

The Impact of Maize Post-Harvest Management Practices on Smallholder farmers' Income in Bugesera District, Rwanda

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Abstract: The Govt of Rwanda has given a priority to maize production in the country's marshlands and hillsides in regions where this crop can be grown as recommended by the crop intensification program (CIP¹), over the last decade huge investments were done in agricultural infrastructures; swamp reclamation, irrigation systems etc... Bugesera District in Eastern part of Rwanda is one of the regions that grow maize at large scale; in that region farmers grow maize as a cash crop and they have increased maize production and productivity in the last decade. The development of maize production has boosted the needs in postharvest handling materials and infrastructures for proper postharvest management aiming to meet market conditions for quality, which are among the key determinants for market prices. Government of Rwanda's investments in the maize value chains aimed at reducing the poverty through increased income for the smallholder farmers. However, this objective faced a variety of challenges mostly due to poor post-harvest practices that lead to the poor quality of maize, and contribute to the maize post harvest losses that is still high. As the maize produces continued to be dried, stored and processed using inappropriate materials and techniques this has led to the persisted high maize postharvest losses and affected the quality (moisture content and impurity), hence make locally produced maize to become less competitive at the market compared with the maize imported from the region. The vision of Govt of Rwanda (Vision 2020) of reducing poverty, food insecurity and increase the per capita income to 900 USD in 2020, from 220 USD in year 2000 (MINECOFIN, 2000) was constrained by this situation for the smallholder farmers to achieve this target. This research analyzed the issues from a triangulated perspective analysis; firstly the analysis of the gain in prices resulting from small farmers selling their maize produces collectively through the Cooperative, secondly the analysis of the gain resulting from improved maize quality (drying and storage practices) and thirdly the analysis of the gains from the improved primary postharvest practices which increase the maize quality (Shelling, drying, winnowing and sorting) both aiming to increase income at individual small farm holder's level. The research findings revealed that for the majority (99%) of the farmers, income from maize produces contributes to more than 50% of their annual

income: 55% said that income from Maize contributes to more than 75% of their annual income while 44% said that it contributes from 50 to 75% of their annual incomes, making the maize to be their main source of incomes at households' level. The research has revealed that the majority, 67% of the farmers sell their maize produces collectively through the Cooperative while 33% they do not, majority of farmers 100% don't have storage and drying facilities at household level: farmers have two options: i) 67% farmers they use "Plastic sheets" for drying the maize and ii) Only 33% of maize produces from small farmers is dried using Cooperative's drying facilities, this explains the reason of the high maize losses and deterioration of the quality at household level and it explains why a small portion of the maize produce could be sold collectively from known channels like cooperative, reason for the persisted low income from the maize at household level despite of the huge investments already made in the last decade.

Keywords: Maize Post-Harvest, Maize Post-Harvest Management Practices, Smallholder farmers.

I. INTRODUCTION

Food loss and waste is a global phenomenon and is not restricted to the African continent. Roughly one-third of the food produced in the world for human consumption gets wasted; food losses and waste amount to roughly USD 680 billion in industrialized countries and USD 310 billion in developing countries. Total quantitative food loss in sub-Saharan Africa has been estimated at a 100 million metric tonnes per year. For grains alone, the value of post-harvest losses are estimated to equate to approximately USD 4 billion/year (at 2007 prices), which could meet the annual food requirements of about 48 million people and exceeds the annual value of grain imports into Africa and the value of total food aid received in sub-Saharan Africa over the past decade. It is in this regard that amongst the seven commitments made by the Heads of State and Governments in Malabo, the third commitment on ending hunger in Africa by 2025 is directly relevant to the efforts to reduce PHL. The target is to halve (decrease by 50%) the current levels of post-harvest losses by the year 2025 (AUC, 2018).

Rwanda as a small country, with arable land estimated to be 48 per cent of the total area of 26,338 km², has about 96 per cent of rural households rely directly or indirectly on agriculture for their livelihoods. Although agricultural plots are generally small (average plot size is 0.6 ha often divided

¹The crop intensification program (CIP) was introduced in Rwanda in 2007 by the Ministry of Agriculture and Animal Resources (MINAGRI), Rwanda, as a solution to the land fragmentation, low use of agricultural inputs and low access to extension services (A. Nahayo et al, 2016).

into three-four sub-plots) this masks a wide range. About 30 per cent of the households cultivate less than 0.2 ha (accounting for about five per cent of total arable land), while about 25 per cent cultivate more than 0.7 ha (accounting for 65 per cent of the national farm-land). 15 per cent of rural household farm less than 0.1 ha; many of which are female-headed households, cultivating only 1.32% of national cultivable land (GoR, 2017).

Over the last decade, it has been remarked a tremendous changes in Rwandan agricultural outputs, the traditional Rwandan farmer has apparently responded to changing socio-political, agro-climatic, land resource and economic circumstances by making radical shifts among crops. For some crops, the change in output is primarily the result of secular shifts in productivity driven by lack of resistance to disease. In other cases, land availability, prevailing prices, lack of labor, lack of land, or food security may be the primary drivers behind substantial crop shifts by smallholders. The World Bank (2003) defines smallholders as those with a low asset base, operating less than 2 hectares of cropland.

This development of Agriculture in Rwanda has boosted tremendously the production both at household's level and Cooperative level, bringing in new needs at all levels in terms of knowledge and infrastructures. The common constraints at the producer level will explain the gaps explain the situation highlighted earlier.

Farmers in Rwanda have the tradition of organizing themselves locally in membership-based organizations around common interests like agricultural production or marketing to pool their resources and facilitate access to credit and farm inputs. Several farmer organizations exist in Rwanda drawing their membership from individual farmers and (mostly) informal farmer groups (GoR, 2017).

Bugesera District is one of seven Districts of the Eastern Province in Rwanda, it covers a total surface area of 1337 Km² of which arable land is estimated at 91,930.34 ha. A big percentage of people of Bugesera are rural based and practice agriculture and therefore the best way to transform their lives economically, is by modernizing agriculture to increase productivity and revenues. The average size of land cultivated per HH is 0,59ha, during the last five years, Maize yield increased from 3tones/Ha to 5.2tones/Ha and the land use rose from 0ha to 28,491Ha (GoR, 2013).

The objective of this study is to assess impact of postharvest management practices on smallholder farmers' income in Bugesera District with focuses on three areas, i) Assess how the use of collective and structured marketing channels for maize produce can increase the income for smallholder farmers', ii) Assess how improved storage and drying facilities can contribute to the increase of smallholder farmers' income and iii) Find out how improved primary maize handling practices (drying, shelling, winnowing and sorting) can contribute to the increase of small holders' income at market.

The rationale for the study

The Government of Rwanda has been implementing a set of reforms to enable Rwanda to evolve from subsistence agriculture and food insecurity towards market-oriented agriculture. Efforts have been concentrated on a few selected priority staple foods and horticulture crops to be grown in the different agro-ecological zones where they are best adapted in terms of performance, and to change the livelihoods of the small farmers as it was defined in the Strategic Plan for the Transformation of Agriculture (PSTA I and PSTA II) and in the Integrated Development Program the priority staple crops and horticultural commodities: beans, Irish potato, rice, maize, wheat, cassava, fruits and vegetables were identified to benefit from public support services along the entire value chain production, post-harvest practices including storage, processing, and marketing practices for to increase the revenues for small farmers.

Also Government of Rwanda views cooperatives as a potential vehicle through which the cooperatives members could create employment and expand access to income-generating activities, develop their business potential, including entrepreneurial and managerial capacities through education and training; increase savings and investment, and improve social well-being with special emphasis on gender equality, housing, education, health care and community development (MINICOM, 2006).

However, despite of the substantial growth in agricultural production over the past 10 years, food security and nutrition remain concerns, especially when looking at the vulnerability to shocks at the household level. Consequently, food security and nutrition are important areas to which agriculture can accelerate its effort (GoR, 2017). While stunting and undernourishment have been reducing at a steady pace, overall stunting rates remain high; at 38% by international compare and 17.8 per cent of 6-23 months olds do not meet the Minimum Acceptable Diet (NISR, 2016), as per the CARI measure, 20% of Rwandan households are food insecure (NISR, 2015).

Smallholder farmers harvest and prepare their maize produces for the final consumer, either to be consumed at home or to be taken to the market for other consumers, preparations of he maize produces involve a series of activities at farm gate level; categorized as primary postharvest handling practices that include drying the maize, shelling, winnowing and sorting. The way these primary post harvest-handling activities are done by the smallholder farmers, it will determine the end quality of maize to be taken to the market, and involved technologies and materials used by farmers are very key determinants.

In Rwanda 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 are 19.8% (CARANA, 2013).

II. LITERATURE REVIEW

2.1. *Smallholder farmers' behaviors and marketing systems*

The agriculture sector in Africa engage a good number of the population and it offers a wide range of economic opportunities along the value chains; the primary production involve the majority of the people engaged in the sector and the post harvest value chains also attract many other people interested in the processing and commercialization of agriculture products, transporters and others. The commercialization of agriculture products involves millions and millions of Africans; in the urban and rural markets, empirically it is proved that women are dominating in some areas of agriculture produce commercialization.

As a consequence, markets in Africa are strongly fragmented; food products are traded in small quantities, and there are many steps in the value chain to take the product from the producer to the consumer. Millions of smallholder farmers produce small surplus amounts of fruits and vegetables, cereals and tubers, dairy and meat. These farmers live scattered throughout the country, often separated by long distances from the major centers of consumption. Thousands of small-scale itinerant traders travel there weekly to buy products to transport and supply the urban markets. In the cities, tens of thousands of micro-retailers buy small quantities of produce on credit, which they sell in a couple of days, after which they buy some more produce to resell. Finally millions of consumers buy small quantities of food products, often every day, as their wallets (and a lack of refrigerators) do not allow them to buy for the whole week at once (IIRR, 2008).

Food markets will remain very unique as it deals with the most essentially basic needs for every person in this world, more than 7 billions can not afford to escape food at least once in 24 hours, this make the food market very dynamic in all the corners of the world. Interactions between the primary food producers and the end food products consumers has been always interfered by the essential and non essential middlemen, it has been always the reality that the smallholder farmers are not the ones getting the most of the profits from the produced food. Urban versus rural food markets have been looked in the lenses of rural markets as suppliers of urban food markets, it make sense in the perspective that most of the food is produced in the rural areas, however, for crops like maize which involves little technologies for processing and that is consumed by all the people in the all categories regardless of the income; value added at the processing cycles put the smallholder farmer who initially is the owner of the produces becoming the buyer of his processed maize at the end of the game and they pay it expensively compared to what they got from the raw maize sold to processors.

Efficient and fair markets systems are needed in the realm of African agriculture food market, the starting fair enough point would be the smallholder farmers getting fair prices for their produces; in most of rural areas farmers faces situations whereby they have to surrender some of their rights to intermediaries and middlemen who end up by becoming the real owners of agriculture produces at the end of the season, at the harvest most of the stallholders farmers are indebted or they have already sold the produced ahead the harvest. Resilience and self reliance for smallholder farmers is requested as the foundation for creating fair markets with smallholder farmers have a say on their produces taken to the market and have the bargaining power over their produces. This ideal situation will happen only when our smallholder farmers are empowered economically and have enough skills, information and knowledge in the areas of post-harvest handling techniques, have updated market information, have enough produces to attract traders and infrastructures like roads are favorable for easy transportation of agriculture produces from one place to another.

Distance from the farm to the market is noted as a major constraint to the intensity of market participation by the smallholder farmers (Bardhan *et al.*, 2012). Ownership of transport means can significantly determine participation in relation to the distance to the market place. This can be attributed to poor access to transport facilities due to high transaction costs. This provides a need to upgrade both rural access roads and roads in peri-urban areas, strengthen delivery systems and encourage market integration (Omiti *et al.*, 2009; Jagwe, 2011; Awotide *et al.*, 2013). Boadu *et al.* (2013) found that geographic location of smallholder farmers has a larger impact on market participation than gender and education. Market integration provides a sure market for the farmers.

Inadequate market systems cause high food losses in developing countries, to minimize losses, the commodities produced by farmers need to reach the consumers in an efficient way. There are too few wholesale, supermarket and retail facilities providing suitable storage and sales conditions for food products. Wholesale and retail markets in developing countries are often small, overcrowded, unsanitary and lacking cooling equipment (Kader, 2005). **Food loss** is defined as the measurable decrease in the quantity or quality of food produce. It is the result of any reduction in the availability of food or in the edibility, wholesomeness, or quality of food that reduces its value to humans. Food loss is considered as the unintended result of an agricultural process or technical limitation in storage, infrastructure, packaging or marketing (World Resource Institute - WRI, 2013) while **Post-harvest losses (PHL)**: Any losses occurring after the separation of the product from the site of immediate growth (harvest) to the moment it reaches the consumer (FAO, 2018).

Regardless the organization of farmers in structures like Cooperatives, household/small holder farmer remain the center of gravity for the quality and quantity of maize, any plans, strategies that intend to maize produce has to be

grounded at household level. Behavior and practices of the smallholder farmers will determine how much and which quality they take to the market, either by themselves or through the Cooperative.

However, for the sake of increasing the bargaining power and raising their voices together, the smallholder farmers will need to act together with one voice and one strong player at market place as they negotiate for good prices for their maize produces or as they engage stakeholders for the provision and negotiation for good terms for the access for agro-inputs. The promotion of collective action among smallholder farmers can help to improve their negotiation power under the economies of scale for agro-inputs, access to finance as they negotiate for loans, access to market information and for the advocacy for any favors to benefit smallholder farmers.

There should be clear definitions of responsibilities of each and everyone between the smallholder farmers and their cooperatives; terms and conditions for collective interests at cooperative's level should prevail but also respect of individual smallholder farmer should be given a second priority. For this to work it requires a set of level of trust and confidence of the farmers in their committees managing the cooperative, well managed cooperatives increase the level of trust and support from their members while cooperatives with issues in their administration and financial management always create a spiral inter members non trust and disrespect of collective measure and strategies due to dysfunctional cooperative bodies, this will always lead to individualisms among the cooperative members. Cooperative should focus on ensuring big investments in the commodity value chains; availing infrastructures for maize collection, grading, post-harvest and storage, they should also enable the necessary investments in terms of training, packaging, control, communication, and reputation building, which are necessary for the marketing of products with special quality.

Access to market information determines market participation by farmers, whether obtained directly or through formal or informal institutional arrangements, it is critical for market participation (Jagwe *et al.*, 2010). As explained by Omiti *et al.* (2009), better output price and market information are key incentives for increased output sales. Access to extension service empowers farmers with information about the market. Inadequate access to extension services hinders market participation (Ngoro *et al.*, 2013). Bardhan *et al.* (2012) explains that extension contact is one of the most important policy variables that favourably influence intensity of market participation among dairy farmers in Uttarakhand. In South Africa, an additional visit by an extension officer was found to be increasing the probability that the farmer will sell his/her livestock (Bahta and Bauer, 2007). Jagwe *et al.* 2010 states that Policies aimed at encouraging market information access,

investments in rural infrastructure and collective action by farmers may help to lower transaction costs and thus enhance market participation.

The decision by farmers on market outlet through which to sell their farm produce is greatly influenced by the price they receive from the outlet (Lupin and Rodriguez, 2012). Convenience and relationship with the producer can also play a major role in this decision. A study by Umberger *et al.* (2010) revealed that long term relationship of farmers with their buyers, price, willingness to negotiate and cash payment are important factors to farmers when choosing a market outlet. Shiimi *et al.* (2010) found that problems with transport and accessibility to market-related information are significant factors affecting choice of a marketing outlet.

2.2. Maize losses due to poor postharvest facilities

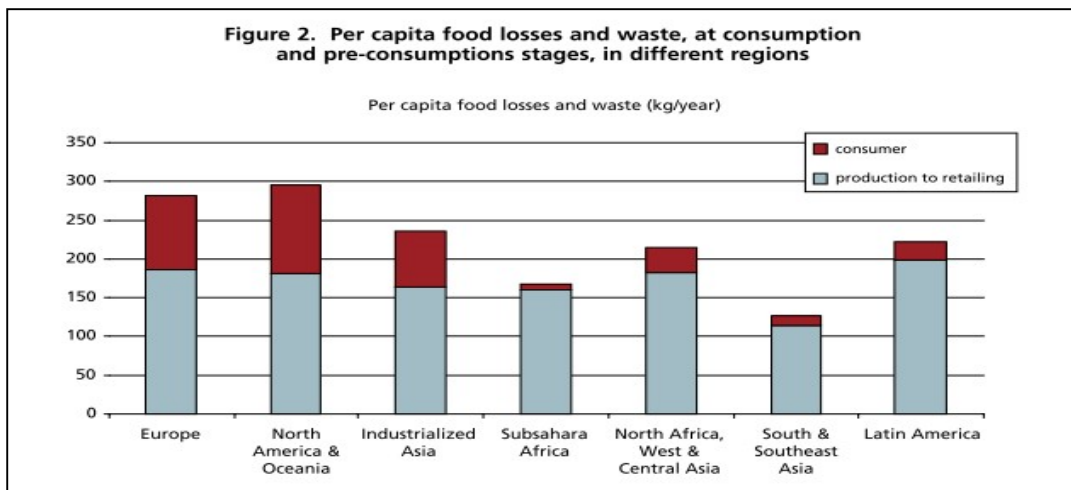
How much food is lost and wasted in the world today and how can we prevent food losses? Those are questions impossible to give precise answers to, and there is not much ongoing research in the area. This is quite surprising as forecasts suggest that food production must increase significantly to meet future global demand. Insufficient attention appears to be paid to current global food supply chain losses, which are probably substantial.

The World is highly challenged by high rate of postharvest losses while the issue of food security and economic development remain the predominant mission of all governments all over the world. The problem becomes very critical in developing countries where the few produced get lost easily and obviously contribute to the problem of food insecurity and poverty generally.

“The issue of food losses is of high importance in the efforts to combat hunger, raise income and improve food security in the world's poorest countries. Food losses have an impact on food security for poor people, on food quality and safety, on economic development and on the environment” (FAO, 2011).

Roughly one-third of the edible parts of food produced for human consumption, gets lost or wasted globally, which is about 1.3 billion ton per year. Food is wasted throughout the Food Supply Chain (FSC), from initial agricultural production down to final household consumption. In medium- and high-income countries food is to a great extent wasted, meaning that it is thrown away even if it is still suitable for human consumption. Significant food loss and waste do, however, also occur early in the food supply chain. In low-income countries food is mainly lost during the early and middle stages of the food supply chain; much less food is wasted at the consumer level.

Graph 2.1 Per capita losses and waste, at consumption and pre-consumption stage



Source: FAO, guidelines on the measurements of harvest and post harvest losses, 2018

Graph 2.1 shows that the per capita food loss in Europe and North-America is 280-300 kg/year. In Sub-Saharan Africa and South/Southeast Asia it is 120-170 kg/year. The total per capita production of edible parts of food for human consumption is, in Europe and North-America, about 900 kg/year and, in sub-Saharan Africa and South/Southeast Asia, 460 kg/year.

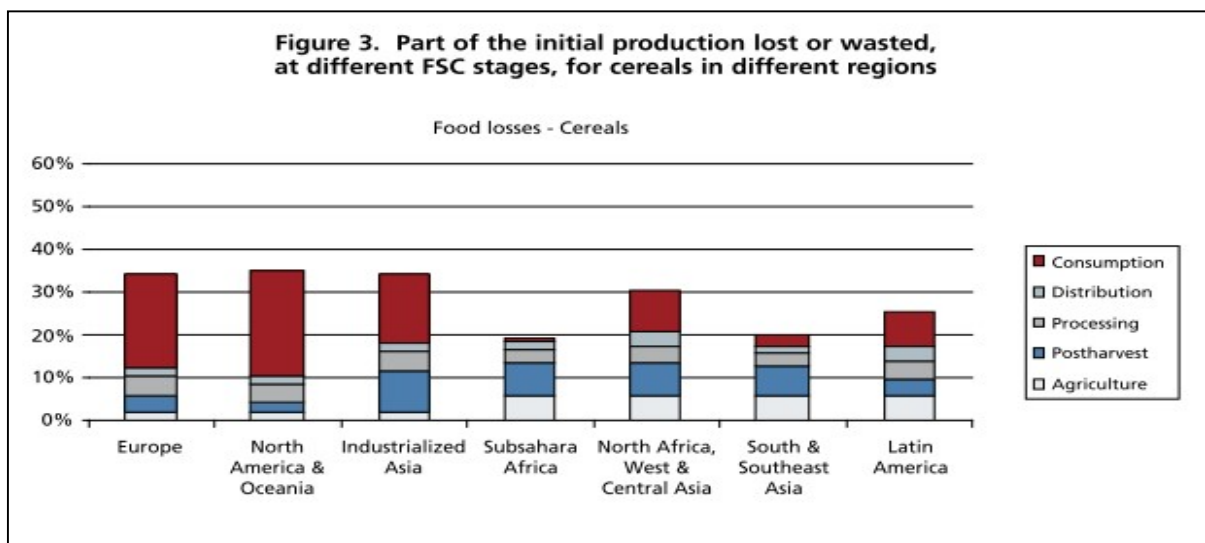
Per capita food wasted by consumers in Europe and North-America is 95-115 kg/year, while this figure in sub-Saharan Africa and South/Southeast Asia is only 6-11 kg/year. Food losses in industrialized countries are as high as in developing countries, but in developing countries more than 40% of the food losses occur at post harvest and processing levels, while in industrialized countries, more than 40% of the food losses occur at retail and consumer levels. Food waste at

consumer level in industrialized countries (222 million ton) is almost as high as the total net food production in sub-Saharan Africa (230 million ton).

The graph below shows the percentage food losses and waste of the edible parts of food products that were produced for human consumption, for the cereals (Figure 2.2), wheat and maize dominant crop supply in medium- and high-income countries, and the consumer phase is the stage with largest losses, between 40-50% of total cereal food waste.

In low-income regions rice is the dominant crop, especially in the highly populated region of South and Southeast Asia. For these regions, agricultural production and postharvest handling and storage are stages in the FSC with relatively high food losses, as opposed to the distribution and consumption levels.

Graph 1.2 Part of initial production lost or wasted



Source: Global food losses and food waste, save food at interpark2011, FAO

Maize storage plays a role food supply series besides post-harvest pipeline; it plays a great role in food security stability as far as seasonality is concerned. In most cases, soon after harvest; grains are subjected to storage for either short or long period as food reserves and/ or seeds. Surprisingly, maximum losses amounting to approximately 40% to total loss may happen during this operation (Aulakh and Regmi, 2013; Majumder et al., 2016).

A study conducted by Tefera and Abass, (2012) and Costa (2014) reported that, farmers are using traditional storage structures such as granary/ polypropylene bags which are exceedingly prone to pest invasion, leading to PHL of about 48–59% in maize grains after being exposed to storage for 90 days.

In SSA, normally farmers have a minimum of seven months maize store-time between two yield seasons. Alternatively, some farmers sell their crops just a little while after harvest amounting for 54 and 38% to cater for domestic and school fees consecutively, even though maize prices increased meaningfully in the period of 180 days of storage (Abass et al., 2014). A different study conducted in Kenya links unpleasant selling price with poor storage facilities in the combination of improper storage store administration skills resulting in immediate sales after harvest (De Groote et al., 2013).

There are several models, which are mainly specific for individual countries in the SSA, for instance, in Ethiopia, farmers store their cereals using bags in house, heaped in house, metallic silo, elevated storage platform, unprotected pile and other traditional methods (Hengsdijk and de Boer, 2017). In the same country, a common maize-based postharvest model used involves storing maize together with teff followed by a single time application of pesticides, which minimize storage cost, based on the fact that, insecticide is been recommended to be applied after every three month of storage. Such strategies appear to protect 76% of the stored grains losing only 24% mainly due to chemical residue and discoloration (Hengsdijk and de Boer, 2017).

In Rwanda 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 are 19.8% (CARANA, 2013).

Smallholder maize farmers get busy with their maize produces from the harvest time, during the post harvest till they sell their maize to the market; this process involves different crucial maize quality and quantity determinant steps: the harvesting, drying, shelling, shelling, winnowing, sorting, aggregation and transport, storage and speculation, marketing, and processing, these steps require technologies, skills and financial capacities at the level of smallholder maize farmer,

any default and non compliance to standards into the process result into deterioration of the maize quality at the end.

There is a funnel channel of maize produces tracing from the smallholder maize farmer level to Cooperative or market place, this is explained by the portion of maize that is not traceable at farm agate level either due the amount of the produce consumed at households’ levels or the portion of maize produce that is lost in the process of post harvest handling before reaching the cooperatives or market places. There is a need to develop strategies that would change the smallholder maize farmers’ practices and invert or redress the model by cutting down the amount of maize produce that is lost before reaching the market.

2.3. Maize losses due to poor primary post harvest practices

In Sub-Saharan Africa (SSA), about 1.2 billion people depend highly on maize as major cereal crop and staple food, thus occupies about one third of total land cultivated (Blackie, 1990). This justifies the importance of crop and farmers “commitment toward its production as well. Maize accounts for over 30% of the small-holder farmer earnings which adds-up to 60% of dietetic supplement in which protein accounts for 50% (Suleiman and Rosentrater, 2015; Amani, 2004). However, despite this contribution, there is significant post-harvest loss ranging from 12-46% of the harvested maize all along its production chain that is harvesting (4-8%), transportation (2-4%), drying (1-2%), threshing and winnowing (1-3%), storage (2-25%) and marketing (2-4%) (Matthews, 2006; Hodges and Bernard, 2014). Inefficiencies along any of the production chain will result in maize post-harvest loss whereby among other aspects storage loss has a role. Such post-harvest losses call for urgent actions including designing post-harvest resilient strategies to be used by maize growers in Sub Saharan Africa. In this review, we provide comprehensive information on aspects underwriting grain losses and propose a farmers’ friendly resilient strategy for minimizing post-harvest loss of maize grains in the Sub Saharan Africa.

Availability and affordability of the technologies used in the maize postharvest processes play a big role in the end results of the processes, however, the level of each and every economies will as well determine the level of technologies that are available and affordable in each countries; developed countries with enough resources obviously will invest enough resources in Research for Development (R&D) for the technologies to reduce postharvest losses, while in developing countries where the agriculture sector receives a very little portion of the budget, the research for development will always succumb to not being a priority for Governments investments, therefore the two different worlds; developed versus developing countries will perceive and react differently towards reducing postharvest losses.

In industrialized countries food gets lost when production exceeds demand, in order to ensure delivery of agreed quantities while anticipating unpredictable bad weather or pest attacks, farmers sometimes make production plans on the safe side, and end-up producing larger quantities than needed, even if conditions are “average”. In the case of having produced more than required, some surplus crops are sold to processors or as animal feed. However, this is often not financially profitable considering lower prices in these sectors compared to those from retailers.

In developing countries and, sometimes, developed countries, food may be lost due to premature harvesting. Poor farmers sometimes harvest crops too early due to food deficiency or the desperate need for cash during the second half of the agricultural season. In this way, the food incurs a loss in nutritional and economic value, and may get wasted if it is not suitable for consumption. High “appearance quality standards” from supermarkets for fresh products lead to food waste. Some produce is rejected by supermarkets at the farm gate due to rigorous quality standards concerning weight, size, shape and appearance of crops. Therefore, large portions of crops never leave the farms. Even though some rejected crops are used as animal feed, the quality standards might divert food originally aimed for human consumption to other uses (Stuart, 2009).

Unsafe food is not fit for human consumption and therefore is wasted. Failure to comply with minimum food safety standards can lead to food losses and, in extreme cases, impact on the food security status of a country. A range of factors can lead to food being unsafe, such as naturally occurring toxins in food itself, contaminated water, unsafe use of pesticides, and veterinary drug residues. Poor and unhygienic handling and storage conditions, and lack of adequate temperature control, can also cause unsafe food.

‘Disposing is cheaper than using or re-using’ attitude in industrialized countries leads to food waste. Industrialized food processing lines often carry out trimming to ensure the end product is in the right shape and size. Trimmings, in some cases, could be used for human consumption but are usually disposed of. Food is also lost during processing because of spoilage down the production line. Errors during processing lead to final products with the wrong weight, shape or appearance, or damaged packaging, without affecting the safety, taste or nutritional value of the food. In a standardized production line these products often end up being discarded (Stuart, 2009; SEPA, 2008).

Lack of processing facilities causes high food losses in developing countries. In many situations the food processing industry doesn’t have the capacity to process and preserve fresh farm produce to be able to meet the demand. Part of the problem stems from the seasonality of production and the cost of investing in processing facilities that will not be used year-round. Large quantities on display and a wide range of products/ brands in supply lead to food waste in industrialized

countries. Retail stores need to order a variety of food types and brands from the same manufacturer to get beneficial prices. Consumers also expect a wide range of products to be available in stores. A wide range of products does, however, increase the likelihood of some of them reaching their “sell-by” date before being sold, and thereby wasted. When shopping, consumers expect store shelves to be well filled. Although certainly beneficial for sales statistics, continually replenished supplies mean that food products close to expiry are often ignored by consumers. This is particularly difficult for small retail stores (SEPA, 2008).

Abundance and consumer attitudes lead to high food waste in industrialized countries. Perhaps one of the most important reasons for food waste at the consumption level in rich countries is that people simply can afford to waste food. The amount of available food per person in retail stores and restaurants has increased during the last decades in both the USA and the EU. A lot of restaurants serve buffets at fixed prices, which encourages people to fill their plates with more food than they can actually eat. Retail stores offer large packages and “getting one for free” bargains. Likewise, food manufacturers produce oversized ready to eat meals (Stuart, 2009).

Research and experience has shown over and over again that if we want the “best quality” we must harvest and handle product in very specific ways. However, in the commercial world we are often confronted with the expense of doing it exactly right versus the compromise of what will get us by. The real world question becomes, what is it worth? (Rich MacLeod, 1999).

All value chains right from the farm gate don’t consider the magnitude of and mere losses of the food, while handling and processing it for the market. This creates that kind of ignorance amongst all stakeholders to the value chains and at the end the consolidated losses along the chains make huge and important loss of the food compared to upstream produces, of course quality and quantity downstream the chains will be affected. Food losses represent a waste of resources used in production such as land, water, energy and inputs. Producing food that will not be consumed leads to unnecessary Carbon Dioxide emissions in addition to loss of economic value of the food produced.

Economically avoidable food losses have a direct and negative impact on the income of both farmers and consumers. Given that many smallholders live on the margins of food insecurity, a reduction in food losses could have an immediate and significant impact on their livelihoods. For poor consumers (food insecure or at-risk households), the priority is clearly to have access to food products that are nutritious, safe and affordable. It is important to note that food insecurity is often more a question of access (purchasing power and prices of food) than a supply problem. Improving the efficiency of the food supply chain could help to bring down the cost of food to the consumer and thus

increase access. Given the magnitude of food losses, making profitable investments in reducing losses could be one way of reducing the cost of food. But that would, of course, require that financial gains from reduced losses are not outweighed by their costs (FAO, 2011).

Losses may occur for two main reasons; during harvesting, handling, processing and transport grain may be scattered, dispersed or crushed. Alternatively, the grain may be subject to bio deterioration. Postharvest losses due to bio deterioration may start as the crop reaches physiological maturity, i.e. when grain moisture contents reach 20-30% and the crop is close to harvest. It is at this stage, while the crop is still standing in the field, that storage pests may make their first attack and when unseasonal rains can dampen the crop resulting in some mould growth. A key issue is the weather conditions at the time of harvest. All small-scale African farmers rely on sun drying to ensure that their crop is sufficiently dry for storage. If weather conditions are too cloudy, humid or even wet then the crop will not be dried sufficiently and losses will be high. Climate at the time a crop should be drying is key to understanding the potential losses of durable crops. However, successful drying alone is not a remedy against all postharvest

losses since insects, rodents and birds may attack well dried grain in the field before harvest and/or invade drying cribs or stores after harvest (Dr R.J. Hodges, Postharvest weight loss estimates).

III. RESEARCH METHODOLOGY

The research used a cross-sectional survey that targeted smallholder maize farmers; ordinary smallholder maize farmers, farmer leaders, local authorities and agronomists at sectors were interviewed by the researcher through questionnaires and interview guide for collecting data and information in regard with maize farming in Bugesera District. The simple random sampling technique was used in identifying respondents. The study involved a descriptive and analytical research design.

The study was carried out in 3 Sectors of Bugesera District; Mareba, Musenyi and Shyara Sectors in which 342 respondents/individual farmers were interviewed representing a total of the 3,114 smallholder maize farmers registered in the three sectors. The questionnaires both open and closed ended were used to collect qualitative and quantitative data.



Figure 1. Map of the research zones

The researcher helped by three research assistants met and interviewed respondents from different places in the three sectors (Mareba, Musenyi and Shyara), mainly the framers were met at the business centers near their villages where they gather frequently in their routines when they come from the field. Research assistants also used farmers small groups (Amatsinda) to reach out to respondents, places like maize collection centers were also important meeting points with a good number of farmers, lastly in some cases we met the farmers at their homes most of time in the evenings.

The study used a simple random sampling and purposive/judgmental sampling to select some of the study respondents. The criterion for choosing respondent farmers was that the respondent should be a maize farmer registered and acknowledged as a maize farmer at Sector level. Working with Agronomist at Sector and Maize Cooperatives level allowed the researcher to get a list of all members, the smallholder maize farmers in the 3 Sectors they are gathered in 126 small groups and each group is represented in the general assembly in their Cooperative, the small groups are

clustered into 8 sites/zones according to the cells where they belong. From the list we selected randomly the respondents. It turned out that the respondents were from all categories of farmers; simple farmers, lead farmers, small groups leaders and representatives of specialized committees and management committee. It consisted of a random sample of 342 respondents who were selected at the beginning of the survey: for the small groups we selected 2 people from each group (2 X 126 = 252 respondents), for the Zones we selected 10 people for each (10 X 8 = 80 respondents) and for the Management committee we took 3 people, Monitoring and Evaluation committee 2 people, Marketing committee 2 people, procurement committee 2 people and we got in total 342 respondents.

IV. RESULTS AND DISCUSSIONS

This section deals with the presentation, interpretation and analysis of the findings on the maize postharvest practices and how they contribute to increase income for smallholder farmer in Bugesera District. In this section, the results are presented according to the specific objectives of the study: the main objective of this study was to assess the impact of postharvest management practices on smallholder farmers' income in Bugesera District with focuses on three areas, i) Assess how the use of collective and structured marketing channels for maize produce can increase the income for smallholder

farmers', ii) Assess how improved storage and drying facilities can contribute to the increase of smallholder farmers' income and iii) Find out how improved primary maize handling practices (drying, shelling, winnowing and sorting) can contribute to the increase of small holders' income at market. Before the results on the specific objectives were presented, the background information of respondents is hereunder presented.

4.1. Bio-data of the respondents

The total number of smallholder maize farmers interviewed was 342 people; meaning 114 farmers in each of the three Sectors of the study (Mareba, Musenyi and Shyara). The selection of respondents was done randomly among the maize smallholder farmers; among the women respondents represent 33% while men represent 67%. Even though women are not well represented in the sample, in the total population they represent 44% of the whole smallholder maize farmers' population, while men are 56%. This is probably an indicator on how much females farmers are always busy allocating their time between home and farm work because the research assistants couldn't meet easily female maize farmers and they were told that female are most of the times busy, but also this can explain how much female are engaged in business at the centers where research assistants met most of the respondents.

Table 4.1 Family situations

Family Situation		
Marital Status	Number	%
Married	326	95.32
Single	9	2.63
Widows	7	2.05
Total	342	100.00
Family membership (X)	Number	%
Equal to 1	9	2.63
{2,3}	76	22.22
{4,6}	152	44.44
7 and plus	105	30.70
Total	342	100.00
Active members/Family (X)	Number	%
{1,2}	152	44.44
{3,4}	152	44.44
5 and plus	38	11.11
Total	342	100.00

Source: Author's field survey

The research has revealed that the majority (95%) of respondents smallholder farmers are married and they have between 4 and 6 people in their household (Table 4.1) and there is a high dependence level of family members because

more than 44% of the families members depend on the heads of households for their survival. This demonstrates how lives in smallholder maize farmers' households in Bugesera District economically depend on Maize generated income

Table 4.2 Sources of Incomes in Umucyo Cooperative

Source of Income			
Activity	Contribution in %	Responses	%
Agriculture	Between 50 and 75	152	44
	Between 75 and 100	190	55
	Between 10 and 25	228	66
Livestock	Between 25 and 50	114	33
	Between 50 and 75	0	0.00
	Between 75 and 100	0	0.00
Salaries (Wages)	Between 10 and 25	38	11
	Between 25 and 50	0	0.00
	Between 50 and 75	0	0.00
Business	Between 75 and 100	0	0.00
	Between 10 and 25	16	4

Source: Author's field survey

The research findings have revealed that the main activity that brings incomes to smallholder maize farmers' households in Bugesera District is the Maize farming: 55% of the farmers have confirmed that Maize farming contributes to more than 75% of their annual income, while 44% revealed that Maize farming contributes from 50 to 75% of their annual incomes

(Table 4.2). Also the majority of smallholder maize farmers (66%) confirmed that livestock (small ruminants, mainly goats) contributes to their incomes at only by 10 to 25%, the results from this research confirm that the maize is the main source of incomes for the maize smallholder farmers in Bugesera District.

Table 4.3 Land size and ownership

Size (X) in acres	Number	%
Less than or equal to 5	0	0.00
Between 5 and 10	266	77.78
Between 10 and 25	76	22.22
Between 25 and 50	0	0.00
Beyond 50	0	0.00
Total	342	100.00
Ownership	Number	%
Owned	82	23.98
Not owned	260	76.02
Total	342	100

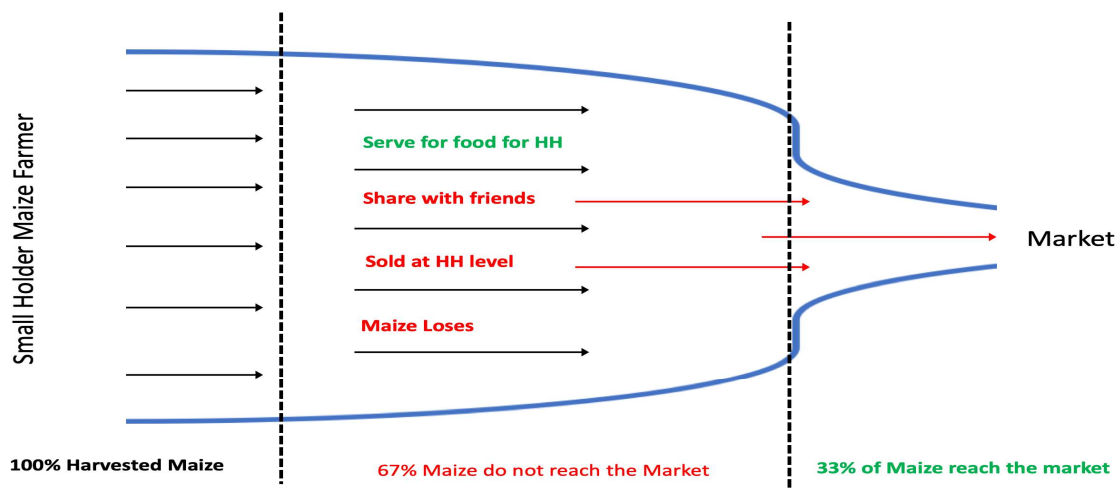
Source: Author's field survey

According to table 4.3 above, the research has revealed that the majority of the smallholder farmers (78%) cultivate the maize on fragmented lands; less or equal to 0.1 Ha, while the rest of farmers (22%) have the land with size is between 0.1 and 0.25 Ha. The research also confirmed that all the surveyed farmers fall in the category of smallholder farmers as per the World Bank's Rural Strategy that defines smallholders as those with a low asset base, operating less than 2 hectares of cropland (World Bank, 2003). Most of the farmlands in Rwanda consist of fragmented plots of land. The average surface area of farm holding in Rwanda is 0.76 Ha.

On an average, the farm holdings are spread over 4 different blocks of lands. Approximately 80% of farms have a surface area of less than 1 Ha each (MINAGRI, 2010).

4.2. Smallholder farmers marketing channels

The maize smallholder farmers in Bugesera District they use mainly two marketing channels for selling their produces; i) Individual smallholder maize farmer selling their maize to the market by themselves and ii) Smallholder maize farmers selling their maize produces together through the Cooperative.



Source: Author’s field survey

The above funnel channel of the maize use reveals the realities that explain easily the smallholder famers’ marketing behavior for their maize produces, the only real economic value for the maize production that can be counted is the 33 % of the maize that is sold through the cooperative (Table 4.5), this is the only portion of the produce that is registered and counted. Indirectly this can show much of the informal that is still in the maize marketing value chain at the smallholder maize famers’ level.

According to table below 4.5, the majority of maize produces 67% do not reach the formal market; this includes what is consumed as food at home, the maize that is processed and sold as maize flour in hiding because normally it should be channeled and be processed with recognized processing units, maize shared with friends and the maize losses due to poor postharvest handling practices, you can not easily attribute an economic value to this portion of maize produce (67%) as it vanishes at household level. This situation raises red flags for a continued mobilization, sensitization and

capacity building and mindset change for smallholder farmers to embrace the entrepreneurship and agribusiness, encourage and show them the benefits of working together and facing the markets together collectively which can increase their bargaining power.

4.3 Situation on availability of storage and drying facilities

According to results from this research, 100% of our respondents don’t have storage and drying facilities at the households’ level, for storage the majority 67% said that they use that production for feeding their family members (food), this explains that this 67% is the maize produce that is not counted in the books at Cooperative level. The findings confirms with the findings in AGRA report (2014); which says that the way the farmers manage maize along its value chain determines extent of post-harvest losses incurred. Farmers are involved in a number of activities, including de-husking, shelling, application of insecticides, packaging, storing and transportation and that about 90% of maize that farmers store is used for own consumption.

Table 4.5 Availability of Storage and Drying facilities

Storage	Respondents	%	End use of maize produces		
			A*	B*	C*
Have	0	0	114	0	228
Don't have	342	100	33.33	0.00	66.67
Total	342	100			
What do they do:					
Dryer	Respondents	%	Used facilities	Respondents	%
Have	0	0	Use Coop facilities	114	33.33
Don't have	342	100	Use Plastic sheets	228	66.67
Total	342	100	Total	342	100.00

Source: Author’s field survey

A*. Dried & Sold through the Cooperative;

B*. Sold at farm gate;

C*. Used for food;

The research has revealed also that all 100% don't have drying facilities at household level and they have two solutions; i) 67% opt to use commonly available materials "Plastic sheets" for drying their maize and ii) 33% option to take the produce to Cooperative level and use Cooperative's drying facilities. With these findings; the research help us to understand that with the lack of storage and drying facilities at household level; a big portion of the maize (67%) is either vanishes as fresh maize at farm gate level instead of being dried for commercial purposes. Also the research has revealed that farmers mostly use plastic sheets to dry their maize,

which may affect, if the farmers are not taught how to use them properly (Plastic sheets), hence the quality of maize will be compromised. At this level there is high rate of maize loss in terms of quantity and quality at household level.

4.5 Results on primary postharvest handling practices

In our research we looked at three primary postharvest handling practices; i) Drying, ii) Shelling or shelling, iii) Winnowing or sorting. The results have shown the following realities from the ground:

Table 4.6 Availability of primary postharvest materials

Materials	Respondents	%					
Threshing/Shelling							
Have	342	100					
Don't have	0	0					
Total	342	100					
Winnowing/Sorting	Respondents	%	Loss (X)	1%≥X	1%≤X≤5%	5%≤X≤10	15%≤X
Have	0	0	Respondents	33	258	35	16
Don't have	342	100	%	9.65	75.44	10.23	4.68
Total	342	100	Total	342			
Drying skills	Respondents	%					
Have	184	53.80					
Don't have	158	46.20					
Total	342	100					

Source: Author's field survey

Results from our research have revealed that 100% of small farmers in Bugesera District have shelling materials that they use for their maize; the results have revealed also that none (0%) of the farmers has appropriate winnowing/sorting materials for maize. The survey has revealed as well that the 75% of smallholder farmers confirmed that due to lack of the winnowing/sorting materials they lose between 1% and 5% of the produce, 10% of the farmers said that the loss is between 5% and 10% while 5% of the farmers said that they lose beyond 15% of the produce. Close to the half of all smallholder farmers (46%) have claimed not to have appropriate skills and knowhow techniques on how to dry the maize (Table 4.6) which confirms with the USAID report on Maize post harvest practices (2013) which revealed that 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%).

V. DISCUSSION OF SMALL FARMERS POST HARVEST PRACTICES

This section highlights our analysis on the results presented and interpreted in the previous section in regards with the research objectives that aimed to assess the impact of postharvest management practices on smallholder farmers' income in Bugesera District with focuses on three areas, i) Assess how the use of collective and structured marketing

channels for maize produce can increase the income for smallholder farmers', ii) Assess how improved storage and drying facilities can contribute to the increase of smallholder farmers' income and iii) Find out how improved primary maize handling practices (drying, shelling, winnowing and sorting) can contribute to the increase of small holders' income at market.

5.1 Impact of marketing practices on smallholder farmers' incomes

The research has revealed that a small portion (33%) of the maize produced by smallholder farmers is sold collectively through the Cooperative, the rest of the maize produces (67%) includes the maize that is eaten at home, processed and sold as maize flour by farmers themselves, maize shared with friends or maize losses due to poor postharvest handling practices. According to our research, there is difference between the prices that farmers can get when they sell their maize out of the Cooperative and what they get when they sell through the Cooperative; through the Cooperatives farmers negotiate good prices and get paid as per contractual terms with the buyers. This was confirmed that it is very known that farmer organizations can assume a large scope of activities and functions in the commodity chain, such as collection, grading, post-harvest and storage (Bosc, Eychenne et al. 2003; Perret and Mercoiret 2003; Stockbridge 2003; ESFIM 2007b;

Meinzen-Dick, Markelova et al. 2009) and that belonging to a farmers group is a social capital aspect that increases farmers bargaining power (Jagwe, 2011).

Through the research, some smallholder maize farmers have confirmed to be aware that belonging to the Cooperative and selling their maize produces through the cooperatives can help them to get better prices as the negotiations are done collectively at the market and they have the same voice and can easily attract big dealers like WFP as it happened in 2009, the income for the smallholder farmers increases when they sell their maize produces through structured market channels.



Picture I & II: Household based storages photos internet

Household based granary is possible and can take any form according to the design and available materials like the examples here above given; cheap materials can be used as well as sustainable and long lasting materials. Also to strengthen the system (Storage and drying), at the level of Cooperative, bigger facilities like warehouses and modern dryers can be used in order to improve the quality of maize from the households.

5.3 Impact of primary postharvest handling skills

The primary postharvest practices, shelling, drying, winnowing and sorting are the quality determinant stages for maize; reducing impurities and meeting the moisture content required at the market 13%. According to the research, 100% of our respondents don't have adequate materials for these functions and they use traditional ways to accomplish these functions whereby high losses of maize is originated hence the quality and quantity of the maize is compromised, and the related income decreases accordingly.

According to the research findings, very few smallholder maize farmer interviewed have demonstrated to have the foundation knowledge on how to calculate the cost of production and could explain the way market prices are fixed, they seemed to agree that maize postharvest losses vary from 20-30% among the maize farmers in Bugesera District, they have cited among other causes, the lack of storage and drying facilities as the major causes of the maize losses. Also the

5.2 Impact of storage and drying practices

The research has revealed that the storage and drying system is totally absent at household level, 100% of our respondents said that they don't have at all storage and drying facilities, also they have confirmed that there is high maize loss attributed to the lack of the facilities at household level and it influences the decisions of smallholder maize farmers on how they allocate their maize produces.

smallholder maize farmers have cited that there are other causes of maize losses including; losses during transport, losses during shelling, losses during milling, and losses of maize flour due to insect infestation, rotting, and leakages in packaging.

Drying is the most critical, both technically and economically, for cereals and legumes crops. Achieving a proper moisture level can stabilize the grain for further handling and storage, and can improve the milling quality. Field drying is the most economical, allowing the crop to naturally reduce moisture content upon maturation and prior to harvest. Rwanda is limited in this regard due to harvests during the rainy season. Use of the sun and air remain the most economical, particularly for very high moisture grain, which make technologies such as drying sheds and concrete drying grounds a natural next choice for producer and first aggregator level investment, although the grain remains exposed to pests, weather, and thieves (GoR, 2012).

The research has revealed low possession of the basic materials for primary postharvest handling among the smallholder maize farmers in Bugesera District, through research for development some usual and traditional materials like "Urutaru, Inkoko" and others can be modernized, improved and play a great role for the maize postharvest handling, or through the innovation encourage the Ministry to

invent new appropriate materials for that use which can cater maize postharvest handling at industrial scale.

The respondents in our research revealed that due to lack of drying facilities they use plastic sheets as alternative option to

dry their maize production, this system can be improved so that at household level smallholder maize farmers can have what to use for drying their maize and avoid impurities to mix and infect the maize.

Drying Maize using plastic sheets Shelling using tin Sheller



Source: Photos by author's field survey

Apart from the challenges motioned at individual smallholder maize farmers in regards to lack of postharvest handling facilities; for maize drying and storage, there are a number of initiatives that are initiated at Umucyo Cooperative where they have maize shellers and storages and plastic sheets for maize sorting and drying. At smallholder maize farmers level, there is no specific post-harvest technology that is employed in the maize value chain almost all first-level post-harvest activities are done by hand and manually. This does not only slow the speed of operations, but also negatively impacts the **quality** and **quantity** of maize taken to the market. The Ministry of Agriculture and other stakeholders such as the agricultural training college, research institutions should undertake initiatives to design and produce appropriate-technology for maize post-harvest handling materials.

Loss in value arising from inadequate and inappropriate drying facilities, the maize cobs/grain when dried in open air and subject to wetting when it rains due to lack of shelter; cool temperatures in high altitude zones make it impossible to bring moisture level down to 13% without facilitated drying. Also losses arise from contamination of maize with soil, insects and other impurities during drying, especially when grain is simply spread on tarpaulins on the bare ground, or old, dirty concrete slabs.

VI. CONCLUSION

Despite the Government of Rwanda's efforts in organizing maize farmers and providing inputs to smallholder maize growers; there are still gaps in maize production management at households' level that lead to the high maize losses linked with poor postharvest handling practices (Storing, drying, shelling/shelling and winnowing/sorting) and to the behaviour

that lead to the allocation of the 67% of the maize as the portion pretended to be consumed at household level and which is not economically valued at all. Much effort has been registered to increase and avail agricultural inputs (Seeds and fertilizers) and the impact has been remarkable in terms of the increased maize productivity per cultivated unit of the land and the production in general. Much more other effort has been observed in modernizing the processing value chains; industrial storages and modern maize processing factories, however, there is still needs to educate smallholder maize farmers with aim to increase their entrepreneurial appetite and equip them with the necessary technologies and postharvest handling techniques to minimize the huge maize losses still observed at farm gate level.

The research findings revealed that for the majority (99%) of the farmers, the household income from maize production contributes to more than 50% of their annual income: 55% said that income from Maize contributes to more than 75% of their annual income while 44% said that it contributes from 50 to 75% of their annual incomes, making the maize to be their main source of incomes at households' level. The research has revealed that the majority, 67% of the farmers sell their maize produces collectively through the Cooperative while 33% they do not, majority of farmers 100% don't have storage and drying facilities at household level: farmers have two options: i) 67% farmers they use "Plastic sheets" for drying the maize and ii) Only 33% of maize produces from small farmers is dried using Cooperative's drying facilities, this explains the reason of the high maize losses and deterioration of the quality at household level and it explains why a small portion of the maize produce could be sold collectively from known channels like cooperative, reason for the persisted low income

from the maize at household level despite of the huge investments already made in the last decade.

Through the research in this Cooperative we have identified two major challenges: (1) Lack of storage and drying facilities at the levels of smallholder farmers/household and at the level Cooperative, (2) Insufficiency of the basic knowledge/skills for maize postharvest handling techniques. We therefore recommend the following strategies with the objectives to increase smallholder farmers' income by addressing the identified challenges and capitalising on existing potentials at smallholder farmer and cooperative's levels.

VII. RECOMMENDATIONS

- Keep on improving the crop productivity so as to get the maximum production out of the available land as most of the smallholder farmers cultivate on small pieces of the land. This shall be achieved mainly through the adoption and use of improved high yielding maize seeds, fertilisers and pesticides;
- Keep on maximizing the cultivated land for maize production in Bugesera, mainly by reclaiming/developing more land in Akanyaru Marshland and the hillsides.
- Keep on strengthening Cooperative structures, sensitizing smallholder farmers on the benefits of belonging to cooperatives and selling their produce together as a Cooperative as it increase their bargaining power at the market for better prices;
- Avail and increase; Storage, Drying facilities and technologies at both Households/small farmers' and Cooperative levels;
- Increase the maize post harvest handling skills and knowledge at smallholder farmers' level by providing appropriate training to farmers and availing primary postharvest materials for shelling, winnowing drying and sorting;
- Strengthen structures and management of Maize Cooperative and increase the capacity of their members aiming at reducing their post-harvest losses, increase yields and maize quality.
- Continue educating and increasing entrepreneurial skills for the maize smallholder farmers with the aim to change their behavior towards professional, market oriented and agribusiness based maize farming.

REFERENCES

- [1] African Union Commission, Post-harvest loss management strategy, August 2018.
- [2] AGRA, Establishing the status of post-harvest losses and storage for major staple crops in eleven African Countries (phase II), March 2014.
- [3] Nahayo et al, factors influencing farmers' participation in crop intensification program in Rwanda, September 2016.

- [4] Ary, D. & Jacobs, L. C., & Razavieh, A. (1996), *Introduction to research in education*. Florida: Harcourt Brace College Publishers.
- [5] Bahta, S. T. and Bauer, S. (2007). Analysis of the Determinant of Market Participation within the South African Small-Scale Livestock Sector. Tropentag Papers, Witzhausen.
- [6] Bardhan, D., Sharma, M. L. and Saxena, R. (2012). Market Participation Behaviour of Smallholder Dairy Farmers in Uttarakhand: A Disaggregated Analysis. *Agricultural Economics Research Review*, 25 (2): 243-254.
- [7] Bardhan, D., Sharma, M. L. and Saxena, R. (2012). Market Participation Behaviour of Smallholder Dairy Farmers in Uttarakhand: A Disaggregated Analysis. *Agricultural Economics Research Review*, 25 (2): 243-254.
- [8] Bijman, J., G. Ton, et al. (2007). Empowering Smallholder Farmers In Markets: National and international policy contexts. ESFIM Working Paper n°1. Paris/Wageningen, IFAP/AGRINATURA.
- [9] Boadu, V. A., Ross, K. and Tembo, G. (2013). Factors Influencing Smallholder Bean and Cowpea Producers' Market Participation in Zambia. Selected poster prepared for presentation at the Agricultural and Applied Economics Association's 2013 AAEA and CAES Joint Annual Meeting, Washington, DC, August 4-6, 2013.
- [10] Bosc, P., D. Eychenne, et al. (2003). The role of rural producer organizations in the World Bank rural strategy. Rural Development Strategy, Background Paper n°8. Washington, The World Bank.
- [11] CARANA, USAID, Maize Post-Harvest Practices, Loss estimates and training needs, season A and B, 2012
- [12] Carmines, G.C., & Richard A. Z. (1977). *Reliability and validity assessment*. Sage publications
- [13] Cochran, W. G. (1977). *Sampling Technique*, 3rd edition. New York: John Wiley and sons.
- [14] Davis, J. A., Valandia, M., Lambert, D. M., Clark, C. D., Wilcox, M. D., Wiszelaki, A. and Kimberly, J. (2013). Factors Influencing Producer Participation in State-Sponsored Marketing Programs by Fruit and Vegetable Growers in Tennessee. The Department of Agricultural and Resource Economics, 314C Morgan Hall, 2621 Morgan Circle, The University of Tennessee, Knoxville, TN 37996.
- [15] Dixon, J. & Taniguchi K., & Wattenbach, H. Ed (2003). *Approaches to assessing the impact of globalization on African smallholders: Household and village economy modeling*. Proceedings of a working session on Globalization and the African Smallholder Study.
- [16] FAO, Guidelines on the measurement of harvest and post-harvest losses, April 2018.
- [17] FAO. (2011). *Global food losses and food waste, save food at interpark*.
- [18] Government of Rwanda, MINAGRI, "Strategic Plan for Agricultural Transformation 2018-2024, November 2017.
- [19] Grinnell, R.M., & William, M., (1990). *Social Service Research*, F.E. Peacock Publishers (Itasca, Ill.)
- [20] Hengsdijk H, de Boer WJ (2017). Post-harvest management and post-harvest losses of cereals in Ethiopia. *Food Security* 9(5):945-958. <https://doi.org/10.1007/s12571-017-0714-y>.
- [21] Hodges, R.J. (2010). *Postharvest weight loss estimates for cereal supply calculations in East and Southern Africa*.
- [22] IDEA Consult International (2011), Cooperatives Diagnosis and SWOT analysis, MINAGRI/RSSP. Kigali.
- [23] IFAD (2013). Climate Resilient Post-Harvest and Agribusiness Support Project (PASP) including blended Adaptation for Smallholder Agriculture Programme Grant (ASAP). Kigali: UN International Fund for Agricultural Development.
- [24] IIRR. (2008). Trading Up, building cooperation between farmers and traders in Africa.
- [25] Jagwe, J. N. (2011). Impact of transaction costs on the participation of smallholder farmers and intermediaries in the banana markets of Burundi, Democratic Republic of Congo and Rwanda. A PhD Thesis (Agricultural Economics) submitted to the

- University of Pretoria.
- [26] Jagwe, J., Macheche, C. and Ouma, E. (2010). Transaction Cost and Smallholder Farmer's Participation in Banana Markets in the Great Lakes Region of Burundi, Rwanda and the Democratic Republic of Congo. *AFJARE*, 6 (1): 302-317.
- [27] Kader, A. A. (2005). *Increasing food availability by reducing postharvest losses of fresh produce*. Proc. 5th Int. Postharvest Symp. Acta Hort. 682, ISHS 2005.
- [28] Kerlinger, F.N. (2010). *Foundations of Behavioral Research*, Quarterly Adult Education
- [29] Lupin, B. and Rodriguez, E. M. (2012). Quality Attributes and Socio-demographic Factors Affecting Outlet Choices when Buying Fresh Potatoes in Argentina. Selected Paper Prepared for Presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference Foz do Iguacu, Brazil, 18th-24th August, 2012.
- [30] Maleske, R. T. (1995). *Foundations for gathering and interpreting behavioral data*. Pacific Grove, CA: Brooks/Cole Publishing Company.
- [31] MINAGRI, National Post-Harvest Staple Crop Strategy, Oct 2011
- [32] MINAGRI. (2010). *Agricultural Mechanization Strategy for Rwanda*. Kigali
- [33] Ministry of Agriculture and Animal Resources. (2004). *National Agriculture Policy*. Kigali.
- [34] Moustier, Phan, et al. (2010). "The role of Farmer Organisations Supplying Supermarkets with Quality Food in Vietnam." *Food Policy* 35(69-78).
- [35] Mugenda, O. & Mugenda, A. (2003). *Research Methods*, Nairobi: ACTS.
- [36] Mutai, B. K. (2000). *How to write a Quality Research Proposal: A Complete and Simplified Recipe*, New York: Telley Publications.
- [37] Nachimias, C. & Nachimias, D. (1976). *Research Methods in Social Sciences*. New York: St. Martins, Press Inc.
- [38] Ndro, J. T., Hitayezu, P., Mudhaura, M. and Chimoyo, M. (2013). Livelihood factors influencing market participation and supply volumes decisions among smallholder cattle farmers in the Okhahlamba Local Municipality, South Africa: Implications for agricultural extension programming. Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013, Hammamet, Tunisia .
- [39] NISR, Comprehensive Food Security and Vulnerability Assessment (CFSVA), (2015)
- [40] NISR, Rwanda Demographic and Health Survey (2014/2015)
- [41] Omiti, J., Otieno, D., Nyanamba, T. and Cullough, E. M. (2009). Factors Influencing the Intensity of Market Participation by Smallholder Farmers: A Case Study of Rural and Peri-Urban Areas of Kenya. *AFJARE* , 3 (1): 57-83.
- [42] Omiti, J., Otieno, D., Nyanamba, T. and Cullough, E. M. (2009). Factors Influencing the Intensity of Market Participation by Smallholder Farmers: A Case Study of Rural and Peri-Urban Areas of Kenya. *AFJARE* , 3 (1): 57-83.
- [43] Ondieki, F. N., Njoroge, L. M., Okello, J. J. and Bahemuka, J. M. (2013). Determinants of participation in identified institutional arrangements in Kenya's export French bean sector. Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013, Hammamet, Tunisia.
- [44] Rodney, S.(1998).*Contemporary Research Methods*. 2nd Edition, Bellevue, Micro-case Corporation.
- [45] Rutto, J. K., Odhiambo, M. O., Njuguna, E. M. and Murithi, F. M. (2013). Determinants of Market Participation Decision in Small Ruminants' Market by Livestock Keepers in Isiolo and Marsabit Districts, Kenya. African Farm Management Association (the 8th AFMA Congress) (pp. 273-282). Moi University, Eldoret Kenya: Moi University Press.
- [46] Sekaran, U. (2009). *Research Methods for Business: A Skill Building Approach*. India: 4th Edition, Wiley India (P.) Ltd.
- [47] Shiimi, T., Taljaard, P. R. and Jordan, H. (2010). Transaction Costs and Cattle Farmers' Choice of Marketing Outlets in North-Central Namibia. Contributed Paper Presented at the Joint 3rd African Association of Agricultural Economists (AAAE) and 48th Agricultural Economists Association of South Africa (AEASA) Conference, Cape Town, South Africa, September 19-23, 2010.
- [48] Stuart, T. (2009). *Waste – uncovering the global food scandal*. London: Penguin Books, ISBN: 978-0-141-03634-2
- [49] Umberger, W. J., Stringer, R. and Mueller, S. C. (2010). Using Best-Worst Scaling to Determine Market Outlet Choice by Small Farmers in Indonesia. Selected Paper Prepared for Presentation at the Agricultural and Applied Economists Association 2010 AAEE, CAES and WAEA Joint Annual Meeting, Denver, Colorado, July 23-27, 2010.
- [50] World Bank. (2003). *Reaching the rural poor: A renewed strategy for rural development*. Washington, D.C