It's that time again:

Reap What You Sow and Keep What You Reap

Olaide Abdul-hameed Bankole*
hameed.bankole@cpparesearch.org

Center for Public Policy Alternatives
City Hall, Lagos, Nigeria

October, 2018

*Research Associate, CPPA. Address all inquiries to the author. All errors and omissions are my responsibility and are not to be construed as opinion of CPPA.

1. Introduction

A major constraint towards improving food security in Africa is poor post-harvest management which results in food losses of between 20 to 30%, estimated at a monetary value of over US$4 billion annually for cereal grains alone (FAO, 2010). Farmers incur economic losses when there is a glut; without appropriate storage technologies, they are exposed to qualitative and quantitative losses and are forced to sell off farm-produce at reduced prices (Kimenju et al. 2009). Post-harvest food losses are measurable along the value chain and vary by farm produce (Hodges, et al. 2011). Average losses range from about 20% in milk & milk (dairy) products and meat, 25% in cereal crops and oilseeds & pulses, 30% in fish & seafood, 48% in roots & tubers and up to 50% in fruits and vegetables (Aulakh and Regmi, 2013).

Nigeria is the largest producer of maize (a cereal crop) but at comparatively low yield (See Figure 2 in Appendix). In addition, the crop constitutes a major proportion of the diets of rural and urban populations (Baoua, et al. 2014). The General Household Survey (Wave 3) reveals that 97.2% of households in Nigeria consume grain and flours.[1] Maize is also a major ingredient in poultry feeds, constituting over 60% of compounded feed.[2] Losses are estimated to be highest at harvesting and during the field drying stage (6.4%), followed by farm storage (5%) and platform drying at 4% (APHLIS, 2011). Ensuring that farmers keep most of their harvested produce becomes imperative due to the recent on-field infestation of maize by Fall Army-worm (FAW), creating a double whammy.[3] Given the low yield and the demand for the crop, the key to improving food security must necessarily include reducing post-harvest losses in the crop. This paper examines the dynamics of post-harvest losses in maize, available technologies to reduce losses and adoption by farmers.

---

[1] See LSMS-Integrated Surveys on Agriculture General Household Survey Panel (2015/2016), pp. 39-41 at https://www.google.com.ng/url?sa=t&source=web&rct=j&url=http://nigerianstat.gov.ng/download/476&ved=2ahUKEwjE4ZbFmabeAhUDz4UKHc-vDiUQFjAAegQIBRAB&usg=AOvVaw1cMu3-S1igbJD5FTZFe5Ey

[2] See https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual_Lagos_Nigeria_4-6-2017.pdf, p.9.

[3] See http://www.fao.org/nigeria/news/detail-events/en/c/1110295/

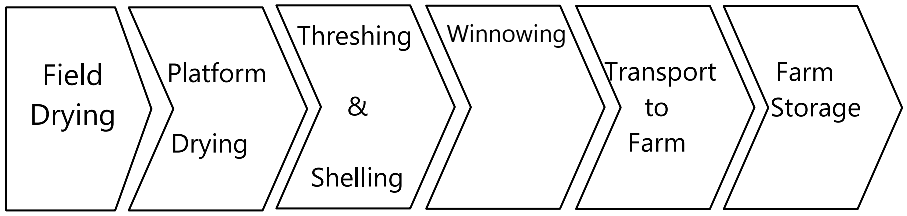

Figure 1: Conventional Pathway for Losses to occur in Maize Value Chain (Source: APHLIS[4])

2. Dynamics of Post-harvest Losses (PHLs) in Maize

Post-harvest losses tend to increase with humidity and temperature and decreases with better market access, higher seasonal price differences, and improved storage practices (Gitonga, et al. 2013; Kaminski and Christiaensen, 2014). The extent of field drying depends on the time of harvesting due to weather conditions and harvesting practices which affects the storage grain quality and the genetic characteristics of maize varieties (FAO 2010). Drying could be done naturally through exposure to sun or shade at relative humidity not higher than 70% or by artificially using driers.[5] For the earlier method, the exposed seeds are at a risk of pest attack which leads to losses. Dryers, on the other hand, allows for control over atmospheric conditions. Losses occurring during threshing and shelling depend on the moisture content of the grains whereby breakage occurs with excessive drying. The use of small and large-scale machines, rather than hand threshing/shelling, reduces the amount of labour (manhours) required for the process.[6]

A highly destructive storage insect pest of maize in West Africa is the Larger Grain Borer (LGB) which multiplies rapidly in seeds at a temperature of 30°C, ambient relative humidity of at least 70% and 13% moisture level (Baoua, et al. 2014). Maize is widely cultivated across Nigeria. According to the Meteorological Agency[7], daily temperature ranges from as low as 30.1°C in Jos, 33.3°C in Ado-Ekiti, 34.2°C in Iseyin, 34.3°C in Kaduna, 34.6°C in Kano, 34.8°C in Ilorin to as high as 35.9°C in Abuja, 36.5°C in Maiduguri and 40.5°C in Sokoto. Night time temperatures are generally below 30°C. Annual mean relative humidity ranges from as low as 29.3% in Maiduguri,

[4] See African Post-harvest Losses Information System - https://www.aphlis.net/en/page/1/crop-tables#/datatables/crops-losses?lang=en&metric=prc&year=2011
[5] See http://www.fao.org/docrep/t0522e/T0522E08.htm#Drying
[6] See http://www.fao.org/docrep/t0522e/T0522E07.htm
[7] See 2018 Seasonal Rainfall Predictions - https://nimet.gov.ng/publication/2018-seasonal-rainfall-prediction-srp, pp. 26-30.

30.4% in Kano, 30.8% in Sokoto, 36.7% in Kaduna, 43.2% in Jos, 47.6% in Ilorin, 50.3% in Abuja to as high as 61.1% in Akure, 70.2% in Lagos, 72.4% in Cross River and 72.5% in Port Harcourt.[8] Going by these estimates, the Southern parts of the country are more conducive to the multiplication of LGB. Its presence has been established in South-Western parts of the country (Osipitan et al., 2007).

3. Loss-Reduction Technologies and Strategies

In Nigeria and other West African Countries, rudimentary methods of grain storage are still being used. These include traditional structures such as mud and thatched rhombus, underground pit, earthen pot and warehouse storage and conical structures (Adejumo and Raji 2007; Tefera, 2012). These structures are, however, prone to physical defects such as cracks which causes leakages, termite infestation and structural failure.

Given that climatic conditions are a prerequisite for losses to occur, hermetic methods have been proffered as a solution in sub-Saharan Africa. Available technologies include Metal Silos, Super Grain Bag and Purdue Improved Crop Storage (PICS). They are moisture proof, rodent proof and airtight. They work by depriving storage pests of oxygen.

- **Metal Silos**

In Kenya, an impact assessment study found that the use of Metal silos resulted in an almost total elimination of storage pests, allowing farmers store gains for a further two months and consequently saving their income (Gitonga, et al. 2013). Farmers were also able to sell their surpluses 5 months later at good prices.

The Metal silos used by the farmers were acquired locally through trained artisans. The pilot phase of the "Effective Grain Storage" project which was conducted in Kenya and Malawi was inspired by the success of Metal Silo in reducing grain losses in Central America.[9] However, its adoption requires high initial investment (Tefera et al., 2011; Gitonga, et al. 2013). Micro-

[8] See http://istmat.info/files/uploads/53129/annual_abstract_of_statistics_2011.pdf , p. 13.
[9] See https://www.cimmyt.org/metal-silo-artisans-trained-in-malawi-and-kenya/

financing is being proffered as a solution to both farmers and artisans alike.[10] Nigerian smallholder farmers stand to gain from a similar initiative which has a tendency to create jobs for artisans.

As a prerequisite, there has to be policy-based incentives for research into the local fabrication of post-harvest technologies and the involvement of the private sector for market development (Tefera, 2012). High taxes on fabrication materials such as metals lead to prohibitive unit prices of metal silo which is capable of divestment in and adoption of the technology (Chapoto and Jayne, 2010). A cost-benefit analysis of storage structures in Kenya showed that the use of metal silos returned the highest ratio and is the most viable among them (Nduku et al., 2013). Therefore, it is expected that farmers would adopt this technology if they have access to credit or are able to pool funds to make the initial investment through cooperatives, as long as the expected revenue will cover up for the total cost of storage.

- **Super Grain Bags**

An experiment conducted in Benin Republic showed that storing maize infested with LGB (*Prostephanus truncatus*) and Maize Weevil (*Sitophilus zeamais*) in hermetic grains bags (HGB) led to the mortality of the pests after 60 days, less than 6% grain loss after 150 days and constant moisture content throughout storage period (Ognakossan et al. 2013). The use of HGB was recommended after comparing its effectiveness to that of polypropylene packaging.

The grain bags used in a similar experiment in Kenya was purchased from a manufacturer whose business is to make technologies for reducing post-harvest losses which do not require the use of chemicals (De Groote et al., 2013).[11] Post-experiment, HGB was recommended for use but the researchers warned that it may be unsuitable in areas where there is a high incidence of LGB as it tends to perforate the bags (De Groote et al., 2013; Ognakossan et al. 2013). It is expected that such a caveat would result in further improvements in the quality of the bag by manufacturers. In Nigeria, farmers could benefit from firms who are interested in expanding their product lines.

[10] See http://wire.farmradio.fm/en/farmer-stories/2010/10/malawi-metal-silos-improve-livelihoods-for-artisans-and-farmers-alike-cimmyt-ntv-kenya-10138
[11] See https://grainpro.com/what-we-offer/#storing

A local firm such as Fas Agro could choose to invest in the manufacture of Hermetic Grain Bags, as it currently only manufactures polypropylene, which is ineffective against Larger Grain Borer.

- **Purdue Improved Crop Storage (PICS)**

The PICS technology is described as "a low-cost, simple, and effective technology for low-resource farmers to help them preserve their dry crops after harvest with minimal losses due to storage insects."[12] Tests conducted in Benin, Burkina Faso and Ghana proved the effectiveness of the bags for maize storage (Baoua, et al. 2014). By storing maize infested with LGB, smaller grain borer and maize weevil, 95-100% mortality of insects were observed at all locations, after six and a half months in PICS storage. Further tests conducted on the seeds revealed that seed viability and germination were unchanged, before and after storage. Jones et al. (2011) also showed that the use of PICS results in higher profitability compared to the use of insecticides in market regions in Tanzania, Kenya, Malawi, Mozambique, and Ghana. Similar experiments could be conducted in Nigeria to establish the effectiveness of the PICS bag.

4. Conclusion

Maize farmers need to increase the post-harvest shelf life and minimize losses of produce, through value addition. The ability to satisfy this need allows them to guard against reduced prices for the crop and smooth out hunger throughout the year both on and off season. However, given that the magnitude of losses in the value chain depends on several factors such as the climatic conditions and available technologies, external assistance is required. Varying degrees of temperature and humidity patterns, across the country, calls for a range of post-harvest technologies.

There is, therefore, a need for incentive-based policies which will encourage private sector investment in research and development into developing technologies that are suitable-for-purpose in different parts of the country. Agro-allied firms have an opportunity to create new products and services which are in demand, thereby consequently increasing their returns on

[12] See https://picsnetwork.org/who-we-are/

investment. It is expected that farmers will adopt appropriate post-harvest storage technologies, provided that the expected revenue covers up for the initial cost of acquisition or investment.

5. References

Adejumo, B.A. and Raji, A.O. (2007). Technical Appraisal of Grain Storage Systems in the Nigerian Sudan Savanna. Available at http://www.cigrjournal.org/index.php/Ejounral/article/view/966.

African Post-harvest Losses Information System (APHLIS) (2011). Value Chain Losses (%), Nigeria. Available at https://www.aphlis.net/en/page/0/crop-losses#/datatables/crop-losses?lang=en&metric=prc&year=2011&country=463

Aulakh, J. and Regmi, A. (2013). Post-Harvest Food Losses Estimation-Development of Consistent Methodology. In: Selected Poster Prepared for Presentation at the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, Washington DC.

Baoua, I.B., Amadou, L., Ousmane, B., Baributsa, D. and Murdock, L.L. (2014). PICS bags for post-harvest storage of maize grain in West Africa, *Journal of Stored Products Research*, http://dx.doi.org/10.1016/j.jspr.2014.03.001.

Chapoto, A. and Jayne, T. S. (2010). Maize Price Instability in Eastern and Southern Africa: The Impact of Trade Barriers and Market Interventions. Prepared for the COMESAOMESA policy seminar on "Variation in staple food prices: Causes, consequence, and policy options", Maputo, Mozambique, 25–26 January 2010 under the COMESAOMESA-MSU-IFPRI African Agricultural Markets Project (AAMP).

De Groote, H., Kimenju, S.C., Likhayo, P., Kanampiu, F., Tefera, T. and Hellin, J. (2013). Effectiveness of hermetic systems in controlling maize storage pests in Kenya. *J. Stored Prod. Res*. 53:27-36.

Food and Agricultural Organization of the United Nations (FAO) (2010). FAO/World Bank workshop on reducing post-harvest losses in grain supply chains in Africa: Lessons learned and practical guidelines. FAO Headquarters, Rome Italy, 18–19 March 2010. Available at http://www.fao.org/3/a-au092e.pdf

Food and Agricultural Organization Statistics Division (FAOSTAT). http://www.fao.org/faostat/en/#data/QC

Gitonga, Z.M., De Groote, H., Kassie, M. and Tefera, T. (2013). Impact of metal silos on households' maize storage, storage losses and food security: An application of a propensity score matching. *Food Policy*, 43:44-45. DOI: https://doi.org/10.1016/j.foodpol.2013.08.005.

Hodges, R.J., Buzby, J.C. and Bennett, B. (2011). "Post-harvest losses and waste in developed and less developed countries: opportunities to improve resource use." *Journal of Agricultural Science*, 149:37-45.

Jones, M., Alexander, C. and Lowenberg-DeBoer, J. (2011). An Initial Investigation of The Potential for Hermetic Purdue Improved Crop Storage (PICS) Bags to Improve Incomes for Maize Producers In Sub-Saharan Africa. *Working Paper #11-3*. Available at https://www.researchgate.net/profile/Michael_Jones48/publication/270568951_AN_INITIAL_INVESTIGATION_OF_THE_POTENTIAL_FOR_HERMETIC_PURDUE_IMPROVED_CROP_STORAGE_PICS_BAGS_TO_IMPROVE_INCOMES_FOR_MAIZE_PRODUCERS_IN_SUB-SAHARAN_AFRICA/links/54ad6d8b0cf2213c5fe3f7f0.pdf

Kaminski, J. and Christiaensen, L. (2014). Post-Harvest Loss in Sub-Saharan Africa — What Do Farmers Say? https://doi.org/10.1596/1813-9450-6831.

Kimenju, S. C., De Groote, H., & Hellin, H. (2009). Preliminary Economic Analysis: Cost effectiveness of the use of improved storage methods by small scale farmers in east and southern Africa countries. International Maize and Wheat Improvement Center (CIMMYT). P.17.

Nduku, T.M., De Groote, H. and Nzuma, J.M. (2013). Comparative Analysis of Maize Storage Structures in Kenya. Contributed paper prepared for submission to the 4th Conference of the African Association of Agricultural Economists (AAAE), 22-25 September 2013, Tunisia. Available at https://pdfs.semanticscholar.org/4097/4684765e2cbedf51180c96466c873d4718ec.pdf

Ognakossan, K.E., Tounou, A.K., Lamboni, Y., Hell, K. (2013). Post-harvest insect infestation in maize grain stored in woven polypropylene and in hermetic bags. *Int. J. Tropical Insect Sci.* 33(1): 71-81.

Osipitan, A. A., Odebiyi, J. A., & Lawal, O. A. (2007). Current status of the larger grain borer, Prostephanus truncatus (Horn)(Coleoptera: Bostrichidae) in five South-western States, Nigeria. *Moor Journal of Agricultural Research*, *8*(1), 69-79.

Tefera, T., Kanampiu, F., DeGroote, H., Hellin, J., Mugo, S., Kimenju, S., et al. (2011). The metal silo: An effective grain storage technology for reducing post-harvest insect and pathogen losses in maize while improving smallholder farmers' food security in developing countries. *Crop Protection*, 30:240–245.

Tefera, T. (2012). Post-harvest losses in African maize in the face of increasing food shortage. *Food Security*, 4(2):267–277.

Appendix

Figure 2: Top 10 Maize Producers in Africa (2016) || *Source*: FAOSTAT (2016)

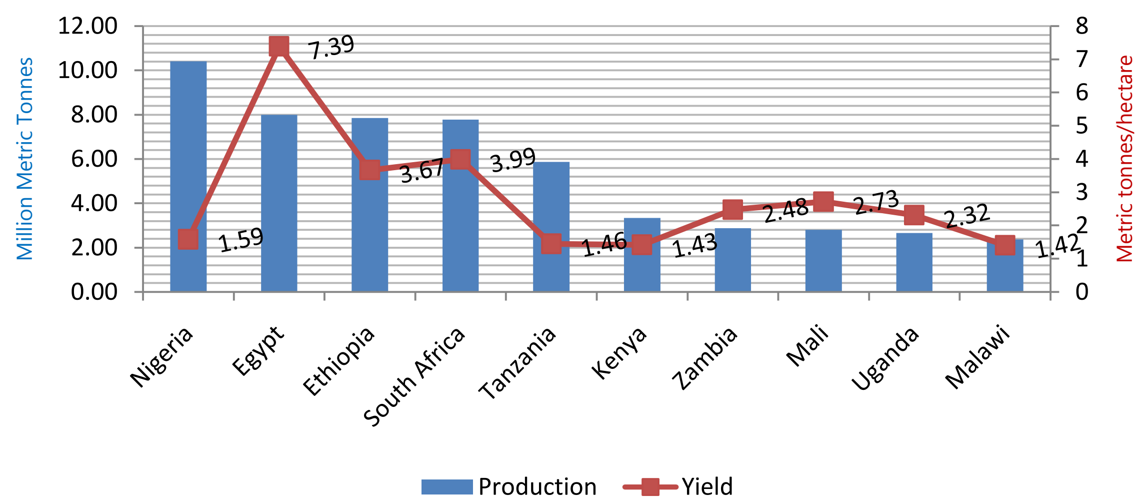

Figure 3: Traditional Conical Structure for Maize Storage
Source: Picture taken by Author at a farming community in Irawo Owode – Atisbo Local Government Area of Oyo State (2017)