and bean infrastructure, and to improve overall transport and logistics operations in Rwanda.

MARKET LINKAGES AND BUSINESS DEVELOPMENT IMPACT

83,676 farmers using storage centers through PHHS assistance.

Direct assistance to **358** private food security enterprises and organizations.

BDS support provided to **59** **SMEs,** including farmers,

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SUCCESS STORY

Women farmers increase revenue through trainings

Working with women farmers to achieve profitable growth addresses their immediate capital needs and promotes empowerment

(Left to right) Agritesco cooperative members Beata Mutesi, Agnes Karombe, Console Munganyinka, Jamima Mukawiringiye, and Claudine Uwimana. Console is showing a STICKS banner.

(Left to right) Twitezimbere cooperative members Patricie Mukarunziga, Annonciate Musabwamana, and Esperance Kakuze.

PHHS improved the competitiveness of smallholder beans and maize farmers in Rwanda by addressing post-harvest inefficiencies while directly connecting smallholder farmers to formal buyers. In collaboration with the World Food Program's Purchase for Progress, PHHS implemented Sell More For More (SMFM), a comprehensive capacity-building program to improve the ability of beans and maize cooperatives to meet buyer requirements. SMFM's Training of Trainers component, was facilitated by STICKS or banners. STICKS records early trainee success in training other cooperative members on post-harvest handling techniques. STICKS were highlighted as an innovative data collection tool at a Feed the Future East Africa Regional Workshop, and SMFM received InterAction's Best Practices and Innovations Award.

The vast majority of post-harvest activities in Rwanda are managed by women. Therefore, they have a significant role in reducing post-harvest losses. SMFM required at least 50% participation by women; and by the end of September 2012, PHHS had built the capacity of over 22,000 women small-holder farmers. Women farmers in the Agritesco and Twitezimbere cooperatives in the Eastern Province demonstrate the significant gender impact achieved by SMFM. The women emphasized that before SMFM, their post-harvest losses were high and they were affected by seasonal price variations that resulted in low prices at harvest (e.g. spot selling to itinerant traders). Following the SMFM trainings, these women farmers are now able to produce a higher quality product that sells at a premium price. They are also empowered to establish more direct relationships with formal buyers (through their cooperatives). This served as a foundation for building a dry storage unit, providing credit to members and improving market information.

Annociate Musabwamana, Twitezimbere cooperative Vice President says, "Before the SMFM trainings, I was not yielding a profit from the crops I was growing; having learned post-harvest handling techniques through the SMFM trainings, I am now harvesting around 300 kilograms of maize [compared to the previous 50 kilograms] and making some profit." This welcomed profit is freeing up money for investment in Annociate's family's healthcare, her children's education, small-scale business investments and personal savings.

In its last months, PHHS introduced and strengthened SMFM by developing the EMPOWER training model which focused on gender. EMPOWER supported women in defining income planning strategies and determining household spending priorities in order to address gender-based inequities in household decision making. EMPOWER will facilitate women farmer's improved long-term management of their income for years to come.

Component 2: Investment Finance

Underinvestment in storage infrastructure was identified in the design of the PHHS project as one of the most acute constraints to a more efficient and competitive agricultural sector in Rwanda. This was based on two assumptions: 1) post-harvest losses were high and 2) seasonal price variations resulted in low prices paid to farmers at harvest and high marketing margins for traders. However, an analysis of historical prices did not support the second assumption and it is suspected that initial estimates of post-harvest losses were high. This called into question the value of focusing on construction of large storage units, so the PHHS project expanded its focus to include basic marketing infrastructure for staples, such as equipment for shelling, cleaning, drying and bagging.

One of the most fundamental constraints faced by cooperatives in Rwanda is financing the aggregation of maize and beans from their members. Until this constraint was resolved, the entire system was broken. As a result of investments made in both storage and basis infrastructure, the capacity of cooperatives to aggregate product and meet the requirements of premium buyers increased dramatically. The project also provided support for cooperatives seeking working capital finance to support aggregation of maize from their members.

Strategic Partnerships through Co-Investment Grants

At the start of the project, in conjunction with the mapping exercise, the PHHS project addressed market linkages constraints by facilitating alliances in order to mobilize investment in post-harvest storage facilities, with the objective of increasing volume of storage. The project partnered with one of the largest grain buyers in Rwanda, ENAS, in order to co-invest in backward linkages with farmers and post-harvest systems. In collaboration with USAID East Africa's Market Linkages Initiative (MLI), the project targeted the middle of the value chain and leveraged MLI grant funds to design grant/investment packages that improved linkages between farmers and buyers. These investments were made in village aggregation centers (VACs), grain bulking centers and post-harvest handling equipment, and cooperative trainings and farmer field days. As a result of the MLI partnership, most market linkage activities in the first year of the project centered around six key grants partnerships; MLI provided the grant funds and management, while PHHS supplemented cost-share grants with technical assistance and field-based grants oversight.

Following the close of the MLI project in September 2011 and due to the success of the initial MLI grants, the PHHS project, upon approval from USAID, realigned its own project budget to facilitate additional grants to cooperatives for storage technology. The project selected an additional 3 cooperatives to receive co-investment grants for storage–Bright Future Cooperative and the COACMU cooperative, both in the Kirehe district, and the INDAKUKI Cooperative in Bugasera. The grant application process included a detailed tendering process led by construction engineers from the project's lead engineering sub-contractor, SOGIS. These additional VAC grants were completed in the first quarter of 2012.

Following the achievements realized by the original grants pilot, the project set aside additional funds in the PHHS extension period for co-investment grants. An additional 10 grantees were selected, representing new geographic locations. Additionally, rather than focus solely on storage grants, the PHHS team solicited proposals for "innovative grants" in order to pilot new business concepts for facilitating investments and improving linkages in the maize and beans value chains.

The PHHS project carried out a cost-benefit analysis of each of the proposed grants. Following this analysis, the project awarded grants to four cooperatives willing to co-invest in village aggregation centers in new Rwandan market locations: a company near the border with the Congo that required silos to increase his capacity to store and trade maize in that region; a company developing a new fortified baby formula product; a local women-run firm piloting an SMS-based market information system; and a regional grain association – EAGC – that was interested in launching a stakeholder forum in Rwanda to improve public-private sector dialogue around grain market issues.

The infrastructure grants supported by PHHS and the MLI project not only improved business performance in the short term, but also increased cooperatives' access to finance. Additionally, the new innovative pilots provided a chance for companies to launch value added processing activities in the project's targeted sectors, thus increasing private sector participation and investment in maize and beans. As a result of these grant activities, throughout the life of the project, 104 storage centers were constructed or rehabilitated and over $1.6million in new private sector investment was facilitated.

INVESTMENT FINANCE IMPACT

$1.6 M of new private sector investment in agriculture.

104 storage centers constructed.

Merchandizing Credit

Financial institutions in Rwanda are reluctant to invest in the agriculture sector due to the perceived level of risk. Historically, banks in Rwanda have also engaged in traditional collateral-based lending that is difficult for farmers and cooperatives to access. Asset-based lending models that leverage the value of aggregator inventories, accounts receivable, purchase orders, etc., are relatively new. In this environment, it is difficult for cooperatives to mobilize capital for basic infrastructure and purchases of grain from their members.

The PHHS project evolved its finance approach from an initial focus on leveraging investment in storage infrastructure to a focus on credit for cooperatives to support purchase surpluses from their members. This "merchandizing credit" model is enabling cooperatives to successfully fulfill orders from buyers like the WFP and PRODEV/MINIMEX. The merchandizing credit product was developed via a partnership between the PHHS project and Kenya Commercial Bank (KCB), and allows cooperatives to borrow against pending orders to finance the purchase of grain from their members. This asset-based mechanism is new to agricultural lending in Rwanda and has shown promising results.

At the beginning of the project, PHHS staff targeted Microfinance Institutions with an interest in lending to agricultural cooperatives or farmers. However, after identifying various opportunities for commercial bank lending in agriculture, beginning in March 2010, the project began conversations with larger commercial banks to discuss the possibility of financing WFP cooperatives in the Eastern Province. The loan product was developed in conjunction with a technical assistance program for cooperatives in business management to ensure adequate capacity to absorb and manage debt on the borrower side.

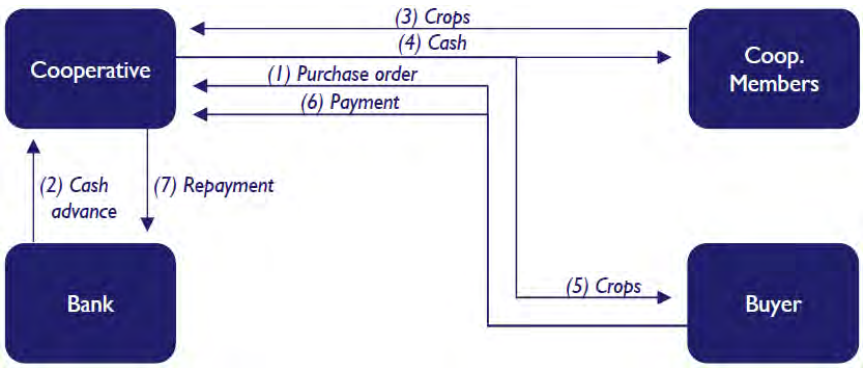
PHHS piloted the merchandizing credit product in early 2011 with a single cooperative, COACMU, which required approximately 150million RWF (over 200,000 USD) in working capital. The issuing bank, Banque Populaire, agreed to finance RWF 52million (80,000 USD) to fulfill the

WFP order. The activity was designed as a test case to assess the banking sector's capacity and willingness to lend to agribusinesses. The loan was structured as a short term working capital loan revolving on a two month period. PHHS worked with COACMU to provide them with a business plan and technical support.

In the pilot case, the bank required traditional collateral including a provision stipulating that senior members of the cooperative provide details on personal assets. Additionally, the loan was disbursed too late, only arriving after the cooperative finalized its collection. To better understand what caused the late disbursement, PHHS reviewed the procedures required for loan approval and disbursement, concluding that the bank's paperwork requirements and procedures needed to be streamlined.

With this in mind, PHHS engaged Kenya Commercial Bank (KCB), Banque Populaire and Urwego Opportunity Bank, to develop a more functional model of working capital finance for PHHS partner aggregators supplying WFP. As a result of these discussions, KCB agreed to develop accommodating credit policies for deals backed by WFP purchase orders that did not require fixed collateral. As a result, PHHS helped KCB to provide INDAKUKI cooperative with a 22.5 million RWF loan in August 2011. As a result of the loan, INDAKUKI cooperative was able to supply a 200 MT maize contract to WFP P4P and repaid their loan in full by the end of 2011.

Figure 2 – Merchandizing credit model.



KCB Bank was the most aggressive in terms of its efforts to expand the merchandizing credit program to new cooperatives and buyers. In order to build on this interest to scale up and expand the product, PHHS consultants Bill Wolfe and John Bosco Razabuka analyzed outcomes from the project's pilot work and provided recommendations on merchandizing credit activities for the extension period of the project, including:

1. There must be a system to stay current on buyer needs, seller stocks and market prices in order to establish new purchase order (PO) contract relationships.
2. Identify other buyers willing to put a premium on quality: RGCC seems to be a promising buyer "candidate" since they are offering producers a premium for quality.
3. Without a focused effort, the inertia of doing things the "old way" via local traders will continue to prevail.

Banque Populaire, although interested in the product and willing to sign a tri-partite agreement with the WFP and the participating cooperative, remained locked into a "traditional" lending structure. They were only willing to provide a 75% advance rate to the cooperative and required significant collateral coverage. Unfortunately, Banque Populaire has continued to have mixed success in lending to cooperatives.

Due to the success of the pilot with KCB, PHHS worked to identify new buyers to target with the merchandizing credit product for Season A 2012. Following meetings with private grain traders to gauge interest in this product, MINIMEX, PRODEV, RGCC and ENAS signed contracts using the same purchase note as the WFP. PHHS also identified additional cooperative suppliers, and supported them in developing business plans and performing financial due diligence in preparation for loan applications. Additionally, the project developed a "package" for the Access to Finance (AFR) Project, in affiliation with MINAGRI, to provide details, tools and direction on how the merchandizing credit product operates.

One of the observations during the project's analysis of the pilot was that a more hands-on approach to implementing these activities was necessary. Although KCB has been interested in expanding the product, they have yet to fully commit their staff to implement its roll-out. In turn, it is clear that although cooperatives seem to understand the benefits of the product, linkages to private-sector buyers willing to enter into purchase order agreements are still weak. As a result, during the extension period of the project, PHHS piloted a new model for facilitating loans through KCB via a local BDS provider –Synergiadev—who was paid an "incentive" fee equal to 1.5% of the loan value once that loan was approved by the bank. Both KCB and PHHS signed a contract with Synergiadev to work with both cooperatives and buyers to structure purchase orders and vet cooperatives for financing. In the last 3 months of the project, Synergiadev was able to close 4 deals and facilitate $178,560 in financing.

PHHS has shown that the PO financing concept is viable; however, the expansion will require consistent efforts to create "new habits" on the part of sellers and buyers. One is the use of local intermediaries like Synergiadev. The model has proven sustainable as KCB is engaging Synergiadev's services directly following the close of the project. As a result of PHHS' work in piloting the merchandizing credit product, $628,868 USD in loans were provided to Rwandan cooperatives

Component 3: Post-Harvest Management

Most farmers lack knowledge of or access to information on appropriate post-harvest handling practices. Some farmers join farmer organizations to aggregate product and to find better markets. Unfortunately, many farmer organizations are poorly managed and the members themselves are unable to produce quality products that meet the specifications of better paying buyers. Farmer organizations also struggle to find relevant technical and business support and local organizations (private support firms and government agencies) lack the ability to provide effective training and

technical assistance. As a result, under the post-harvest management component, the PHHS project focused largely on rolling out a comprehensive capacity-building program targeting maize and bean cooperatives in the Eastern and Southern provinces through a Training of Trainer (ToT) model. The training included two major components: 1) training on post-harvest handling and storage techniques; and 2) assessing the effectiveness of the training. The project also developed a training curriculum for cooperative leaders that features four modules on leadership, marketing, record keeping, and action planning.

Anchoring the training program in the relationship with WFP served as a catalyst for adoption of practices introduced during the training. As cooperatives improved their capacity to meet the requirements of more sophisticated buyers, this gave them negotiating power and allowed for diversification beyond the initial anchor buyer. The project has supported this diversification, with cooperatives initially supplying WFP moving on to supply commercial buyers. The powerful combination of well-designed training and a sustainable market linkage made this possible.

Post-Harvest Management Training/*Sell More For More*

The World Food Programme's (WFP) Purchase for Progress (P4P) initiative was officially launched in Rwanda in April 2010. With the introduction of a premium-paying buyer into the Rwandan market, the PHHS project capitalized on the new demand for higher quality products by partnering with them to address supply side constraints. The WFP approached PHHS to help them select cooperatives and design a training that would improve cooperative capacity to supply a premium product that would meet WFP standards. WFP was willing to pay a premium price to cooperatives meeting those standards.

Following initial discussions, PHHS and WFP P4P selected 25 cooperatives from two regions that had the potential to meet the criteria of providing maize and beans to the program. PHHS and WFP assessed the cooperatives for any previous or ongoing training from other agencies so that there was no duplication of training. PHHS developed a training pilot by working through district agronomists employed by the Ministry of Agriculture. However, after evaluating the extent and quality of onward training of farmers and cooperatives, the project changed directions to focus on a lead farmer ToT model.

As a result, in the latter part of 2010, PHHS developed and launched a joint WFP P4P training program, Sell More for More, to improve cooperatives' capacity to meet WFP requirements in maize. The training program consists of six modules: leadership, marketing, business planning, record-keeping,

post-harvest handling and warehouse management. The ToT component is facilitated by "sticks" banners that provide a visual of good post-harvest management practices and allow the trainer to record the number of farmers trained. The maize trainings were carried out throughout the 2011 calendar year.

During the extension period of the project, the Natural Resources Institute was engaged to implement a needs assessment for beans and develop a training report on areas of required technical assistance and capacity building. This was done alongside PHHS local partner WEACS, who then worked with PHHS to develop a training program based on the needs identified. In the final year of the project (2012-2013), new post-harvest management trainings were targeted toward bean cooperatives, focusing again on meeting WFP quality standards.

Based on recent assessments by the project, cooperatives supported with the training and grants for appropriate post-harvest technology were able to reduce their losses from an estimated 35-40% to less than 5%. Additionally, because the training required at least 50% participation by women, significant gender impact was achieved. This is especially important because the vast majority of post-harvest activities are managed by women, so they have a significant role in reducing post-harvest losses.

Cooperative Leadership Training

The project also developed a training curriculum for cooperative leaders that relies on Leadership Kits. A Leadership Kit is composed of four modules: Leadership, Management, Records, and Operations. Each module is a three-day workshop that is delivered by a local firm—AFFICCO— to

the current and emerging leaders of the cooperative (approximately 15 people). The workshops are conducted with two cooperatives together (30 people total) to facilitate sharing of experiences and to encourage future collaboration.

All workshops followed a 5/25 design: for every 5 minutes of formal presentation by the facilitator there must be 25 minutes of activities, small group discussions or peer dialogues. All participants were also issued Planning Books in which they capture ideas and action items for their cooperative. The output of the first two modules is a Marketing Plan; the output of the second two modules is a Business Plan.

Different cooperatives that have participated in trainings together are now working together to share resources, including storage infrastructure. The project has also seen improvements in understanding how to write and manage contracts and some cooperatives have started demanding that new contracts be drawn up in Kinyarwanda instead of English. Related to this, cooperatives are reaching out to traders and buyers much more frequently to receive price information before negotiating contracts.

BDS Partnerships

One unique feature of the Sell More for More training program was that training activities were implemented through two local training providers -- WEACS and AFFICO—while the WFP trained cooperatives in warehouse management. Using local partners improved the sustainability of the training program, as Rwanda now has two local service providers that are capable of implementing post-harvest management and cooperative management trainings without the technical guidance of an international

contractor. The local service providers have also been successful in developing a training approach and strategy that marries international best practice with local practice and context.

The engagement of WEACS and AFFICO provides a solid foundation for a future service industry supporting agribusiness, but that industry is not yet commercially viable. Competition from donor and government-subsidized programs supporting agriculture is such that cooperatives and agro-processors aiming to improve supply chain efficiencies do not generally need to procure these services from commercial providers. However, WEACS and AFFICO have been successful in securing sub-contracts from other donor organizations, thus creating a market for local service provision in line with USAID Forward priorities.

As a result of the SMFM program, over 60,000 people have been trained. Retention and application of skills has also been noticeable. Following a 2012 assessment of the SMFM program, 87% of trained farmers were applying best practices in post-harvest management compared to 46% before trainings occurred. This has resulted in increased income for 93% of those surveyed, better quality products for 91% and higher prices received among 77% of trainees.

Figure 3 – Sell More For More STICKS banner.

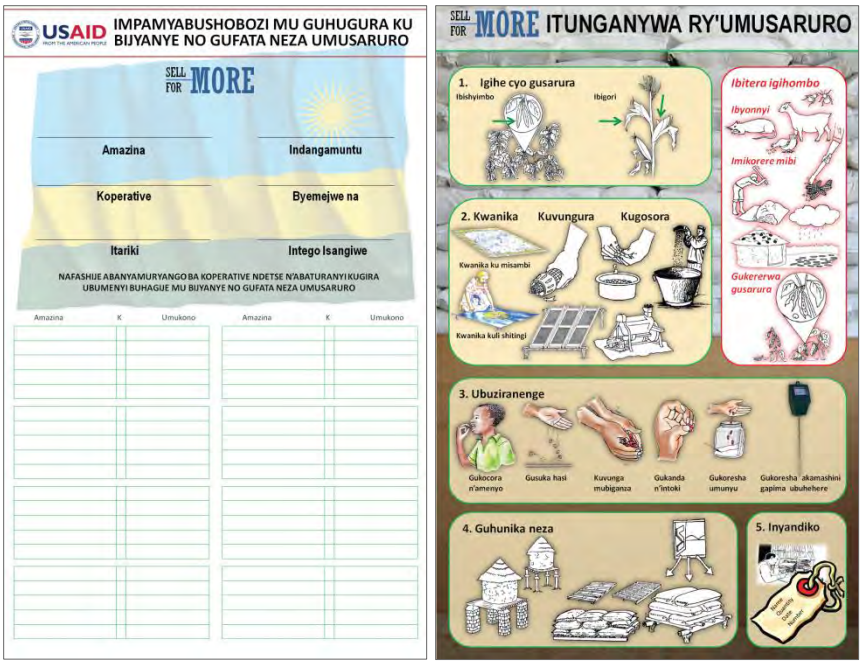
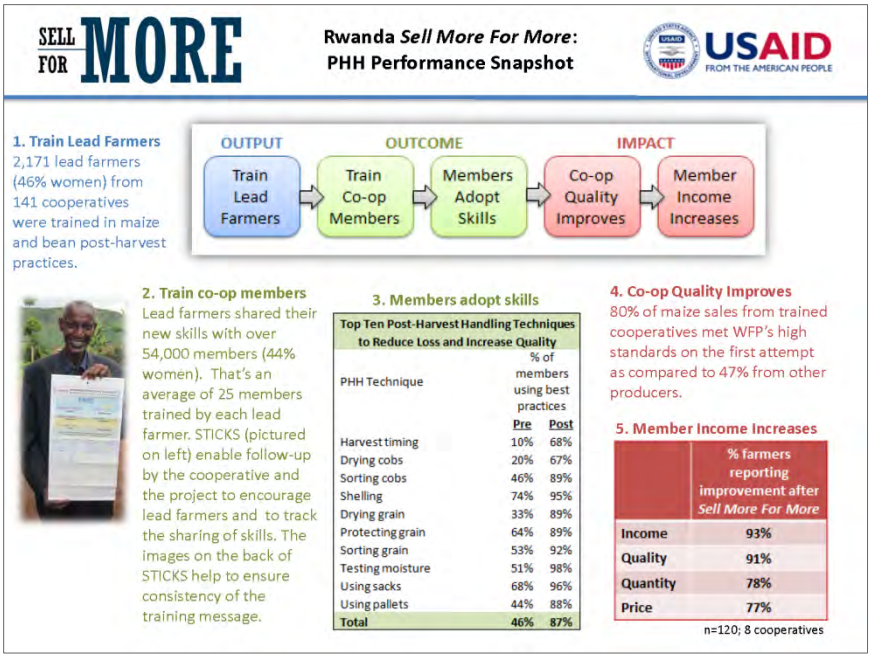


Figure 4 – Sell More For More performance snapshot.



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FROM THE AMERICAN PEOPLE

SUCCESS STORY

Sell More for More trainings empower local farmers

Maize cooperative leaders receive training in post-harvest handling, storage, and management.

Farmers from two different cooperatives in the Eastern Province of Rwanda work together in small groups to brainstorm new ideas for increasing the quality and productivity of their crops. Rwandan trainers facilitated the leadership session, the first of seven modules that provide technical and business practices to lead farmers.

"I was particularly pleased with the cooperative leadership development we completed. I am optimistic to see that from these workshops the cooperatives are going to increase production and sales."

Evariste Kaberuka, President,
Ibyizabiri Mbere Cooperative

With high-crop losses estimated between 30-40%, it is imperative for farmers in Rwanda to learn proper storage and handling techniques for their crops. *Sell More For More* trainings are part of USAID's Post-Harvest Handling & Storage (PHHS) project, in partnership with the World Food Program's Purchases for Progress (P4P) program. These trainings provide technical and business practices in post-harvest handling, storage and management to the leadership of 24 maize cooperatives.

A kick-off training for the Eastern Province of Rwanda was held on 17 January for 30 farm leaders of the Ibyizabirimbere and Terimberemuhinzi cooperatives. Lead farmers attend the six-week training and then pay it forward by committing to train the remaining farmers in their cooperatives.

The majority of farming cooperatives in Rwanda are less than five years old. Many only have volunteer boards and few paid staff. Making the leap from getting organized to actually making money is significant. These trainings give farmers the necessary tools and technical expertise needed to lead their growing members.

The trainings pair up cooperatives–bringing farmers together who might never have the opportunity to learn from one another in such an intentional setting. "This learning between cooperatives is powerful," says John Leary, Senior Technical Assistance Director for PHHS. "Participants have a sense of ownership over the process."

Dennis Weller, Mission Director for USAID Rwanda, attended the kick-off celebration. "I was struck by the eagerness of the farm leaders to apply business principles to farming. Farmers and cooperatives are working together to better dry and store their crops; this training of lead farmers—men and women—is a good demonstration of how the U.S. is working under the Feed the Future initiative to accomplish greater food security," Weller said.

Public Sector Strategy

The PHHS project worked closely with the government of Rwanda to prioritize project objectives and activities that were strategic for the Ministry of Agriculture (MINAGRI) and to improve the enabling environment and government support for commercial marketing of staples. Additionally, the project's knowledge of the private sector and lessons of the ground were used to inform policy decisions.

PHHS implemented several initiatives aimed at supporting the government of Rwanda's policy framework and programs targeted at grains sector. The project supported MINAGRI to:

- Develop a National Post-Harvest Staple Crop Policy;
- Improve data/evidence driven policy by building the capacity of government stakeholders to monitor, utilize and manage postharvest loss information through improvements in data collection;
- Develop a detailed strategy for the government Market Information System – ESOKO; and
- Design a Strategic Grain Reserves Manual to assist the government in managing their strategic grain stocks.

Furthermore, the project has made an effort to improve information flow between public and private sector by working with MINAGRI in an advisory role and supporting Rwandan civil society to facilitate public-private dialogue between value chain actors.

Component 4: Post-Harvest Strategy Development

In the first year of the project, USAID engaged the PHHS project to assist Rwanda's Ministry of Agriculture (MINAGRI) in developing a National Post-Harvest Staple Crop Policy to address issues related to increasing production, including post-harvest losses due to poor handling, and lack of storage and processing infrastructure. Under this component, the PHHS project finalized a report and action plan providing evidence-based

examples, policy guidelines and suggestions for interventions by MINAGRI in order to encourage private sector driven approaches to addressing post-harvest losses. Specific recommendations included improving efficiency of transport systems between production and secondary aggregation points, and leveraging the Rwanda Strategic Grain Reserve's buying power to support marginal, but viable markets that would benefit from road improvements.

Following the assessment, three project consultants specializing in agribusiness, policy and budgeting developed a budgeted implementation strategy for the Post-Harvest Policy and presented it at several public-private sector workshops. Following this consultancy, the PHHS team decided it would be necessary to hire a full-time, dedicated policy advisor to oversee the passage of the strategy within Parliament. With the support of the full-time advisor, the PHHS team assisted MINAGRI to develop a strategy to address the development of a strong Rwandan post-harvest sector and complement GORs plans for a strategic grain reserve system.

The post-harvest strategy was approved by the Inter-Ministerial Coordination Committee and formally passed by the Cabinet in December 2011. It should be noted that due to the large number of policy papers and the complexity and difficulty of getting them accepted by Rwandan Government, very few policy papers are actually passed. This relatively swift passage should be seen as a success, but only an initial step toward a comprehensive approach by the government to developing the post-harvest sector. Following passage of the policy, PHHS continued to support MINAGRI in its implementation of the strategy.

MINAGRI Advisory Support

The PHHS project also supported the Ministry of Agriculture in developing its policy planning capacity, shifting to a more accurate approach for assessing what future surpluses will be and how the government can respond in ways that maximize the volume of surpluses reaching the market. The Ministry of Agriculture-led Post Harvest Task Force is the central mechanism for inter-agency planning, with individual agencies and Ministries responsible for different aspects of strategy implementation.

The PHHS Policy Advisor provided support to the Task Force and advised the government on areas such as the creation of a national grains and cereals corporation, a national commodities exchange, and a national strategic reserves policy. During the extension period, the policy advisor served as an embedded advisor within MINAGRI to increase the advisory services provided to the government.

Among the initiatives resulting from the project's advisory role, PHHS partnered with MINAGRI to improve on-farm storage through the use of hermetic bags. 953 agro-dealers and 563 lead farmers were trained in May 2013 in the use of two different airtight bags. A national hermetic bag opening day was held in June 2013, the purpose of which was to show farmers and traders the impact that the hermetic bags have on controlling insect infestation and maintaining stable moisture levels in grain. The Policy Advisor, as co-chair of the MINAGRI ICT Committee, also contributed to a pilot to develop a fertilizer voucher scheme via a mobile Visa money platform link agro-dealers, government subsidy payments, and government purchases for the state reserve. The PHHS policy advisor also contributed to the Grow Africa Initiative proposals for Rwanda in order to attract outside investment in strategic agricultural sectors.

Post-Harvest Loss Assessment

In the first quarter of 2011, PHHS began working with the MINAGRI Post-Harvest Task Force to develop a suitable approach to the estimation of post-harvest losses. An initial focus on maize and rice was prioritized and the PHHS project engaged the Natural Resources Institute (NRI) to use the *African Post Harvest Losses Information System (*APHLIS) system in determining postharvest losses in 2011. NRI consultants, in collaboration with PHHS, trained MINAGRI data collectors in how to administer the APHLIS survey instrument as part of a comprehensive system for Rwanda to monitor key factors affecting postharvest losses. The PHHS team also field tested the postharvest survey questionnaire with the MINAGRI data collectors, developed a user friendly spreadsheet for entry of the postharvest survey data, trained the MINAGRI data entry team on its use, and assisted the survey team in planning the 2011 Season A postharvest survey.

NRI returned to Rwanda following the survey of losses for Season A 2011 to analyze the figures and work with MINAGRI on data analysis. As a result, NRI developed postharvest loss figures for Season A and presented these findings to MINAGRI. PHHS also adapted and improved the Season A questionnaire for Season B 2011 in order for MINAGRI data collectors to carry out further loss research and input data into the APHLIS system.

Following the initial assessments in 2011, PHHS responded to MINAGRI's request to support their survey efforts for Season A 2012 through technical assistance and financial support to MINAGRI's enumerators. The project saw this development as a positive step forward since it showed that MINAGRI had taken ownership of this survey.

As a result of concerns that the APHLIS system was not predicting Rwandan losses accurately enough, PHHS helped the GoR analyze other

models. The APHLIS model relies on secondary data to provide coefficients for post-harvest loss data. Therefore, the aim of a new tool was to include more Rwanda-specific coefficients.

Beginning in the third quarter of 2012, the PHHS project housed a Fulbright Scholar from Purdue University, Mike Jones, specializing in storage and postharvest management. Mr. Jones coordinated post-harvest loss assessment activities with the Postharvest Task Force and RAB and worked with MINAGRI and PHHS to develop an economic and physical post-harvest loss model for beans and maize. This economic tool measures economic losses due to reduced quality and has the potential to help government and private sector make informed decisions about which postharvest inputs are economically effective.

A national survey was administered from October 9-17, 2012, which gathered cross-sectional data on farmer's losses from harvest to end use. Extension agents were trained to use physical "visual scale" samples of damaged grain in data collection. In this way, farmers could identify quality of grain throughout the marketing season and more precisely estimate losses. The data, overall, came close to the APHLIS-generated figures. Following the October assessment, Mr. Jones led a team of three MINAGRI enumerators (conducting surveys in 22 national rural markets in Rwanda) to quantify price discounts resulting from insect-damaged beans and maize. The survey appraised actual grain samples with 0%, 5%, 10%, 20%, and 30% insect damaged grain.

Mr. Jones and the MINAGRI enumerators followed up with another assessment for Season A 2013. Compared to the Season A 2012 assessment, which occurred 4-5 months after harvest, results for Season A – carried out 1-2 months after harvest—indicated a logical increase in traders' discounts for lightly damaged grain earlier in the season, and nearly ubiquitous rejection of heavily damaged grain. The national average discount per hole in 100 grains increased 69.4% between survey periods, from 0.36% at the end of Season B to 0.61% at the beginning of Season A.

When compared to Season A, Season B showed a 67.3% increase in discounts per 1% grain damage between survey periods. Rejection rates increased dramatically, even for 10% damaged grains. The economic analysis was able to demonstrate that postharvest losses result in a significant decrease in what the market is willing to pay, and thus indicates a trend towards price differentiation based on quality. The survey also showed farmers the economic returns that are possible from improved postharvest handling and storage.

The PHHS team also trained enumerators to physically measure losses at the harvesting and drying phases. Next season, following the close of the

PHHS project, they will measure shelling and transport losses. MINAGRI staff is now fully trained on post-harvest loss estimation and have started estimating maize losses on their own; beans and rice will follow. MINAGRI has committed to managing the post-harvest loss assessments based on the methodology developed by the PHHS project.

Although the project was not able to measure changes in postharvest losses during the period of the project, the maize assessment carried out in 2012-2013 was able to show a 3.79% decrease in physical losses among farmers who were trained in postharvest management. Additionally, the activity was successful in developing a post-harvest loss monitoring system and building the capacity of the Rwandan government to continue reporting loss trends in the future. This will be critical for the government to monitor changes in losses over time, and contribute to data-driven policy decisions. PHHS has given the Rwandan government the tools to manage a robust system for data collection and analysis beyond the life of PHHS, and use that information to direct government resources toward market constraints. Results from the survey can be found in Annex II.

Esoko Assessment and Strategy

In 2012 and early 2013, PHHS carried out an e-Soko strategy assessment in partnership with MINAGRI and FAO. The team also worked closely with the FAO and MINAGRI to develop a detailed action plan, which laid out a five-year road map for the development of an "e-Soko 2.0 Patch" and "e-Soko +". The Strategic Plan identified constraints within the current platform and provided a strategy and budget for the e-Soko 2.0 Patch and e-Soko + strategies. The strategy takes into account both private and public sector interests and ways of getting necessary private sector buy-in, including the eventual privatization of the system's operation. The Strategic Plan was presented to MINAGRI in January 2013 and following some revisions was formally submitted to MINAGRI in May 2013. MINAGRI had asked for strategies and budget implications associated with implementing a market information system, a market-based trading platform and an electronic extension system. This, plus a detailed work plan and terms of reference were provided. Budget constraints, however, may mean that a less ambitious system will result.

Advocacy Platform

PHHS facilitated a Rwanda Grain Stakeholder Forum held on May 28th, 2013. The Forum was led by the Eastern Africa Grain Council (EAGC) and brought together 37 participants from the grain value chain private sector (including traders, processors, millers and warehouse operators),

government representatives from MINAGRI and the Rwanda Agricultural Board (RAB), development partners, and cooperatives.

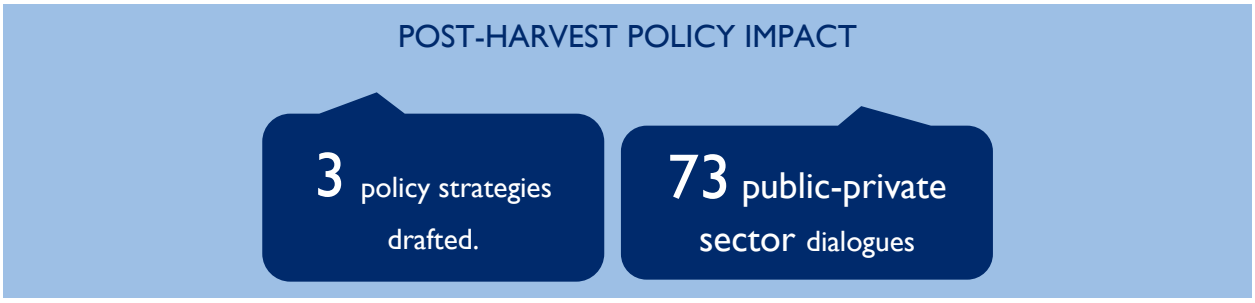
The goal of the workshop was threefold:

- Identify and create an avenue for joint policy and advocacy dialogue between the private and public sector in Rwanda.
- Create a structured platform to facilitate private sector participation and engagement through EAGC's Rwanda Chapter.
- Prioritize EAGC program delivery to Rwandan grain stakeholders

The Forum brought together grain and cereals stakeholders to discuss and debate challenges and opportunities in their sector. It also launched EAGC's presence in Rwanda following the establishment of a satellite office within the PHHS project office. The forum introduced the EAGC's role and capacities in developing partnerships and platforms among grains stakeholders, and leading advocacy activities that contribute to growth of the grains sector, both at the national and regional level. As a result of the event, EAGC added the Rwanda East Africa Commodity Exchange, the Rwanda Development Organization, and the RGCC as members. Feedback from the forum also provided the EAGC with a road map on how to improve its Rwanda chapter and best represent private stakeholders.

Strategic Grain Reserves Manual

PHHS mobilized a consultant to work with MINAGRI in designing the Operations and Procedures Manual in the final month of the project. The NSGR manual, developed in conjunction with MINAGRI's Post-Harvest Task Force, will be a guide for the government to address potential shocks to food supply that the market or other government programs cannot or have not adequately addressed in the past. The principal objective of NSGR is to improve food security, while simultaneously avoiding market distortions to the greatest extent possible. It will be a tool used to guide timely response to food emergencies. MINAGRI also requested that PHHS provide guidance on utilization of the NSGR as a price support mechanism that would benefit farmers. The final report was submitted to MINAGRI in September 2013.

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Annex I: Performance Monitoring Plan (PMP)

		Year 1: Oct 2009-Sept 2010			Year 2: Oct 2010 - Sept 2011			Year 3: Oct 2011 - Sept 2012			Year 4: Oct 2012 - June 2013			Totals for Life of project todate		
PERFORMANCE INDICATORS	**Unit**	**Target**	**Results**	**Results vs. target**	**Target**	**Result**	**Results vs. target**	**Target**	**Result**	**Results vs. target %**	**Target**	**Result**	**Results vs. target %**	**ORGINAL PROJECT TARGETS**	**NEW LIFE OF PROJECT OVERALL TARGETS**	**LIFE OF PROJECT RESULTS TODATE**
Key Result Indicator for all components																
Custom: Commodities entering USAID-supported storage.	MT	5,000	0	0%	19,000	18,665	98%	10,000	19,463	195%	10,000	6,815	68%	34,000	44,000	44,943
COMPONENT ONE - MARKET LINKAGES																
Custom: Farmers using storage/conditioning/processing centers with PHHS assistance*	# Men	18,000	0	0%	12,000	30,399	253%	22,000	28,441	129%	3,000	16,832	561%	50,000	58,000	83,676
	#Women										3,000	8,004	267%			
FtF 4.5.2-11 Number of food security private enterprises,producer organisations,water users associations,women's grops,trade and business organisations, and CBOs receiving direct assistance	Number	50	59	118%	10	84	840%	41	23	56%	107	192	179%	88	208	358
COMPONENT TWO - INVESTMENT FINANCE																
Custom: Grants awarded to cooperatives/businesses for new equipment or infrastructure	Number	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	10	9	90%	N/A	15	14
FtF 4.5.2-38 Value of new private sector investment in agriculture in the agric sector or food chain leveraged by FTF implementation	US$	$50,000	$387,000	774%	$450,000	$595,312	132%	$965,000	$600,000	62%	$85,000	$178,560	210%	$1,450,000	$1,550,000	$1,760,872
Custom: Storage/conditioning/processing centers constructed/purchased with project assistance	Number	100	0	0%	100	93	93%	50	7	14%	0	4	100%	250	250	104
FtF 4.5.2-37 Number of MSMEs, including farmers, receiving business dev't services from USG-assisted sources	Number	2	3	150%	13	39	300%	5	3	60%	10	14	140%	16	30	59
FtF 4.5.2-30 Number of MSMEs including farmers receiving USG assistance to access bank loans	Number	6	6	100%	6	8	133%	11	10	91%	16	19	119%	18	39	43
Custom: Firms receiving assistance to invest in improved technologies	Number	1	2	200%	37	35	95%	2	0	0%	2	2	100%	40	42	39

		Year 1: Oct 2009-Sept 2010			Year 2: Oct 2010 - Sept 2011			Year 3: Oct 2011 - Sept 2012			Year 4: Oct 2012 - June 2013			Totals for Life of project todate		
PERFORMANCE INDICATORS	**Unit**	**Target**	**Results**	**Results vs. target**	**Target**	**Result**	**Results vs. target**	**Target**	**Result**	**Results vs. target %**	**Target**	**Result**	**Results vs. target %**	**ORGINAL PROJECT TARGETS**	**NEW LIFE OF PROJECT OVERALL TARGETS**	**LIFE OF PROJECT RESULTS TODATE**
COMPONENT THREE - POST HARVEST MANAGEMENT																
Custom: Decrease in post-harvest food losses in project sites**	% (Maize)	5%	N/A	N/A	5%	N/A	N/A	5%	N/A	N/A	4%	4%	TBD	15%	19%	4.00%
	% (Beans)										3%	N/A	TBD		3%	N/A
FtF 4.5.2-7 Number of individuals who have received USG supported short-term agricultural sector productivity of food security training***	# Men	11,000	91	1%	9,000	24,359	271%	19,000	26,463	139%	8,250	4,645	56%	34,000	54,000	60,085
	# Women										6,750	4,527	67%			
FtF 4.5.2-5 Number of farmers and others who have applied new technologies or management practices as a result of USG assistance	# Men	11,000	0	0%	11,000	22,522	205%	6,650	6,323	95%	9,350	7,872	84%	44,000	45,650	43,455
	# Women										7,650	6,738	88%			
FtF 4.5.2-13 Number of rural households benefiting directly from USG assistance	Number	18,000	0	0%	12,000	24,450	204%	19,000	26,042	137%	13,439	8,217	61%	50,000	62,439	58,709
COMPONENT FOUR - POST HARVERST POLICY																
FtF 4.5.1-24 Number of policies/regulations/administrative/studies/ procedures drafted and presented for public stakeholder consultations as a result of USG assistance	Number	0	0	100%	1	1	100%	0	0	100%	3	3	100%	1	4	4
Custom: Public-private sector dialogues utilized as a result of PHHS assistance	Number	4	13	325%	4	18	450%	12	13	108%	30	29	97%	10	50	73

Note that Indicators 4.5.2-7 and 4.5.1-24 targets have been adjusted

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POST HARVEST HANDLING AND STORAGE (PHHS) PROJECT

FINAL REPORT

ANNEX II: MAIZE POST-HARVEST PRACTICES, REVISED LOSS ESTIMATES AND TRAINING NEEDS SEASONS A AND B, 2012

PROJECT # EEM-I-00-07-00006-00
Task Order 09

DISCLAIMER

CONTENTS

EXECUTIVE SUMMARY

Following the completion of the first baseline survey of postharvest handling and storage of maize in 2011, MinAgri and USAID's Post-Harvest Handling and Storage (PHHS) - Rwanda undertook two national post-harvest assessments in Season A and Season B of 2012. The Season A survey was administered from May 14-25, 2012 with a total of 637 national surveys. The Season B survey was administered Oct 9-17, 2012 with a total of 416 surveys (in two versions). A third pilot exercise was conducted in 9 districts with 54 farmers in Season A 2013 to verify harvest and drying loss estimates with Season B 2012 questionnaire results.

In Season A, general data were taken on environmental conditions at harvest as well as post-harvest technology use and marketing practices, very similar to data collected in 2011. Post-harvest loss estimates were made for Season A using general parameters and formatting from the African Post-Harvest Losses Information System (APHLIS).

In Season B, this assessment was expanded to gather more detailed information about practices, marketing, grain quality, and farmers' losses at several key stages of the post-harvest process.

These key stages investigated in Season B 2012 include 1) Harvesting/Field Drying, 2) Further Drying [APHLIS notes 'platform drying'], and 3) On-farm storage. This was a cross-sectional survey in which farmers recalled events and condition of grain at certain end-use points, aided by a wide range of visual cues in grain damage samples. Five visual samples of maize per enumerator were utilized, with 0, 5, 10, 20, and 30% grain damage. Loss parameters from this survey were targeted to contextualize the APHLIS parameters to the Rwandan environment and serve as better local estimators of post-harvest losses. Recognizing the imperfect nature of cross-sectional data collection for this purpose, the data at a minimum serves to identify key zones of disparity between APHLIS and MinAgri estimates to prioritize the next step of in-depth field data collection.

Both Season A and B surveys note various training courses farmers have taken, which can then be cross-tabulated with technology use and post-harvest practices to note potential influences of extension education.

The Season A 2013 pilot field validation was a physical measurement of discarded and damaged maize during the harvest/drying period. Physical measurement of losses was not possible in the Season B 2012 survey due to late survey timing. Results provide loss estimates for farmers with rainy harvest periods and farmers with dry harvest periods. The validation served to compare methodologies of simple questionnaire (2012B) vs. physical measurement with balances (2013A).

Major findings for each report section are as follows:

Base production, supply parameters, and purchasing

Maize is grown on 78.0% - 98.3% consolidated land primarily as a cash crop. In Season A, 86.7% of national maize grown was marketed and 83.4% was marketed in Season B. At the individual level, 75.1% of farmers sell some maize in Season A and 77.8% in Season B. Farmers generally sell maize locally,

either bringing to markets, selling directly to traders, or selling to neighbors. Cooperatives become important or dominant outlets in the South year round and Kigali in Season A.

At the provincial level, maize is stored an average of 2.9 - 4.8 months in Season A, with a national average of 4.1 months. In Season B, maize was stored between 2.7 - 3.9 months, with a national average of 3.2 months. Most marketed maize is sold within three months of harvest, the quantity considered by the APHLIS system to be "sold soon after harvest", totaling 66% of all maize sold in Season A and 89% in Season B. Farmers report saving maize for consumption as well, with an average of 22.3kg per household member in Season A and 18.9kg per member in Season B.

Nationally, 31.7% of households buy some form of maize in Season A and 45.9% in Season B. Kigali farmers are more likely to buy than any other province. Purchasing in the Eastern province is very uncommon in Season A (3.3%) but quite common in Season B (65.9%). Flour is the dominant exclusive form purchased (85.4% and 64.2%), though grain purchase (or 'both') is increases significantly in Season B.

Harvesting Conditions and Practices

Farmers experience more rain at harvest in Season A (56%) than Season B (12%). This has strong implications for post-harvest losses in the harvest and drying stages. Season B survey data go deeper into loss implications. When there is rain at harvest, 40.0% of farmers discard at least some cobs at harvest, while without rain this drops to 25.7%. Farmers in Kigali were more affected (71.4%) while Eastern province farmers had a much lower incidence (9.6%).

Season B 2012 questionnaire data reported farmers discarding a national average of 8.3% of cobs (weighted by provincial production). Provincial averages range from 4.9% in Western Province to 12.6% in the North. When rain is present at harvest, the provincial average quantity of cobs left is consistently higher than in non-rainy conditions. Nationally weighted by provincial production, this totals 9.6% with rain at harvest and 7.8% without. These two parameters are the first utilized in "Harvest/Field Drying" contextualized APHLIS measurements.

The Season A 2013 field verification provided very different parameter estimates than the questionnaire methodology. The questionnaire method asked farmers to recall specific data several months after harvest activities in an imperfect format, while the field verification methodology brought MinAgri agents to farmers' homes to physically measure damaged and undamaged cobs with a balance. The accuracy of the physical measurement approach is much more reliable and also ultimately judged to more accurately reflect the Rwandan ground realities.

Farmers evaluating combined harvest/drying losses discarded 3.1% of maize cobs in rainy harvest zones and 0.9% in drier harvest zones. The field measurement thus drives a much different overall post-harvest loss estimate than APHLIS, as this general model provides estimates of 16.3% in rainy harvest zones and 6.4% in dry harvest zones.

Losses in the harvest/drying period in rainy harvest regions of the Northern Province at 6.3% were double the national average. Encouragingly, farmers in rainy harvest zones who received training had more than 50% lower harvest/drying losses than producers who did not receive training. This is a very

positive sign for education impact and it is recommended to focus harvest/drying education in the rainy harvest zones for maximum future impact.

Drying Practices

Farmers use diverse mechanisms to dry maize, varying greatly by geographic region. In Season A and B, the most common methods were suspended (35% and 28%), on a plastic sheet (30% and 20%), and drying rack or covered platform (27% and 18%). When there is no rain at harvest, farmers report almost no losses (0.4%), however when there is rain this rises considerably (3.7%). These parameters are taken for use in the "Platform Drying" part of the APHLIS model. At the provincial level, this ranges from 0.0% reported losses to 8.3%.

Maize Shelling

Shelling practices remain diverse as well. In both seasons, about half of Rwandan producers use only their hands. This rate is consistently high in the Western Province (76.6% and 90%). Producers receiving training were much more likely to use a mechanical hand sheller (16% compared to 36% in Season A, and 11% to 30% in Season B). Training seems to provide exposure and/or facilitated access to this technology. There is some, albeit weak, evidence that farmers engage less in "beating to shell in sack", with 7% compared to 3% in Season A and 2% compared to 1% in Season B.

Maize Storage

Maize is more likely to be stored as grain vs. cob when destined for the market in both seasons (83 and 94.6% vs. 72.9 and 81.5%). This corresponds with higher usage of polypropylene sacks for storage. Season B data delves deeper into storage practices. Polypropylene sacks are generally used "new", however, for both consumed and marketed maize storage, there are groups in the South (18% and 8.2%) and West (13% and 6.5%) who re-use old untreated sacks. This may be an opportunity for further extension education. As well, rates of palette use are consistently lower in the Northern and Western province than others – not just associated with suspended storage. That stated, the North and West are the dominant locations for suspended maize cob storage.

The majority of Rwandan farmers do not use storage protectants. National rates of application are 44.5% in Season A and 38.3% in Season B. This varies tremendously by province and season. In Season A, 80.2% of Eastern province farmers applied while 18.5% did so in the Western province. In Season B, 58.1% of Eastern farmers applied while only 16.7% did in the West. In Season A, farmers receiving training in pesticide application to stores or grain have a large and statistically significant greater application rate (80.0%) than those not receiving education (39.5%). In Season B, 37.5% with training applied while 27.3% without training applied, though the difference is not statistically significant. Training seems particularly responsive in the Western province, where, in Season A, 100% of farmers receiving training applied while only 13.1% without training applied protectants. Malathion is by far the most common storage protectant used, employed by 45.3% and 65.8% of farmers in Season A and B who applied some form of protectant. As Malathion is referred to as "DDT" by many untrained farmers, this market share may be as high as 66.8% in Season A and 75.7% in Season B. Insecticide application may be associated with a slight increase in storage before sale, however less than one week.

This study found storage losses in maize which were higher than those predicted by the APHLIS model. To estimate physical (weight) losses, visual samples were used with nine possible quality specifications (including "between" displayed sample levels). While APHLIS predicts zero losses in less than four months of storage, the weighted national average was 4.9% losses in on-farm storage. This parameter is the third and final used in a revised format of the APHLIS losses model.

Within this 4.9% loss, rats composed 2.9%, while insects averaged 1.3% and molds 0.7%. The highest storage losses reported are in Northern (7.6%) and Western (6.2%) provinces, driven primarily by rats. This highlights an important point, as rats rarely receive attention in post-harvest extension education programs. The South reported the highest losses from insects (1.9%), followed by Western province (1.5%). Kigali province actually did report no losses in storage, possibly driven by quick sales of most of the harvest and use of storage protectants. Average damage rates in sold maize (1.1%) were considerably lower than average rates for consumed maize (4.8%). This undoubtedly reflects very rapid sales. There is some evidence that use of insecticide is related to lower damage rates in sold maize (2.0% vs. 0.5%) and consumed maize (5.7% vs. 2.5%).

Extrapolating loss rates with national production, it is estimated that the economic impact of maize storage losses in Season B 2012 alone are between RWF 1.78 – 2.58 Billion. While considerable variance is present, farmers receiving storage training had 28.6% lower storage losses. This reflects a potential benefit of storage education in Season B 2012 of about RWF 300 Million.

Training

About half of farmers reported education in harvesting (50.8 and 49.7%), drying (50.0 and 45.9%), and shelling (42.3 and 41.0%). This average masks great provincial diversity, however, as few to no producers in Kigali province report receiving training. While populations and production are small in Kigali, this is also the province with the highest reported incidence of rain in harvest periods and highest APHLIS loss estimates, and may be a point of attention for education regimens.

Training is particularly low in use of pesticides on grain (11.3 and 11.7%) and use of pesticides on structures (10.2 and 6.1%). As rates of storage protectant application were a significant 40% higher among trained farmers, this could serve as a useful point of attention.

APHLIS Post-Harvest Losses Calculation and comparison with new MinAgri parameter estimates

The national average post-harvest losses, according to the APHLIS system, were 21.1% in Season A and 17.5% in Season B. The increased losses in Season A are driven by higher incidence of rain at harvest as well as breaking the "4 month" storage threshold, at which point modeled APHLIS storage losses increase from 0% to 2.6%. The total APHLIS-calculated losses for the year 2012 is 19.8%.

Parameters from the most accurate MinAgri physical loss evaluations suggest significantly lower losses. With field-measured harvest/drying losses and storage losses assessed through questionnaires and grain samples as visual aids, maize post-harvest losses for Season B 2012 are estimated at 9.1% (±.1.0%). When APHLIS predicts 16.3% total losses for areas without rain at harvest, contextualized Rwandan parameters predict 8.8% (±0.9%). When APHLIS predicts 25.0% for rainy harvest regions,

contextualized parameters predict 10.8% (±1.7%). Lower Rwandan estimations are primarily driven by lower losses in the harvest and drying periods.

Table i-1: APHLIS vs. MinAgri parameter comparison for 2012 National Post-Harvest Losses

Post-Harvest Loss Parameter	APHLIS		Only MinAgri / PHHS Season B 2012 Survey		Proposed Correction With Field Verification of Harvest/Drying Loss Parameter + Season B 2012 Survey Storage Loss Parameter	
	No Rain	Rain at Harvest	No Rain	Rain at Harvest	No Rain	Rain at Harvest
Harvesting/ field drying	**6.4%**	**16.3%**	**7.8% (1.3)**	**9.6% (2.5)**	**0.9% (0.2)**	**3.1% (1.0)**
'Platform' Drying	**4.0%**	**4.0%**	**0.4% (0.2)**	**3.7% (2.3)**		
Threshing and Shelling	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%
Transport to farm	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%
Farm storage	**0.0%**	**0.0%**	**4.9% (0.9)**	**4.9% (0.9)**	**4.9% (0.9)**	**4.9% (0.9)**
Transport to market	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%
Market storage	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%
Increment Total*	**16.3%**	**25.0%**	**15.4% (2.8)**	**19.8% (9.2)**	**8.8% (0.9)**	**10.8% (1.7)**
Season B 2012 Total+	**17.5%**		**15.9% (± 3.6%)**		**9.1% (1.0)**	

(standard errors)

*The total is not simply the summation of parameters, but a continual adjustment process based on remaining grain stocks after each stage.

+ With weighted regions of 'rain at harvest'

SAMPLING SUMMARY

Farmers in 2012A were randomly selected from Ministry of Statistics household records.

Farmers in 2012B were also randomly selected from Ministry of Statistics household records. Questionnaires in 2012B have been divided into Version 1, to concentrate on the pre-storage post harvest steps, and Version 2 which covered storage and beyond. The reason for this division was the level of detail desired, considered unreasonable for each farmer to respond for the entire post-harvest process. The number of questionnaires answered varies according to province. In 2012A, the Northern Province had the highest number of questionnaires (210/637) and in 2012B the Southern Province had the highest number 69/209 questionnaires of Version 1 and 70/207 questionnaires of Version 2.

The questions covered mainly the quantity of maize harvested, sold and consumed; the postharvest techniques used in different postharvest steps; where and when maize was marketed; what and which quantity of protectants used; the training received and what kind of government support received for postharvest handling operations.

The pilot field verification of harvest losses conducted in Season A 2013 had a total of 54 farmers, six randomly selected farmers from nine randomly selected districts within participants of the Season A 2012 post-harvest questionnaire.

Table 0-1: Geographic distribution of Surveys

Province	Maize: Season A 2012			Maize: Season B 2012					
				Survey Version 1: Harvest, Drying, Shelling			Survey Version 2: Storage and Marketing		
	No. districts	No. villages	No. surveys	No. districts	No. villages	No. surveys	No. districts	No. villages	No. surveys
East	5	40	91	6	32	52	6	36	44
Kigali	3	23	59	2	7	14	3	8	16
North	5	98	210	5	27	33	5	22	29
South	7	70	129	8	44	69	8	40	70
West	7	77	148	6	21	41	7	33	48
Total	27	308	637	27	131	209	29	139	207

Province	Maize: Field Verification for Harvest Losses, Season B 2013
	No. surveys
East	12
Kigali	6
North	12
South	12
West	12
Total	54

KEY BASE PRODUCTION AND SUPPLY PARAMETERS

Nationally, average area of maize cultivation is quite similar for Season A and B, at 0.73 and 0.67 hectares, respectively. Almost all farmers are cultivating on consolidated land. In Season A, only the Eastern and Western province drops below 80% consolidated land production. In Season B, only Kigali province drops below 90%. Green maize is harvested by nearly half of national farmers in both seasons, though farmers may have an incentive to under-report this quantity due to official restrictions. However, reported green maize harvested only composes a small percentage of total maize production, at 1.3 and 0.9 bags in Seasons A and B. Average households successfully harvested 1,014kg in Season A with highest productions per household in Eastern and Kigali province. In the comparatively minor Season B, households harvested 725kg, with the greatest production in Eastern province. Reported yields averaged 1,504kg/ha in 1,344kg/ha in Seasons A and B, respectively. Notable outliers in provincial yield data are Kigali province in Season A, reporting 3,050kg/Ha, and Western province in Season B, reporting 699kg/Ha.

Maize in Rwanda is largely grown as a cash crop. In Season A, households sold or intended to sell 87% of maize production, similar to nearly 84% in Season B. About two-thirds (66%) of maize sold in Season A was sold before 3 months, the period designated by the African Post-Harvest Losses Information System (APHLIS) as "soon after harvest". In Season B, maize sold "soon after harvest" increases to 89%. Notably, maize stored for market longer than 3 months composed more than half (59.6%) of maize sold by Eastern province households and just less than half (48.6%) in Southern province in Season A. In Season B, this shrinks to 15.5% in the Eastern province and 4.3% in the Southern province.

Reported maize per person retained for consumption is similar in Seasons A and B, at 22.3kg and 18.9kg, respectively. Average storage time for all maize was 4.1 and 3.2 months in Season A and B, respectively.

Table 0-1: General Background Data -- Season A

	National	East	Kigali	North	South	West
Area of maize harvested per household (Ha/HH)	0.73	1.34	0.90	0.92	0.31	0.32
% of HH cultivating maize on consolidated land	86.8%	78.0%	98.3%	86.2%	96.9%	79.7%
% HH harvesting green maize	48.5%	8.8%	0.0%	82.9%	16.3%	69.2%
Avg. no. bags of green maize harvested (bags/HH)	1.3	0.3	-	1.6	0.7	2.3
Avg. weight of maize successfully harvested (kg/HH)	1,013.6	2,033.2	2,859.8	801.0	574.5	389.1
Avg. maize yield (kg/Ha)	1,504.1	1,601.7	3,050.1	1,160.0	1,630.5	1,555.5
Avg. total quantity of maize for market (kg)	878.4	1,846.3	2,700.5	650.6	478.1	229.8
Avg. quantity of maize sold within 3 months of harvest (kg/HH)	580.4	746.5	2,683.3	334.2	366.7	204.2
Avg. quantity maize kept for household consumption (kg/HH)	131.4	161.4	115.7	137.4	100.7	137.4
Avg. number people per HH	6.1	5.9	6.4	6.0	5.8	6.6
Avg. number months maize will be held	4.1	3.5	2.9	4.5	3.7	4.8
Avg. maize kept for consumption per person	22.3	26.5	20.3	24.3	18.9	20.6

Table 0-2: General Background Data – Season B

	National	East	Kigali	North	South	West
Area of maize harvested per household (Ha/HH)	0.67	1.12	0.78	0.67	0.47	0.53
% of HH cultivating maize on consolidated land	95.7%	97.7%	81.3%	96.4%	97.1%	95.8%
% HH harvesting green maize	48.8%	32.6%	46.2%	85.7%	27.1%	72.9%
Avg. no. bags of green maize harvested (bags/HH)	0.87	0.69	*	1.72	0.36	1.39
Avg. weight of maize successfully harvested (kg/HH)	724.62	1,652.61	824.38	877.14	328.17	340.42
Avg. maize yield (kg/Ha)	1,344.32	1,420.01	1,145.66	1,605.08	1,628.96	698.64
Avg. total quantity of maize for market (kg)	608.45	1,583.11	506.25	563.11	283.88	258.42
Avg. quantity of maize sold within 3 months of harvest (kg/HH)	541.58	1,337.89	506.25	511.68	271.56	242.79
Avg. quantity maize kept for household consumption (kg/HH)	106.94	115.91	314.33	162.86	32.63	110.73
Avg. number people per HH	5.75	6.55	4.44	6.61	4.73	6.45
Avg. number months maize will be held	3.2	3.9	3.4	2.7	2.8	3.1
Avg. maize kept for consumption per person	18.90	17.04	60.82	29.17	6.76	18.54

MAIZE PURCHASING

Households purchasing maize were slightly different between Season A and B, at 31.7% and 45.9% nationally. Figures in Kigali and the East varied widely, however, changing by season from 57.1% to 100% in Kigali and from 3.3% to 65.9% in Eastern province. Of households purchasing maize, the large majority (85.4% and 64.8% in Season A and B) only bought maize in flour form. However, about one-third of households purchasing maize (33.3% and 34.5%) in Eastern and Northern provinces only bought maize as grain in Season A. As quantities purchased in each form were not reported in this survey, making it difficult to disentangle the relative importance of grain and flour in the buying habits of this category (28.4%) of farmers purchasing maize throughout Season B.

Table 0-3: Household Purchase of Maize Season A

Season A	National	East	Kigali	North	South	West
% HH buying maize	31.7%	3.3%	57.1%	28.4%	31.5%	44.6%
Of those buying maize, form bought:						
% HH buying only flour	85.4%	66.7%	100.0%	62.1%	97.4%	92.4%
% HH buying only grain	13.6%	33.3%	-	34.5%	2.6%	7.6%
% HH buying both grain and flour	1.0%	-	-	3.4%	-	-

Table 0-4: Household Purchase of Maize Season B

Season B	National	East	Kigali	North	South	West
% HH buying maize	45.9%	65.9%	100.0%	17.9%	27.1%	54.2%
Of those buying maize, form bought:						
% HH buying only flour	64.2%	82.8%	25.0%	60.0%	84.2%	53.8%
% HH buying only grain	7.4%	3.4%	-	20.0%	15.8%	7.7%
% HH buying both grain and flour	28.4%	13.8%	75.0%	20.0%	-	38.5%

MARKET OUTLETS

About three quarters of Rwandan farmers are marketing at least some of their maize production. Though market outlets vary in importance by province, local markets and local traders are accessed nationally by 75.8% and 68.1% of producers in Seasons A and B, respectively. Cooperative outlets are minor overall, but an important outlet for farmers in the Southern province in both seasons, as well as Kigali province in Season A. Neighbors are another minor outlet overall, with notable elevated importance in the Western province in Season A.

Table 0-5: Maize Market Outlets Season A

Season A	Selling Maize	Market Outlet						
		Co-operatives	Local market	Local trader	National trader	Neighbor	RADA	Market outside Rwanda
National	75.1%	16.3%	54.9%	20.9%	-	13.4%	4.3%	0.2%
East	83.0%	13.3%	65.3%	21.3%	-	-	-	-
Kigali	91.1%	39.2%	5.9%	54.9%	-	-	-	-
North	78.1%	0.7%	79.3%	15.2%	-	16.6%	0.7%	-
South	69.8%	36.0%	29.3%	16.0%	-	10.7%	24.0%	-
West	64.9%	14.7%	55.8%	14.7%	-	28.4%	-	1.1%

Table 0-6: Maize Market Outlets Season B

Season B	Selling Maize	Market Outlet						
		Co-operatives	Local market	Local trader	National trader	Neighbor	RADA	Market outside Rwanda
National	77.8%	28.6%	38.8%	29.3%	4.1%	6.1%	2.0%	-
East	90.9%	15.0%	42.5%	37.5%	5.0%	2.5%	-	-
Kigali	81.3%	-	100.0%	-	-	-	-	-
North	67.9%	-	50.0%	50.0%	-	16.7%	-	-
South	77.1%	64.8%	20.4%	9.3%	-	1.9%	3.7%	-
West	70.8%	3.6%	46.4%	46.4%	7.1%	14.3%	3.6%	-

HARVESTING CONDITIONS, PRACTICES, AND LOSSES

Harvest conditions, confirming common knowledge, were much wetter for farmers in Season A 2012 (56%) than Season B 2012 (12%). In Season A, rain at harvest was a particular problem for farmers in Kigali, Southern, and Western provinces. In Season B, farmers in Kigali and Western provinces had higher relative rates of rain at harvest.

The expanded loss survey for Season B allows some analysis of reported affects of rain at harvest. Estimating harvesting losses simply through the Season B questionnaire was difficult, however, requiring farmers to recall fairly precise data from a harvest period four months prior. Therefore, a pilot field-measured validation of the original farmer-reported harvest losses was conducted in Season A 2013. In this validation, "good" maize and "bad" maize were separated physically weighed with a balance by extension agents. "Bad" maize cobs were those with mold damage sufficient to simply feed animals or outright reject. This pilot yielded considerably different results than original Season B questionnaire results regarding losses with and without rainy harvest conditions. With precise physical measurements at the time of harvest, this is ultimately judged to be a much more accurate report of harvest losses.

Table 0-1: Comparison of Harvest Loss Assessment Methods in Season B 2012 and Pilot Field Verification in Season A 2013

	Season B 2012 PHL Questionnaire: "Harvest and Drying" Version	**Season A 2013 (Pilot) Field Verification**
# of Farmers Surveyed	209	54
# of Districts Surveyed	27	9
Average Surveys Per District	7.7	6
Method Employed	Questionnaire only, due to the survey implementation in October 2012 and harvest periods ending by July/August. Farmers asked to recall: 1) Average # of cobs per stalk 2) Of 10 stalks, # of cobs discarded in the harvest period	Randomly selected farmers (drawn from Season A 2012 sample) were provided with many sacks before harvest and requested to separate "good" and "bad" cobs at the point where pre-shelling selection occurs (during harvest, before drying, or after drying). Post-Harvest Task Force agents visited farmer residences after selection occurred and physically weighed the "good" maize, "bad" maize destined for animals, and "bad" maize to be discarded.

Comments	Recall data for losses were much higher than MinAgri field experience suggested would be reasonable. While recall data is certainly imperfect, this method was the only option at the survey implementation period. Verification through direct field measurement was decided to compare with recall data.	Direct field measurement of harvest losses is a much more precise way to approach harvest losses. Delay in reporting of initial survey results resulted from this verification since the harvest period for Season A extends into April, however this appears justified since this methodology is much more trustworthy. A pilot to trial the methodology was implemented since this was a new methodology. A more comprehensive sample will be taken in the future when deemed necessary.

SEASON B 2012 QUESTIONNAIRE HARVEST LOSS RESULTS

Two metrics are discussed; the first is whether farmers reported leaving (not harvesting) at least some cobs in the field and the second is a reported estimation of the quantity of cobs not harvested. Reliability of reporting is thought to be much higher for the binary choice of "whether cobs were left" vs. the continuous estimation of quantities left. However, this estimation may give a reasonable indication of harvesting losses more specific to the Rwandan environment, contextualizing beyond the general East and Southern African "harvesting/field drying" figure presented by current APHLIS estimates.

Sole attention to the national average may disguise the diversity between provinces. The global average of farmers not harvesting at least some cobs was 27.3%, with much higher percentages in Kigali and Northern provinces. Very few farmers (9.6%) in Eastern report harvesting losses in Season B. However, the national average of producers leaving some cobs in the field when reporting rain at harvest was 40.0%. This contrasts with only 25.7% of producers not experiencing rain at harvest. While the sample size of those with rain at harvest (n=25) results in a wide confidence interval not producing stastically significant differences, the disparity in the results should not be overlooked.

While important, rain appeared to not be the only cause of losses at harvest, as in Kigali and Northern provinces 60.0% and 44.8% of producers are still reporting some harvesting losses. Interestingly and contrary to expectations, a greater percentage of Western province farmers report leaving at least some cobs in the field when there is no rain than when there was rain at harvest. However, the same Western province farmers reported removing a greater absolute percentage of cobs during rainy periods. This is one contradictory result from simple recall data which prompted calls for a verification field measurement in Season A 2013.

The second metric to evaluate post-harvest losses during the harvesting period is the quantity of cobs left in the field. Completed data on this metric was significantly lower than the binary choice of whether any cobs were left, at 46.4%. However, respondents with data indicate that, nationally, about 8.5% of cobs were not harvested. It is important to note that the national figure is adjusted by the provincial maize production weights in Season B. The highest losses in this category were in the north, where farmers estimate that 12.6% of cobs were left or discarded in the harvesting process. While some provinces show large differences in harvest losses whether rain was present or not, the weighted national averages only slightly differ. This may suggest other variables besides rain influence harvest losses, or that issues in data collection necessitate more direct and precise field measurement.

When cobs are left in the field, 61.4% of farmers simply feed their animals in the field. The remainder is left in the field to rot, with isolated cases selling as green maize.

Table 0-2: Rain incidence at harvest and farmers rejecting some cobs

Province	Season A	Season B			
	Rain at Harvest	Rain at Harvest	Leaving any cobs		
			Global average	Only if **rain**	Only if **no rain**
National	56%	12.0%	27.3%	40.0%	25.7%
East	35%	11.5%	9.6%	33.3%	6.7%
Kigali	95%	28.6%	71.4%	100.0%	60.0%
North	40%	12.1%	45.5%	50.0%	44.8%
South	67%	1.4%	23.2%	-	23.5%
West	67%	24.4%	26.8%	20.0%	29.0%

Table 0-3: Season B Harvest period expansion: Harvest/Field Losses when cobs rejected

Quantity of Cobs Left in Field, i.e. Field and Harvesting Loss	% cobs left in field	When rain at harvest: % cobs left	When no rain at harvest: % cobs left
Simple Full Survey Average	8.5%	10.6% ± 2.6%	7.9% ± 1.3%
Weighted National*	8.3%	9.6% ± 2.5%	7.8% ± 1.3%
East	9.3%	10.0%	9.0%
Kigali	6.2%	9.2%	5.0%
North	12.6%	20.0%	11.9%
South	8.7%	**	7.9%
West	4.9%	6.7%	4.5%
Blanks (no response)	*53.6%*		
*National average adjusted by provincial production		** No data in this category	

Table 0-4: Alternative uses for field rejected cobs

What Done with cobs left in field	National
Animal feed*	61.4%
Left to rot in field	36.8%
Sold later as green maize	1.8%
Blanks (no response)	0.0%

*The APHLIS model currently considers use of maize as animal feed to be a 100% loss.

SEASON A 2013 PILOT FIELD VERIFICATION RESULTS

Discriminate analysis shows important effects of rain and training on harvest losses, though increasing the sample size will increase confidence in future statements.

Rain at harvest was previously measured as "any rain at harvest". This restriction in practice was regarded as excessive, not even allowing one day of rain in a median 21 harvest days. Eleven (11) farmers had zero days of rain at harvest, while an additional five (5) farmers saw one day of rain. While zero days of rain had average losses of 1.24% ± 0.2%, one day of rain had 0.23% ± 0.23%. Combining one day of rain with the "rainy at harvest" category thus dramatically increased the variance of the "rainy" coefficients and downwardly biased the reality of rain's effect on harvest losses. Two days of rain (n=7) was much higher, at 3.66% ± 3.36%. Therefore, one day of rain was judged to not be "adverse conditions" for farmers, and only two days of rain or greater at harvest was considered "rainy" conditions.

When there are two or more rainy days in the harvesting period, average losses arrive at 3.08% ± 1.03%, which is statistically significantly higher than 0.92% ± 0.19% with one or no rainy days. Training appears to have a large effect on losses in rainy zones, as a statistically significant reduction of 3.80% ± 2.28% at the 90% confidence interval (Ha: diff>0; p=0.054). In non-rainy zones, a very slight increase in losses is seen, while this is almost surely not driven by any training and may be attributable to extremely low sample sizes in this sub-set (n=7 and n=9).

Among non-trained farmers, there is a large statistically significant difference 5.21% ± 3.47% between producers in rainy and non-rainy zones (though sub-sample size is small). When farmers are trained, the harvest loss differences are less than 1% and not statistically significant. The stark difference here suggests that vulnerable producers in rainy zones see tangible benefits from harvesting and drying extension trainings.

Table 0-5: Physical losses after harvesting and drying under different climate conditions and training: Discriminate Analysis

	Training in Harvesting/Drying	No Training in Harvesting/Drying	Total: Rain	Signif.
Two or more rainy days in harvest period	2.08% ± 0.75%	5.87% ± 3.28%	3.08% ± 1.03%	(*)
	(n=28)	(n=10)	(n=38)	
One or no rainy days in harvest period	1.25% ± 0.24%	0.67% ± 0.27%	0.92% ± 0.19%	(*)
	(n=7)	(n=9)	(n=16)	
Total: Training	1.91% ± 0.60%	3.41% ± 1.79%	2.44% ± 0.74%	(-)
	(n=35)	(n=19)	(n=54)	
Signif.	(-)	(*)	(*)	

Significant row or column difference at *90%, **95%, ***99% confidence level

(-) means no statistical significance

Results from the harvest loss verification show larger differences with the recall data. The source of these differences could be related to the manner in which the question was posed in the previous survey. The approach attempted to provide a reasonable manner for recall estimation but in practice forced a non-zero answer to be in increments of 5% loss (max of 2 cobs per stalk and the question asked "of ten stalks, how many cobs removed?"). Therefore over-estimation is possible when a farmer remembered there were "some" cobs removed. The multiple-month time lapse between the harvest and survey period no doubt compounded the difficulty for farmers to accurately estimate. Additionally, farmer rates of training were higher in the field verification than previous 2012 surveys. However, even the non-trained farmers in the verification had an average of 3.41% losses, indicating that the overall disparity is not simply due to this fact.

No questionnaire can typically replace the accuracy of field measurements. The field verification results are judged to be a much more accurate reflection of the field reality.

Further implications come from the fact that nearly all farmers reported separating "good" from "bad" cobs after drying. Only an isolated group (n=6) from Burera district of the Northern Province reported separating before drying (farmers there continue to dry for an additional month after a late harvest period, so a follow-up was not conducted for the pilot). Since the field verification group by default overwhelmingly covered both "harvest" losses and "drying" losses in the same coefficient, they are presented together. When this loss exercise is continued in the future in Rwanda, it is recommended that coefficients should be presented together and farmers separating both before and after drying should receive a second data collection visit to accommodate possible additional losses.

Table 0-6: Comparison of Harvest/Drying Loss Parameter Results from Questionnaire and Field Verification

Comparison Between Studies	Questionnaire (recall) Data for Harvest Period conditions and losses		Pilot Field Verification in Season A 2013
	Season A 2012	Season B 2012	
"Rain" at Harvest	56%	12%	77%
Farmers Receiving Harvest or Drying Training	51%	50%	64.8%
Two or more days of rain in harvest period– judged proxy for "*rainy* at harvest"	-	-	70.4%
"Harvest Period" + "Drying Period" losses **with** rain(y) harvest	-	9.6% ± (2.5%) + 3.7% ± (2.3%) = 13.0% ± (11.7%)Ŧ	3.1% ± (1.0%)
"Harvest Period" + "Drying Period" losses **without** rain(y) harvest	-	7.8% ± (1.3%) + 0.4% ± (0.2%) = 8.2% ± (3.5%)	0.9% ± (0.2%)

(-) Not measured in that particular survey

Ŧ Combined losses is (Harvest Loss)+(1-Harvest Loss)*(Drying Loss). Combined standard error is $\sqrt{SE_1^2 + SE_2^2 + 2 * Cov_{b_1,b_2}}$

DRYING PRACTICES

Farmers employed many different drying methods across the country. In Season A, the most common methods were drying racks, on plastic sheets, and suspended from the house. Similarly in Season B, platforms, plastic sheets, and suspension from sticks were most popular. "Dangerous" or "sub-optimal" drying practices were not extremely common, with 'on ground without sheeting' (1%), 'outside on platform without roof' (11%), and 'suspended from sticks and uncovered' (4%). Only isolated cases in the North dried on the ground, but between 5-14% of producers throughout the provinces dried on platforms without roofs. Uncovered suspension from sticks was concentrated in the East (12%) and a small percentage in the South (4%).

Table 0-1: Drying Practices, Season A

Season A	National	East	Kigali	North	South	West
Drying floor (no sheet)	3%	2%	2%	5%	-	5%
Drying Ground	3%	-	-	9%	-	-
Drying Rack	27%	26%	-	17%	55%	26%
Drying Shelter	-	-	-	-	-	1%
On mat	3%	-	-	3%	-	7%
On plastic sheet	30%	57%	98%	14%	21%	16%
Suspended from house	35%	14%	-	53%	24%	45%
Blank (no response)	**3%**	**0%**	**9%**	**2%**	**5%**	**2%**

*Non-blank answers total to 100%

Table 0-2: Drying Practices, Season B

Season B	National	East	Kigali	North	South	West
Dried on a mat	1%	-	-	-	-	2%
On roof	1%	-	-	-	1%	-
On ground without sheeting	1%	-	-	3%	-	-
On plastic sheet	20%	21%	50%	3%	26%	10%
Outside on a platform WITH roof	18%	14%	29%	27%	3%	37%
Outside on a platform WITHOUT roof	11%	14%	14%	12%	12%	5%
In house (unspecified)	17%	16%	-	27%	4%	37%
Drying Hanging (unspecified)	2%	-	-	-	4%	-
Suspended from sticks and COVERED	28%	23%	7%	27%	45%	10%
Suspended from sticks and UNCOVERED	4%	12%	-	-	4%	-
Blank (no response)	**4%**	**17%**	**0%**	**0%**	**0%**	**0%**

*Non-blank answers total to 100%.

Table 0-3: Losses in Drying Process: Questionnaire Method

Season B Drying Losses	Global Average	No Rain at Harvest	Rain at Harvest
National*	1.0%	3.7%	0.4%
East	0.2%	0.0%	0.2%
Kigali	1.3%	4.4%	0.0%
North	1.7%	8.3%	0.7%
South	0.5%	0.0%	0.5%
West	1.5%	5.0%	0.3%

*Weighted by provincial production

MAIZE SHELLING

Shelling practices were also quite diverse and showed some variation depending on training received. In both Season A and B, about half of producers only used hands to shell. The rate was particularly high in both seasons in the West (76.6% and 90%) and, during Season B, Kigali (85.7%) and the North (75.8%).

In both Season A and B, simple hand shellers (18.2% and 18.8%) and mechanical hand shellers (24.4% and 17.4%) were the next widely reported. Among producers received training, mechanical hand sheller use increased from 16% to 36% in Season A and from 11% to 30% in Season B, the most dramatic disparity between producers trained and non-trained in shelling practices.

In Season A, some decrease in the damaging practice of "beating in sacks" is seen after training, yet the practice does persist in spite of clear advice against. It is notable that the East, North, and West show large decreases in the practice with training, yet Southern province farmers have higher percentages in trained populations. In Season B, beating in sacks is very infrequent nationally and largely isolated to the North.

Table 0-1: General Shelling Methods, Season A

Season A	National	East	Kigali	North	South	West
Beat in Sack	5.4%	3.3%	-	8.1%	6.3%	4.1%
Beat in Sack and Hand Sheller	0.2%	-	-	0.5%	-	-
Hand Sheller	18.2%	11.0%	49.1%	27.3%	14.8%	0.7%
Hand and Knife	0.2%	-	-	0.5%	-	-
Maize not shelled	0.6%	-	-	1.0%	-	1.4%
Mechanical Hand Sheller	24.4%	63.7%	-	13.4%	33.6%	16.6%
Motorized Mech Sheller	0.8%	5.5%	-	-	-	0.0%
Hands and Hand sheller	1.1%	-	-	2.9%	-	0.7%
Hands only	49.2%	16.5%	50.9%	46.4%	45.3%	76.6%
Blanks	**2%**	**0%**	**9%**	**0%**	**1%**	**2%**

Shelling Methods with Training Considered	National		East		Kigali		North		South		West	
	Tr[1]	No Tr	Tr	No Tr	Tr	No Tr	Tr	No Tr	Tr	No Tr	Tr	No Tr
Beat in Sack	3%	7%	1%	9%	**	-	2%	11%	10%	3%	1%	7%
Beat in Sack and Hand Sheller	-	-	-	-	**	-	2%	-	-	-	-	-
Hand Sheller	16%	20%	9%	18%	**	49%	42%	21%	17%	13%	-	1%
Hand and Knife	-	-	-	-	**	-	2%	-	-	-	-	-
Maize not shelled	-	1%	-	-	**	-	-	1%	-	-	-	3%
Mechanical Hand Sheller	36%	16%	72%	36%	**	-	6%	16%	45%	24%	21%	12%
Motorized Mech. Sheller	2%	-	7%	-	**	-	-	-	-	-	-	-
Hands and Hand Sheller	3%	-	-	-	**	-	10%	-	-	-	1%	-
Hands only	40%	56%	10%	36%	**	51%	37%	50%	28%	60%	77%	76%

** no data available

[1]Tr = Training ; No Tr = No Training

Table 0-2: General Shelling Methods, Season B

Season B	National	East	Kigali	North	South	West
Beat maize with stick in sack	1.4%	2.0%	-	6.1%	-	-
Only hands	52.2%	30.0%	85.7%	75.8%	27.5%	90.2%
Only hands, beat maize with stick in sack	0.5%	-	-	3.0%	-	-
Hand shelling with ring	9.2%	16.0%	14.3%	-	10.1%	4.9%
Hand shelling (mechanical)	18.8%	44.0%	-	3.0%	23.2%	-
Mechanical Shelling (powered)	17.4%	8.0%	-	9.1%	39.1%	4.9%
Not yet shelling	0.5%	-	-	3.0%	-	-

Table 0-3: Shelling methods with training considered, Season B

Season B with training considered	National		East		Kigali		North		South		West	
	Tr[1]	No Tr	Tr	No Tr	Tr	No Tr	Tr	No Tr	Tr	No Tr	Tr	No Tr
Beat maize with stick in sack	1%	2%	-	6%	-	-	6%	6%	-	-	-	-
Only hands	37%	63%	31%	28%	100	85%	88%	65%	12%	42%	75%	92%
Only hands, beat maize with stick in sack	-	1%	-	-	-	-	-	6%	-	-	-	-
Hand shelling with ring	10%	8%	13%	22%	-	15%	-	-	15%	6%	-	5%
Hand shelling with rotating level	30%	11%	56%	22%	-	-	6%	-	21%	25%	-	-
Mechanical Shelling (powered)	21%	15%	-	22%	-	-	-	18%	52%	28%	25%	3%
Not yet shelling	-	1%	-	-	-	-	-	6%	-	-	-	-

[1] Tr = Training ; No Tr = No Training

MAIZE STORAGE

STORAGE FOR CONSUMED MAIZE

Maize retained for consumption purposes is largely stored as grain in Season A (72.9%) and Season B (81.5%). Cob storage is most common in the West and especially the North in both seasons. This correlates strongly with, but is not isolated to, the practice of storing suspended cobs in the roof of the house.

Grain form storage is generally in tandem with polypropylene (PP) sacks or jute bags, which are used by 83.9% and 90% of farmers in seasons A and B, respectively. In Season B, more in-depth information was gathered on PP sack quality. About 81% of farmers using PP sacks used new bags, ranging provincially from 67-100%. In the South and West, 18% and 13% of producers (respectively) used old, possibly contaminated, sacks without washing or pesticide treatment. Use of pallets was also wide spread, with lowest rates in the North and West. Much of non-use of pallets is simply related to practices of cob suspension from roofs; however, there are some cases where jute and PP sacks are utilized without elevation from the ground.

Table 0-1: Maize form in storage, Season A (consumed)

Season A	National	East	Kigali	North	South	West
Cobs with sheath	8.2%	12.2%	2.4%	5.5%	11.3%	9.0%
Cobs without sheath	18.3%	-	-	30.5%	10.4%	23.4%
Flour	0.3%	-	-	1.0%	-	-
Flour and Grain	0.2%	-	-	0.5%	-	-
Grain	72.9%	87.8%	97.6%	62.5%	78.3%	67.6%

Table 0-2: Maize form in storage, Season B (consumed)

Stored Grain Form	National	East	Kigali	North	South	West
Cobs with sheath	2.1%	-	-	3.7%	-	4.3%
Cobs without sheath	14.4%	3.2%	-	51.9%	3.6%	10.6%
Cobs without sheath, grain	1.4%	3.2%	-	3.7%	-	-
Grain	81.5%	93.5%	92.3%	40.7%	96.4%	85.1%

Table 0-3: Storage Containers, Season A (consumed)

Season A	National	East	Kigali	North	South	West
Baskets	4.2%	1.3%	-	1.5%	6.1%	9.3%
Jerry Cans	2.1%	-	-	-	-	8.6%
Jute sacks	7.7%	28.2%	21.4%	0.5%	10.5%	-
Pitcher	0.2%	-	-	-	-	0.7%
On Ground	0.2%	-	-	-	-	0.7%
Placed on roof	0.3%	-	-	-	-	1.4%
PP sacks	76.2%	70.5%	78.6%	81.8%	81.6%	66.4%
PP sacks, woven big basket	0.2%	-	-	0.5%	-	-
Pot	0.2%	-	-	-	-	0.7%
Hung on Rack	0.2%	-	-	-	-	0.7%
Suspended in House	8.4%	-	-	15.2%	1.8%	11.4%
Suspended in house, PP sacks	0.2%	-	-	0.5%	-	-

Table 0-4: Storage Containers, Season B (consumed)

Season B-- Storage Method	National	East	Kigali	North	South	West
Jerry Cans	2%	-	-	-	-	6%
None	1%	-	-	-	-	4%
On the ground	1%	-	-	5%	-	-
Polypropylene Sacks	90%	97%	100%	75%	100%	83%
Polypropylene Sacks, baskets	1%	3%	-	-	-	-
Suspended in house	5%	-	-	20%	-	6%

Table 0-5: Polypropylene sack type, Season B (consumed)

HH Consumption: If using sacks, what was the condition	National	East	Kigali	North	South	West
new sacks	81%	100%	100%	91%	71%	67%
old sacks washed	3%	-	-	-	11%	-
old sacks, treated with pesticide	7%	-	-	-	-	21%
old sacks, untreated	9%	-	-	-	18%	13%
old sacks, untreated and new sacks	1%	-	-	9%	-	-

Table 0-6: Use of palettes (consumed)

Palletting (consumed)	Season A	Season B
National	90.4%	81.8%
East	97.5%	84.8%
Kigali	100.0%	100.0%
North	92.6%	58.3%
South	93.0%	86.4%
West	78.6%	78.6%

STORAGE OF MARKETED MAIZE

Maize stored for marketing purposes was stored as grain at slightly higher rates, at 83% in Season A and 94.6% in Season B. Storage in PP and jute sacks is similarly higher, at 90.5% and 95%. For producers storing in PP sacks, provincial "new sacks" use averages 77.4-100% with a national rate of 89.2%. Use of untreated and unwashed old sacks is found in low levels in the East (3.0%), North (7.1%), South (8.2%) and West (6.5%).

Table 0-7: Maize form in Storage, Season A (sold)

Season A	National	East	Kigali	North	South	West
Cobs (unspecified)	17%	-	-	22%	11%	34%
Grain	83%	100%	100%	78%	89%	66%

Table 0-8: Maize form in storage, Season B (sold)

Season B	National	East	Kigali	North	South	West
Cobs with sheath	0.7%	-	-	-	-	2.9%
Cobs without sheath	4.1%	-	-	25.0%	-	5.7%
Cobs without sheath, grain	-	-	-	-	-	-
Grain	94.6%	100.0%	100.0%	68.8%	100.0%	91.4%
Cobs (unspecified)	0.7%	-	-	6.3%	-	-

Table 0-9: Storage Methods, Season A (sold)

Season A	National	East	Kigali	North	South	West
Baskets	3.1%	-	-	-	5.9%	9.0%
Jerry Cans	1.0%	-	-	-	1.0%	4.0%
Jute sacks	8.9%	26.1%	23.4%	-	13.9%	-
Pitcher	0.2%	-	-	-	-	1.0%
On Ground	0.2%	-	-	-	-	1.0%
Placed on roof	0.2%	-	-	-	-	1.0%
PP sacks	81.4%	73.9%	76.6%	91.7%	79.2%	74.0%
Hung on Rack	0.2%	-	-	-	-	1.0%
Suspended in House	3.1%	-	-	3.6%	-	9.0%
Suspended in house, PP sacks	1.6%	-	-	4.8%	-	-

Table 0-10: Storage methods, Season B (sold)

Season B	National	East	Kigali	North	South	West
Jerry Cans	1%	-	-	-	-	3%
Jute Cans	1%	-	-	-	-	3%
None	2%	-	-	-	-	8%
Polypropylene Sacks	94%	100%	100%	93%	100%	82%
Pot	1%	-	-	-	-	3%
Suspended by house	1%	-	-	7%	-	-
Tank	1%	-	-	-	-	3%

Table 0-11: Polypropylene Sack type, Season B (sold)

For Sale: If using sacks, what was the condition	National	East	Kigali	North	South	West
new sacks	89.2%	97.0%	100.0%	85.7%	91.8%	77.4%
old sacks washed	-	-	-	-	-	-
old sacks, treated with pesticide	3.8%	-	-	-	-	16.1%
old sacks, untreated	6.2%	3.0%	-	7.1%	8.2%	6.5%
old sacks, untreated and new sacks	0.8%	-	-	7.1%	-	-

Table 0-12: Use of palettes (sold)

Palletting (SOLD maize)	Season A	Season B
National	80.9%	85.9%
East	100.0%	93.1%
Kigali	100.0%	100.0%
North	71.3%	66.7%
South	85.0%	87.5%
West	73.3%	85.7%

PROTECTANT USE IN STORAGE

Nationally, the rate of protectant application, chemical or otherwise, was 44.5% in Season A and 38.3% in Season B. In both Season A and B, the Western province had the lowest levels of application at 18.5% and 16.7%, respectively. In Season B, the North was similarly low. In contrast, rates of application are higher in Eastern province. This region of lower elevation has a warmer climate which is generally related to greater storage pest threat.

Among those applying protectants, Malathion dominates the storage protection regimen at 45.3% and 65.8% in Seasons A and B. Many times farmers use Malathion but do not know the proper name of the chemical, confusion which was recorded separately in this survey. Inclusion of unknown chemicals could potentially increase Malathion up to 69.1% and 75.4% in Seasons A and B. Kelorine has an appreciable market presence in the North, while SuperGuard use is generally isolated to Kigali province in both seasons. Natural storage protectant use is rare, under 4%, and includes black pepper and ash.

It is important to note that training is particularly low for pesticide treatment of grain and stores, between 6.7 and 11.1% nationally (discussed in detail in training section). Much higher education rates are found in Eastern province than any other (which may be a natural response to greater relative need), while no respondents from Kigali province had received training in this area.

There is also some evidence that insecticide application is related to longer storage before marketing, though the difference is slight and not stastically significant. This suggests that insect threat may be only one of several factors which would limit storage period before sale (i.e. credit constraints).

It appears training in this subject area is important and related to higher application rates. Training would also certainly contribute to more effective and possibly safer application procedures. In Season A, there is a stastically significant 40.5% difference between pesticide application rates of farmers receiving and not receiving insecticide training[1]. While there is a 10.2% difference in national application rates in Season B, it is not statistically significant and provinces differences are more ambiguous.

Table 0-13: Use of storage protectants [including training], Season A

Season A Use of Storage Protectants	Trained on pesticide with maize grain	Protectant use (All farmers)	Use when receiving training in pesticide	Use with no training
National	11.3%	44.5%	80.0%	39.5%
East	34.1%	80.2%	93.5%	72.7%
Kigali	0.0%	67.3%	n/a	67.3%
North	11.0%	42.8%	64.0%	39.9%
South	8.5%	44.0%	60.0%	42.6%
West	4.7%	18.5%	100.0%	13.1%

[1] While the difference is consistent in the provinces during Season A, due to low training rates it is not possible to conclude statistical significance for application rate differences in provincial trained/non-trained respondents.

Table 0-14: Use of storage protectants [including training], Season B

Season B Use of Storage Protectants	Trained on pesticide with maize grain	Protectant use (All farmers)	Use when receiving training in pesticide	Use with no training
National	11.7%	38.3%	37.5%	27.3%
East	8.3%	58.1%	50.0%	58.5%
Kigali	0.0%	50.0%	n/a	50.0%
North	24.7%	25.0%	37.5%	20.0%
South	13.4%	44.3%	42.9%	44.4%
West	9.0%	16.7%	28.6%	14.6%

Table 0-15: Storage Protectants Specified, Season A

Season A	National	East	Kigali	North	South	West
Malathion	45.3%	60.9%	5.7%	28.7%	68.5%	70.0%
Unknown white powder	23.8%	18.8%	31.4%	28.7%	24.1%	5.0%
Metiano	0.8%	1.4%	-	1.1%	-	-
Actellic	4.9%	13.0%	-	4.6%	-	-
Kelorine	9.4%	2.9%	-	26.4%	-	-
Phostoxin	0.8%	2.9%	-	-	-	-
SuperGuard	7.5%	-	57.1%	-	-	-
Ikinini	0.8%	-	5.7%	-	-	-
Skana	1.9%	-	-	5.7%	-	-
Thiod	0.4%	-	-	1.1%	-	-
Ngirire	0.4%	-	-	-	-	5.0%
Pyrethrum and Sikombe	0.4%	-	-	-	-	5.0%
Sikombe	0.4%	-	-	-	-	5.0%
Pepper and ash	3.4%	-	-	3.4%	7.4%	10.0%
Blanks in farmers using protectants	**3%**	**0%**	**2%**	**3%**	**3%**	**5%**

***Non-blank sum to 100%**

Table 0-16: Storage Protectants Specified, Season B

Season B	National	East	Kigali	North	South	West
Malathion	65.8%	45.0%	-	57.1%	100.0%	50.0%
Actellic	-	-	-	-	-	-
Unknown chemical	9.6%	20.0%	14.3%	28.6%	-	-
Kelorine	4.1%	10.0%	-	14.3%	-	-
Super Skana	4.1%	15.0%	-	-	-	-
Durspan	1.4%	5.0%	-	-	-	-
D6	1.4%	5.0%	-	-	-	-
Super Guard	8.2%	-	85.7%	-	-	-
Simikombi	2.7%	-	-	-	-	25.0%
Natural: (unspecified)	2.7%	-	-	-	-	25.0%

Table 0-17: Season B: Marketing of Maize (timing, marketed before survey period)

Percent Marketed After (weeks)	Total	Using Insecticide	Not Using Insecticide
2	9%	7%	12%
4	40%	35%	48%
6	19%	22%	13%
8	23%	27%	16%
10	5%	3%	9%
12	2%	3%	2%
14	2%	3%	0%
Season B: Avg. weeks before marketing	5.8	6.1	5.4

STORAGE LOSSES (SEASON B ONLY)

Storage losses can be measured in dry weight loss (quantity loss) and the percentage of maize grains damaged (quality loss). Both are important metrics and have been quantitatively linked in academic literature (Holst, Meikle, and Markham, 2000). To estimate storage losses, visual scale samples were utilized to identify grain quality at each end use (consumption, sale, or grain state in storage at time of survey). Visual scales have been used in some exemplary postharvest losses research to decrease the reliance on farmer quantification, which is generally poor (Adams and Hartman, 1977). Visual scale samples ranged from 0%, 5%, 10%, 20%, and 30% grain damage, as well as quality "in-between" each sample. Through conversion factors in Holst, Meikle, and Markham (2000), these levels of grain damage constitute 0%, 1.0%, 2.1%, 4.5%, and 7.1% dry weight loss.

Rats appear to be the largest cause of storage losses at 2.9% nationally, with particularly high levels of concern in Northern and Western provinces. Insect losses only exceeded rat losses in the Southern province. Mold in storage appear to be a relatively isolated issue in the North and West, nationally averaging 0.7%. Insect losses are estimated nationally at 1.3%, though this might be a slight underestimation as a few months remained in the storage period at the time of the survey. With low to zero stock levels generally found, however, the difference is unlikely to be high.

Table 0-18: Storage Losses and components, Season B

Est. TOTAL dry weight storage losses (quantity)	Est. Total Storage Losses	By Individual Components		
		Insects	Molds	Rats
National	4.9%	1.3%	0.7%	2.9%
East	2.4%	1.1%	0.0%	1.3%
Kigali	0.0%	0.0%	0.0%	0.0%
North	7.6%	0.7%	2.0%	4.9%
South	2.7%	1.9%	0.0%	0.8%
West	6.2%	1.5%	0.8%	3.9%

While economic losses at this time are too difficult to estimate for the whole post-harvest system, farm storage losses, evaluated at post-storage October 2012 (survey period) average prices, show national storage losses between RWF 1.7 – 2.6 billion. More conservative economic estimates at September 2012 prices show very little difference. This is caused by rats, insects, and molds. As extension material currently focuses more on insects and molds, greater inclusion of rat prevention strategies will be very beneficial to reducing storage losses. Additionally, greater mold storage losses in the North due to wet conditions pose a greater challenge to storage training for loss reduction, which should be considered in promotion of grain vs. green maize form consumption and marketing.

Table 0-19: Season B 2012 Maize Storage Economic Loss Estimates

Region	Some Training in Storage	By Individual Components			Est. Total Farm Storage Losses	Est. Total Quantity Loss (MT)	Est. Economic Loss (Oct'12, RWF)	Est. Economic Loss (Sep'12, RWF)
		Insects	Molds	Rats				
National	34.3%	1.3%	0.7%	2.9%	4.9%	8,166	2,178,244,878 (±400,085,794)	2,121,887,878 (±389,734,431)
East	56.8%	1.1%	0.0%	1.3%	2.4%	1,066	266,659,329	229,372,758
Kigali	6.3%	0.0%	0.0%	0.0%	0.0%	0	0	0
North	64.3%	0.7%	2.0%	4.9%	7.6%	2,842	745,144,810	742,119,925
South	18.6%	1.9%	0.0%	0.8%	2.7%	629	166,456,058	156,400,306
West	29.2%	1.5%	0.8%	3.9%	6.2%	3,701	999,984,681	993,995,367

Training in some realm of storage, received by 34.3% of farmers, reduced losses from 5.60% (±1.3) to 4.03% (±1.2) storage losses. While not statistically significant, this could translate to a roughly 300M RWF benefit just from storage training for Season B alone.

Table 0-20: Season B 2012 Maize Storage Training Benefit Estimation

National (Seas. B)	Farmers trained in storage	Storage losses if trained	Storage losses if not trained	Economic losses if no farmers trained (Oct prc, RWF)	National benefit with storage training (Oct prc, RWF)	Economic losses if no farmers trained (Sep prc, RWF)	National benefit with storage training (Sep prc, RWF)
	34.3%	4.03% (±1.2)	5.60% (±1.3)	2,489,422,718 (±577,901,702)	311,177,840	2,425,014,236 (±562,949,733)	303,126,358

*Estimates not statistically significant and primarily meant to illustrate process for determining benefit

Comparisons with the Tropical Savanna small-holder "Farm Storage" section of the APHLIS model show this study's estimates are higher than averages of other sub-Saharan African studies (used to compute APHLIS estimates). This study strongly suggests through visual scale measurements that a non-zero loss estimate is more appropriate for Rwanda's average 3.2 months of storage.

Overall, this suggests storage losses are much higher than the APHLIS model would predict. However, estimates of non-rat storage losses average nationally at 2.0%, which is much closer to the predicted four (4) month APHLIS storage loss.

Table 0-21: APHLIS specifications for storage losses with respect to time stored

APHLIS Model Specification in Maize "Farm Storage"*	APHLIS Est. Total Storage Losses	MinAgri Survey (avg. 3.2 mo. Storage)
Avg. Storage < 4 months	0.0%	4.9%
Avg. Storage =/> 4 mo and < 7 mo	2.6%	**
Avg. Storage =/> 7 mo	5.3%	**

*Specifying Rwanda's absence of the Larger Grain Borer (Prostephanus truncatus),

**Insufficient data due to short storage times and timing of survey at roughly 4 months of storage

a particularly destructive grain storage pest in many surrounding countries.

Source: Downloadable APHLIS Post-Harvest Losses Calculator

Storage losses from insects were computed through visual scales with unique pre-coded "% grain damage" levels. Broken down by storage losses for each end-use of grain, damage levels in household consumed maize are much higher than maize previously sold. The very low average of grain damage in marketed maize is most likely due to an average storage period of 5.4 weeks, with nearly 50% of maize sold within one month and 90% within two months. Damage rates were four times higher in untreated marketed maize than treated, but the absolute difference is small.

Consumed grain has a national average damage rate (weighted by provincial production) of 4.8%. The damage rate is twice as high in untreated maize than treated. In the North, South, and West there is a particularly high difference in damage rates with respect to treatment use. Grain remaining in house was evaluated by the MinAgri extension agent rather than the farmer only. This grain was not specified to be for consumption or sale, as future use may be unpredictable (or both uses from same bag). Global loss rates compare closely with consumed maize loss rates, however provincial estimates are much more ambiguous between treatment use.

Table 0-22: Maize damage level, previously marketed grain

Est. Maize Damage Levels (not weight loss) of PREVIOUSLY MARKETED GRAIN	Total: Damage Level	Total: Derived Weight Loss
Total	1.1%	0.22%
Farmers Using Insecticide	0.5%	0.10%
Farmers Not Using Insecticide	2.0%	0.41%

Table 0-23: Maize damage level, previously consumed grain

Est. Maize Grain Damage Levels (not weight losses) of PREVIOUSLY CONSUMED GRAIN	Damage Rates			Derived Est. Weight Loss		
	Total	Farmers Using Insecticide	Farmers Not Using Insecticide	Total	Farmers Using Insecticide	Farmers Not Using Insecticide
National	4.8%	2.5%	5.7%	0.98%	0.51%	1.18%
East	4.2%	3.7%	5.0%	0.86%	0.76%	1.03%
Kigali	0.0%	0.0%	0.0%	0%	0%	0%
North	2.4%	0.4%	3.1%	0.49%	0.08%	0.63%
South	5.9%	0.8%	6.7%	1.22%	0.16%	1.39%
West	6.6%	2.5%	7.1%	1.37%	0.51%	1.48%

Table 0-24: Maize damage level, grain remaining in home

Est. Maize Grain Damage Levels (not weight losses) of REMAINING GRAIN IN HOUSE	Damage Rates			Derived Est. Weight Loss		
	Total	Farmers Using Insecticide	Farmers Not Using Insecticide	Total	Farmers Using Insecticide	Farmers Not Using Insecticide
National	4.7%	4.2%	4.9%	0.97%	0.86%	1.01%
East	5.4%	6.1%	4.6%	1.12%	1.26%	0.95%
Kigali	n/a	n/a	n/a	n/a	n/a	n/a
North	2.5%	1.9%	2.8%	0.51%	0.39%	0.57%
South	4.1%	0.8%	4.8%	0.84%	0.16%	0.98%
West	6.0%	5.0%	6.3%	1.24%	1.03%	1.31%

TRAINING BY SUBJECT AND PROVINCE

Roughly half of Rwandan farmers have received some form of post-harvest training. Provincial rates of training are slightly ambiguous between respondents of each season, but consistently show higher rates of training in the East. Training rates for each link in the post-harvest process are roughly similar for Seasons A and B respondents at the national level. For both seasons, the most frequently reported training areas are in harvesting (50.8 and 49.7%), drying (50.0% and 45.9%), and shelling (42.3% and 41.0%). Less frequently reported training are in "use of pesticide on maize grain" (11.3% and 11.7%), "use of pesticide on store structures" (10.2% and 6.1%), and transport from store to market (9.4% and 7.4%).

Table 0-1: Training received, Season A 2012

Season A	Harvesting	Drying	Shelling	Transport field to store	Good types of store	Good storage hygiene	Use of pesticide on maize grain	Use of pesticide on store structures	Sorting to improve quality	Transport from store to market
National	50.8%	50.0%	42.3%	16.1%	26.4%	22.6%	11.3%	10.2%	22.0%	9.4%
East	79.1%	79.1%	75.8%	48.4%	47.3%	42.9%	34.1%	34.1%	35.2%	34.1%
Kigali	13.8%	-	-	-	-	-	-	-	-	-
North	34.8%	34.8%	29.5%	7.1%	32.4%	28.6%	11.0%	9.0%	25.7%	7.6%
South	68.2%	69.0%	46.5%	13.3%	20.2%	16.3%	8.5%	7.8%	9.3%	7.8%
West	55.4%	56.8%	52.7%	17.6%	20.9%	16.2%	4.7%	3.4%	28.4%	2.0%

Table 0-2: Training received, Season B 2012

Season B	Harvesting	Drying	Shelling	Transport field to store	Good types of store	Good storage hygiene	Use of pesticide on maize grain	Use of pesticide on store structures	Sorting to improve quality	Transport from store to market
N'nl	49.7%	45.9%	41.0%	22.8%	26.1%	26.0%	11.7%	6.1%	24.1%	7.4%
East	70.8%	67.7%	67.7%	20.8%	28.1%	42.7%	8.3%	5.2%	16.7%	6.3%
Kigali	33.3%	20.0%	13.3%	-	3.3%	-	-	-	-	-
North	52.5%	52.5%	49.2%	22.9%	41.1%	31.2%	24.7%	11.5%	29.7%	6.6%
South	45.3%	45.3%	40.5%	40.0%	23.0%	22.8%	13.4%	7.9%	30.9%	12.7%
West	33.7%	24.7%	14.6%	9.0%	25.8%	19.1%	9.0%	4.5%	27.0%	5.6%

APHLIS POST HARVEST LOSSES

Losses are calculated using the African Post Harvest Losses Information system, a general modeling tool for East and Southern Africa developed by the National Research Institute (NRI). The model functions as a meta-analysis of a wide range of post-harvest losses studies across Africa. Unfortunately, no parameter-contributing studies have yet been produced in Rwanda. With the absence of local data, APHLIS can provide an evidence-based estimate to inform discourse. Limitations of the model stem from its generality, as this calculator only takes into consideration three main parameters: rain at harvest, period of storage and the production marketed immediately after harvest. Therefore, individual farmer characteristics, practices, or training levels cannot be considered. In this calculation, rain at harvest is weighted by percentage incidence to avoid only a binary "yes" or "no" generalization for the province, while other parameters are held constant.

Under APHLIS specifications, Season A provincial losses range from 19.8% to 24.9%, with a national average of 20.1%. In Season B, due to significantly less incidences of rain at harvest, provincial loss estimates range from 13.8% to 17.7%. The national average in Season B is 15.4%. APHLIS estimates that the full 2012 year weighted average post-harvest losses would be 18.4%.

Table 0-1: APHLIS Losses by Province, Season A

Season A 2012	East		Kigali		North		South		West		National	
Rain at Harvest	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Production Share (MT)	6,302	6,031	3,733	325	37,180	56,899	38,994	19,555	62,424	60,943	148,633	143,753
Months Stored (Consumed And Marketed)	4.2		3.6		4.5		3.8		4.3		4.2	
Marketed "at Harvest" or within 3-months of harvest (production) %	41.6%		90.8%		42.1%		62.6%		51.3%		58.7%	
Post Harvest Loss (APHLIS) %	25.1%	16.3%	25.6%	16.8%	25.1%	16.3%	24.6%	15.7%	25.3%	16.4%	25.4%	16.6%
Season Weighted Average Loss %	20.8%		24.9%		19.8%		21.6%		20.9%		21.1%	

Table 0-2: APHLIS Losses by Province, Season B

Season B 2012	East		Kigali		North		South		West		National	
Rain at Harvest	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Production Share (MT)	5,224	39,178	531	1,328	4,533	32,861	338	22,966	14,559	45,131	25,184	141,465
Months Stored (Consumed And Marketed)	3.9		3.4		2.7		2.8		3.1		3.2	
Marketed "at Harvest" or within 3-months of harvest (production) %	81.0%		61.4%		58.3%		82.7%		71.3%		74.7%	
Post Harvest Loss (APHLIS) %	25.2%	16.4%	24.6%	15.7%	24.5%	15.6%	25.3%	16.5%	24.9%	16.1%	25.0%	16.3%
Season Weighted Average Loss %	17.4%		18.2%		16.7%		16.6%		18.2%		17.5%	

Table 0-3: APHLIS Losses By Province, Year 2012

Total APHLIS Post-Harvest Losses for 2012					
East	Kigali	North	South	West	National
18.2%	22.8%	18.9%	20.2%	20.0%	19.8%

COMPARISON OF POST-HARVEST LOSS ESTIMATES FROM APHLIS VS. MINAGRI SURVEYS

This current Season B 2012 survey attempted to gain local context for post-harvest loss parameters through farmer-reported data. The variables in question to contextualize were 1) Harvesting/Field Drying, 2) Further Drying, and 3) Farm Storage. Some study results were quite similar to APHLIS estimates, while others differed. APHLIS parameters themselves are built from averages of many study parameters, most of which vary considerably within each category. Therefore, it would not be unusual for this study's parameters to deviate somewhat from APHLIS "average" parameter estimates.

The APHLIS parameter for "Harvesting/Field Drying" with and without 'rain at harvest' comes from a Swaziland study in the early 1990s (Rick Hodges, personal communication, 2012). MinAgri-determined parameters are slightly higher than APHLIS without rain at harvest (6.4 to 7.8%), a relative difference of 21.8% greater and an absolute difference of 1.4%. With rain at harvest, MinAgri estimates are much below APHLIS (16.3 to 9.6%), with a relative difference of 41.1% less and an absolute difference of 6.7%.

The title of 'platform drying' to describe the drying process would only apply to a select group of farmers in this sample (see drying section), however the vocabulary of APHLIS is maintained. While the MinAgri estimate with 'rain at harvest' was quite close to the APHLIS parameter, without rain there is little to no reported loss.

The APHLIS parameter "Farm Storage" simply returns zero (0.0%) losses if storage is less than four months. However, this study suggests a non-zero on-farm storage loss for an average storage period of 3.2 months; ultimately this was a national production-weighted average of 4.9%. This measurement was not just farmer-reported estimations, but also through the use of visual scales and agent evaluation of present stocks.

Overall, the end resulting "total post-harvest losses" are quite similar. Compared to APHLIS estimates, the final estimates when weighting for regions with and without 'rain at harvest' are 17.5% to 16.1%. This represents a relative difference of 8.0% and an absolute difference of 1.4%.

Notably, key parameter differences are canceled out in a slightly disguising way. This difference would be more exaggerated if there was 1) a greater instance of 'rain at harvest' [i.e. Season A], or 2) longer maize storage periods on-farm.

Interestingly with the current model format, the disparity decreases if less maize is marketed within three months of harvest. This is because less marketed maize signifies larger stores on-farm, which raises the MinAgri parameter loss estimate (since APHLIS maintains a zero 'farm storage' coefficient for less than 4 months storage).

Table 0-1: APHLIS vs. new MinAgri Parameters: Summary of Season B 2012 Physical Losses

Post-Harvest Loss Parameter	APHLIS		Only MinAgri / PHHS Season B 2012 Survey		Proposed Correction With Field Verification of Harvest/Drying Loss Parameter + Season B 2012 Survey Storage Loss Parameter	
	No Rain	Rain at Harvest	No Rain	Rain at Harvest	No Rain	Rain at Harvest
Harvesting/ field drying	**6.4%**	**16.3%**	**7.8% (1.3)**	**9.6% (2.5)**	**0.9% (0.2)**	**3.1% (1.0)**
'Platform' Drying	**4.0%**	**4.0%**	**0.4% (0.2)**	**3.7% (2.3)**		
Threshing and Shelling	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%
Transport to farm	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%
Farm storage	**0.0%**	**0.0%**	**4.9% (0.9)**	**4.9% (0.9)**	**4.9% (0.9)**	**4.9% (0.9)**
Transport to market	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%
Market storage	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%
Total*	**16.3%**	**25.0%**	**15.4% (2.8)**	**19.8% (9.2)**	**8.8% (0.9)**	**10.8% (1.7)**
Season B 2012 Total+	**17.5%**		**15.9% (± 3.6%)**		**9.1% (± 1.0%)**	

*The total is not simply the summation of parameters, but a continual adjustment process. Download the APHLIS post-harvest losses calculator online for a detailed explanation (458kb): http://www.aphlis.net/index.php?form=downloads

+ With weighted regions of 'rain at harvest

COMPARATIVE INCORPORATION OF FIELD MEASURED "HARVEST/DRYING LOSSES" TO BACK-CAST PREVIOUS SEASONS

In light of new harvest/drying and storage loss parameter estimates which have been contextualized for Rwanda, it becomes necessary to address past post-harvest loss estimations made only with general model parameters. While revised estimates are made for harvest/drying and storage (the most impactful parameters which needed Rwandan context), it should be noted that the other four APHLIS loss "categories" are still taken from the general model parameters. The revision reveals post-harvest losses which were most likely lower than previous estimates suggested.

Harvest/Drying and Storage loss parameters were chosen for verification because they have the largest impact on losses in the APHLIS model. As the remaining variables are investigated to get Rwanda-specific parameters, overall post-harvest losses will most likely continue to change. Back-casting will be an important way to track losses over time without mixing methodologies. The large difference in overall post-harvest loss estimates for Season B 2012 between methodologies, presented in Table 9.1, underscores this point.

Table 0-1: Back-casting Post-Harvest Losses with New Field Measurements

	2011 A	**2011 B**	**2012 A**	**2012 B**
Rain at Harvest (%)	65%	34%	56%	12%
Est. Post-Harvest Losses*	10.25% (1.5)	9.76% (1.3)	9.85% (1.3)	9.14% (1.1)
Total quantity reported produced (MT)	341,479	166,644	406,389	166,649
Est. total quantity lost during post-harvest (MT)**	35,000	16,264	40,029	15,231

(standard errors)

*Weighted by provincial production and rain at harvest

**Based on production estimation methodology of measuring in the field prior to harvest. If production was estimated from farmer questionnaires, then harvest and drying losses of dried grain would be excluded.

SHIFTS IN SEASON B 2012 POST-HARVEST LOSSES IF EXCLUDING THE NORTHERN PROVINCE

Some discussion has centered on whether or not it is strategic to recommend that the Northern Province shift away from dry maize production, give the high post-harvest losses in this region. Table 11-1 and 11-2 illustrate that in Season A and Season B 2012, national post-harvest losses would have decreased by 0.9% and 0.3%, respectively. These correspond to a 9.0% and 3.3% relative reduction, respectively, in each season. Due to variance in the model, this difference is not statistically significant. The greater impact in Season A is because of heavier harvest-period rainfall, and the Northern Province has about double the national average harvest/drying losses during rainy harvests. The greater impact excluding Northern Province would be seen when harvests are particularly rainy. Losses in areas of "rainy" harvest periods are an absolute 3.5% higher (and relatively 32.1% higher) in the Northern Province than the national average.

Table 0-1: Projected Shifts in Season A 2012 Post-Harvest Losses if Excluding the Northern Province

Stage	Region	Season B 2012 Post-Harvest Losses Questionnaire			Following Harvest Losses Field Verification		
		Rain	No Rain	All	Rain	No Rain	All
Harvest and Drying Losses	North Prov.	26.7% (19.5)	12.5% (4.4)	18.2% (10.4)	6.3% (2.6)	0.9%* (0.2)	3.1% (1.2)
	Total Country	13.0% (11.7)	8.2% (3.5)	10.9% (8.1)	3.1% (1.0)	0.9% (0.2)	2.1% (0.7)
	Country w/o North	8.9% (11.3)	7.0% (2.3)	8.2% (8.1)	1.6% (0.8)	0.9%* (0.2)	1.3% (0.6)
On-Farm Storage Losses**	North Prov.			7.6% (2.2)			
	Total Country			**4.9% (0.9)**			
	Country w/o North			4.2% (1.5)			
	Absolute Net Country Change			**-0.7%**			
All Post-Harvest Stages (not shown: other non-measured APHLIS loss parameters)	North Prov.	33.0% (15.4)	20.1% (3.5)	25.3% (8.3)	14.4% (2.2)	9.5% (2.2)	11.5% (2.2)
	Total Country	19.8% (9.2)	15.4% (2.8)	17.9% (6.4)	10.9% (1.7)	8.8% (0.9)	10.0% (1.3)
	Country w/o North	16.0% (8.9)	14.3% (1.9)	15.4% (6.4)	9.3% (1.5)	8.7% (1.5)	9.1% (1.5)
	Absolute Net Country PHL	**-3.8%**	**-1.1%**	**-2.5%**	**-1.6%**	**-0.1%**	**-0.9%**

	Change						
	Percent Country PHL Change	**-19.2%**	**-7.1%**	**-14.0%**	**-14.7%**	**-1.1%**	**-9.0%**

*Use of other province data for proxy since all Northern Province farmers in Season A 2013 verification had more than one day of rain in harvest period.

**Parameters from questionnaire, where visual samples aided farmers' damage level identification

Table 0-2: Projected Shifts in Season B 2012 Post-Harvest Losses if Excluding the Northern Province

Stage	**Region**	**Season B 2012 Post-Harvest Losses Questionnaire**			**Following Harvest Losses Field Verification**		
		Rain	**No Rain**	**All**	**Rain**	**No Rain**	**All**
Harvest and Drying Losses	**North Prov.**	26.7% (19.5)	12.5% (4.4)	14.2% (6.2)	6.3% (2.6)	0.9%* (0.2)	1.6% (0.5)
	Total Country	13.0% (11.7)	8.2% (3.5)	8.8% (4.5)	3.1% (1.0)	0.9% (0.2)	1.2% (0.3)
	Country w/o North	8.9% (11.3)	7.0% (2.3)	7.2% (3.3)	1.6% (0.8)	0.9%* (0.2)	1.0% (0.3)
On-Farm Storage Losses**	**North Prov.**			7.6% (2.2)			
	Total Country			**4.9% (0.9)**			
	Country w/o North			4.2% (1.5)			
	Absolute Net Country Change			**-0.7%**			
All Post-Harvest Stages (not shown: other non-measured APHLIS loss parameters)	**North Prov.**	33.0% (15.4)	20.1% (3.5)	21.6% (4.9)	14.4% (2.2)	9.5% (2.2)	10.1% (2.2)
	Total Country	19.8% (9.2)	15.4% (2.8)	15.9% (3.6)	10.9% (1.7)	8.8% (0.9)	9.1% (1.0)
	Country w/o North	16.0% (8.9)	14.3% (1.9)	14.5% (2.7)	9.3% (1.5)	8.7% (1.5)	8.8% (1.5)
	Absolute Net Country Change	**-3.8%**	**-1.1%**	**-1.4%**	**-1.6%**	**-0.1%**	**-0.3%**
	Percent Country PHL Change	**-19.2%**	**-7.1%**	**-8.8%**	**-14.7%**	**-1.1%**	**-3.3%**

*Use of other province data for proxy since all Northern Province farmers in Season A 2013 verification had more than one day of rain in harvest period.

**Parameters from questionnaire, where visual samples aided farmers' damage level identification

SUMMARY AND EXTENSION RECOMMENDATIONS

GENERAL

1) Maize continues to primarily be a cash crop, with 87% of production sold in Season A and 84% in Season B.
2) Maize is stored longer in Season A than Season B, at 4.1 months vs. 3.2 months. This correlates with higher production in Season A.
3) Post-Harvest losses in Season A 2012 are estimated to be higher than Season B 2012, at 9.85% and 9.14%, respectively, due to greater Season A incidence of rain at harvest.
4) Most maize destined for the market is sold very quickly after harvest. In Season B, nearly 50% was sold within one month and 90% sold within two months. Mostly due to shorter holding periods, insect damage in marketed maize is a low average 1.1% compared to 4.8% in consumed maize.
5) If farmers desire to increase this period of storage before sale, careful attention must be paid to their dominant constraints—financial or technical ability to store.
    a. If technical ability to store is the dominant constraint, the Post-Harvest Task Force can help to increase knowledge about grain preservation technologies and proper structures.
    b. If the dominant constraint is financial, credit support is a more crucial focus.

TRAINING

Many farmer post-harvest practices have notable differences depending on training received.

1) Trained farmers in areas with rainy harvests have significantly lower harvest/drying losses. Harvest/Drying education seems to make little impact in areas with dry harvest periods. Therefore, expansion of harvest/drying training programs will have a greater impact on reducing post-harvest losses if concentrated on areas within provinces with rainy harvest periods.
2) Farmers trained in shelling practices and exposed to new technologies have notably higher adoption rates of more sophisticated shelling equipment.
3) Training in storage protectant use is the lowest of all post-harvest activities. There is a greatly elevated and statistically significant rate of storage protectant adoption among limited farmers who have received training. This category should be pursued in training regimens.
4) Rats are the largest reported contributor to on-farm storage losses, yet training on rat prevention techniques is largely absent from current curriculum. Rats should receive a greater focus in future post-harvest training.
5) The Western province is behind other provinces in many categories. The West has consistently higher usage of old and untreated sacks, low palette use, and simple technology utilization. This could be a region to particularly focus expansion of post-harvest education.

POST-HARVEST LOSSES MODEL PARAMETER ESTIMATIONS

1) Farmer-reported estimates in this study are meant to start a constructive discourse about contextualizing APHLIS parameters to Rwandan conditions, while maintaining the APHLIS calculation format.
2) A questionnaire should not be used to estimate harvest/drying losses. Instead, agents should use the simple methodology from the field verification to measure damaged and undamaged maize with balances. While the questionnaire method resulted in estimates somewhat close to the APHLIS general model parameters, the field verification loss parameters are significantly lower. A larger sample size for subsequent harvest/drying loss studies would help expand analysis on training and rain impact.
3) There are large differences between storage losses from this study and the APHLIS general model parameters. This Rwandan study suggests a non-zero parameter is much more appropriate for losses when storing for less than 4 months.
4) It is recommended to continue refining post-harvest loss parameters from the general model to the Rwandan context. The next most impactful parameters to contextualize are transport to farm (2.4% loss) and market storage (2.7% loss).

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