Implication Analysis of Pre and Post-Harvest Losses of Maize to Household Food Security in Kongwa and Kondoa Districts-Tanzania

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ABSTRACT

The contribution of food losses occurring in the food system to reduced household food security is undoubted. This study therefore investigated the status of the pre- and post-harvest losses in maize and their implication on household food availability, utilization and access in Kongwa and Kondoa districts. The study sites were selected because of their potential in maize production and losses. A mixed method approach was used to collect data for the study including secondary and primary data. Secondary data collection was achieved through literature review of published papers, reports, proceeding, policy documents and strategies relevant to agriculture. Primary data collection was achieved through discussion with key informants (14 people), focus group discussion (6 groups from each village comprising of 4 males and 4 females). A total of 376 (5.9%) households were surveyed and Transect Walk was also done to verify information obtained. Qualitative data was analyzed thematically using NVIVO software whereas quantitative data was descriptively analyzed using Statistical Package for Social Sciences (SPSS) software. The cumulative pre and post-harvest losses estimates were compared against provided pre and post-harvest losses threshold values. The comparison between pre and post-harvest losses was confirmed by two ways ANOVA analysis using Levene test. Findings showed that status of maize pre and post-harvest losses are below the thresholds of 31.2% and 40% whereby maize post-harvest losses are significantly ($p = 0.015$) higher than pre harvest losses. Pre harvest losses in maize were also significantly ($p < 0.011$) associated with reduced food availability while post-harvest losses are significantly ($p < 0.000$) associated with reduced food utilization. The study recommends increased awareness among farmers on the implication of food losses to household food security through trainings and seminars from agriculture extension officers.

Keywords: *Pre- and post-harvest losses, household food security*

INTRODUCTION

Food systems comprises of pre harvest system and a post-harvest system. A pre-harvest system is defined as a system that is concerned with food production while post-harvest system refers to a series of interconnected activities from the time of harvest through crop processing, marketing and food preparation to the final decision by the consumer whether to eat or discard the food (de Lucia and Assenato, 1994) and thus play an important role in providing stability in the food supply chain.The outcome of sustainable food system is food security (Ingram, 2011), while the lack of sustainability of the food system led to food insecurity condition (FAO et al., 2017).Food system can operate in a linear sequence or cyclic and is influenced by many factors including social, political, cultural, technological, economic and natural environment (HLPE, 2014; UNEP, 2016). Occurrence of food losses within the pre and post-harvest system impairs the sustainability of food system. The management of pre and post-harvest systems has grown more complex (Mrema and Rolle, 2002). This is because of increased dynamics of the food systems, limited knowledge of food loss estimates and consideration that losses are often economical rather than physical and yet the economic value of food losses are unknown (Sheahan and Christopher, 2017).

Attempts to estimate the magnitude of the value of losses before time and resources are spent on trying to reduce them are of paramount importance. Despite efforts made over the years to develop acceptable techniques for measuring food losses in grain, it has remained an imperfect science (Greeley, 1982). This is because the food system lacks uniform sequence from producer to consumer (Stevenson and Pirog, 2008). Hence given the lack of a consistent chain, care must be taken to avoid generalizing from particular measurements. Moreover, there are two basic approaches currently adopted to estimate losses either to actually measure what has been lost or use questionnaire to collect subjective loss estimates from those who experience the losses. (Hodges *et al*., 2010). In Africa, the African Post -Harvest Losses Information System (APHLIS) established in 2009 attempts also to address the lost estimates problem by providing cumulative weight losses in specific cereal crops, climate and scale of farming using algorithm of many sub-Saharan African countries. The data used by APHLIS are the averages of

all the data available in the scientific literatures for that particular crop. However, Tyler (1982) warns that it is important to not only rely on the provided estimates as they keep changing in real environment with time. Hence new food loss status and comparison are needed since situation is dynamic.

Estimates of food losses varies greatly among countries, commodities, production areas and seasons (Kader, 2017). Although pre harvest losses estimations are difficult, global estimates of pre harvest losses on different crops according to Oerke (2007) indicates that losses occurring in rice, maize, wheat and soybeans are 37.4%, 31.2%, 28.2% and 26.3% respectively while 1.3 billion tons of food lost are wasted annually due to post harvest losses (FAO, 2011). Total quantitative food loss in sub-Saharan Africa has been estimated at 100 million metric tons per year. It is further estimated that in sub-Saharan Africa 50% of fruits and vegetables, 40% of roots and tubers and 20% of cereals are loss before reaching the market (Daminger*et al*., 2016). On the other hand, a total quantitative food loss in sub-Saharan Africa has been estimated at 100 million metric tons per year. These estimates provide a global perspective of food losses regardless of the causal factor.

In Tanzania, it is estimated that post-harvest losses in cereal crops are high and may range from 30-40% annually. Since the post-harvest system comprises of different stages hence the losses occurring at each stage also differ significantly. According to ICIPE (2013), 1 - 4.5% losses occur during harvesting while 2.8 -17% occur during storage in the maize post-harvest system. Moreover, Abass*et al*. (2013) further added that in semi–arid areas important quantitative losses in maize post-harvest system occur in the field is by 15%, during processing by 13 -20% and during storage by 15 -25%. The annual average losses of cereals crop in Tanzania during and between the years 2014 to 2018 were reported to be 775,768 tons in maize, 115,818 tons in rice, 62,246 tons in sorghum, 193,223 tons in wheat, 138,302 tons in cassava, 135,158 tons in banana and 105,936 tons in pulses (FEWS NET, 2014). In the semi-arid areas, it has been estimated that losses occurring in maize, sunflower and pigeon peas are 32%, 16% and 12% (Abass*et al*., 2013). It has been reported thatmonetary loss in cereal grains due to post-harvest losses in Tanzania is approximately to US$265,000 out of the US$1.7 million used to produce maize annually (FAO *et al*., 2017).

The contribution of food losses to foodinsecurity is undoubted; however, studies have not yet provided the actual implication of the current status of the pre- and post-harvest losses to the prevailing rural household food insecurity. Although Oerke (2007) hinted global estimates of maize pre harvest losses to be 31.2%, there is no current status of the maize pre harvest losses at the household level in semi-arid of Tanzania. Conversely, studies on food losses have only indicated that maize losses in the semi-arid occur by 40% (Suleiman and Rosentrater, 2015; Abass *et al*., 2013). It is not clear on how the food losses affect household food security. Since the food security pillars operates in a hierarchy nature as indicated by Webb and Rogers (2003) then lack of food availability not only affects utilization but also limits access and stability in the long run. It is on this ground that this study specifically seeks to establish the current status of food losses occurring in the pre and post-harvest system and then assess their actual implication on rural household food security. This is important for effective food loss reduction interventions within the pre and post-harvest system for improved rural household food security.

METHODOLOGY

Location and characteristic features of the study area

This study was conducted in Kongwa and Kondoa districts in Dodoma Region (Figure 1). Dodoma Region is the capital city and centrally positioned in Tanzania mainland, lying between latitude 4º and 7º south and longitude 35º-37º east. A total of six sample villages were selected that is Bumbuta, Bukulu and Salanka in Kondoa District, while Mb'ande, Njoge and Pandambili were selected in Kongwa District respectively. Selection of the study area was based on the presence of maize crop growers and proven experiences of food losses across the pre and post-harvest system. A total of 45,098 and 81,069 households grow maize in Kongwa and Kondoa districts respectively (URT, 2003). The population of Dodoma Region is ranked 8th of the 21 regions in Tanzania while total population in Kondoa and Kongwa districts are 269,704 and 309,973 people respectively (URT, 2013). Dodoma region has a local steppe climate which is semi-arid due to low and erratic rainfall which falls seasonally between November/December to April/May (MAFSC, 2006). The region receives an annual average rainfall between 500mm to 800mm with high geographical, seasonal and annual variation, but some parts in Mpwapwa and Kondoa districts experience higher rainfall amount (URT, 2003). The region is comprised of three agro-ecological zones namely;

maasai steppe, rainy and maize zone (URT, 2019). Its major economic activities and source of incomes are earned from selling food crops, cash crops and livestock with relatively sale of forest products.

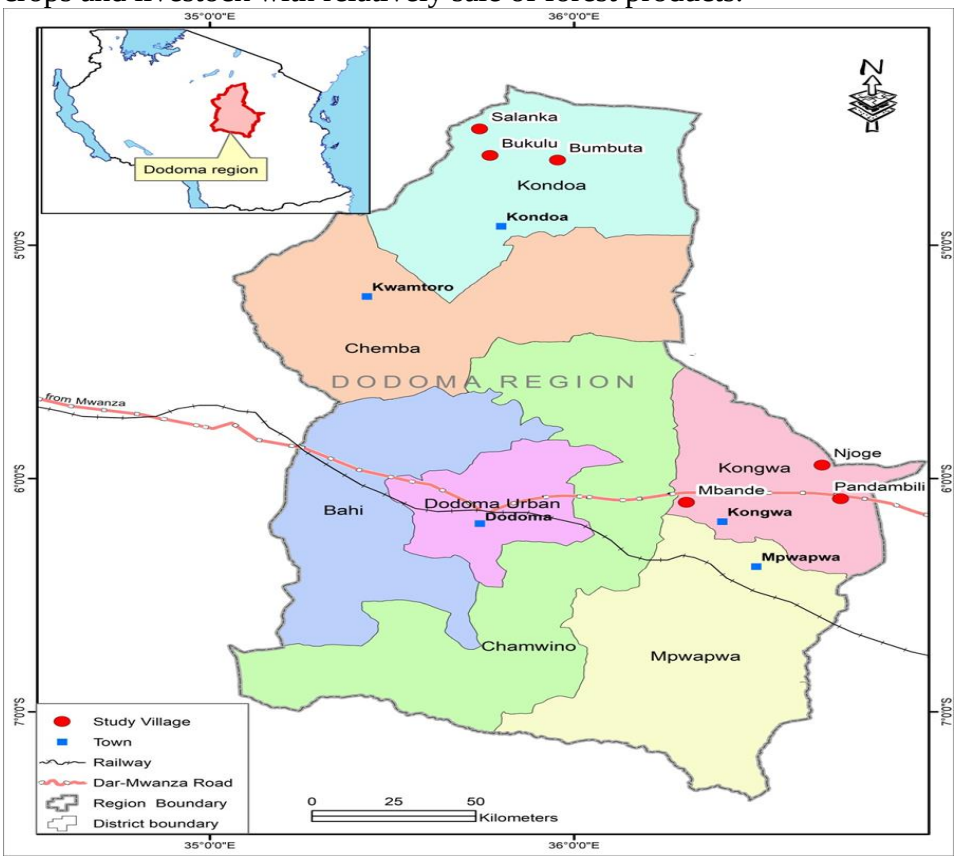

Figure 1: Location of studied villages in Kongwa and Kondoa Districts

Source: GIS LAB –UDSM (2019)

Data Collection

Both primary and secondary data were collected. Primary data included individual food loss estimates, size of land cultivated, amount of produced obtained and consumed. These data were collected through participatory rural appraisal technique that is key informant interview and focus group discussion while the information provided was cross check through household survey. A total of 12 key informants were interviewed using key informant checklist including; 2 district agriculture officers at Kongwa and Kondoa districts, 1 market manager at Kibaigwa Maize

International Market in Kongwa District, 3 department managers at Post-Harvest Management Department, Crop Management Department, Crop Monitoring and Early Warning Department from Ministry of Agriculture Food Security and Cooperatives, and 6 elderly persons from the sampled villages. Six focus group discussions were conducted using key informant checklist from each village, they comprised of 8 long experienced maize smallholder farmers (4 males and 4 females). A total of 376 households that is 5.9% were sampled from the village household registry using Yamene (1976) sample formula (see formula below and Table 1). A semi-structured questionnaire was used administered to the sampled households. Secondary data on the other hand was collected through relevant literature review.

$$n = \frac{N}{1 + N(e)^2}$$

Whereby;
n = total sample size
N = total household number (from the six villages that is 6370)
e = precision level of 5%

The sample size for each village was calculated;

$$\textit{Sample size for each village} = \frac{\textit{total household in each village x 376}}{6370}$$

While the percentage of the sample size was calculated;

$$\textit{\% of the sample size} = \frac{\textit{sampled size in each village x 100\%}}{376}$$

Table 1: Total household sampled and surveyed

Districts	*Wards*	*Village Name*	*No. of HH*	*Sample Size*	*% of the Sample size*
Kondoa	Bumbuta	Bumbuta	0292	17	0.27
	Salanka	Salanka	1500	88	1.38
	Soera	Bukulu	0851	50	0.78
Kongwa	Njoge	Njoge	1452	86	1.35
	Sejeli	M'bande	1400	83	1.30
	Pandambili	Pandambili	0875	52	0.78
TOTAL			**6370**	**376**	**05.9**

Source: Field Work, (June, 2018)

Data Analysis

Since, there were no established time series pre and post-harvest losses data on maize crop at the village, district, and ministry level. The recognizable data was the percentage estimate of 31.2% for maize pre harvest losses and 40% for maize post-harvest losses provided in the literatures. During the data collection process households were at different stages across the pre and post-harvest system. According to Hodges *et al*. (2010), there are basically two approaches adopted to estimate food losses either to actually measure what has been lost or to use a questionnaire to collect subjective losses estimates from those who have experienced them.

Therefore, quantification of the pre harvest losses for each household in the studied villages was derived as a difference between the capacities of land to produce versus amount obtained whereby for one acre of farm land it was approximated to produce 60 bags which is equivalent to 100 kg of maize. Households who obtained an equally amount of yield as per expected capacity of land were regarded not to experience pre-harvest losses. Data for households who experienced pre harvest losses were converted into percentage for easier comparison with the 31.2% estimate provided by Oerke (2007). Conversely, although the post-harvest system in the studied area comprised of five stages that is harvesting, transporting, drying, and threshing/shelling and storage, the quantification of food losses across the stages involved percentage estimates depending on what households obtained after harvesting versus amount remaining during storage. The percentage loss estimates where then compared against the 40% estimates provided by Abass *et al*. (2013) for easier assessment of the current status of maize post-harvest losses in the studied areas.

Thereafter, two ways ANOVA test was used to make a comparison between pre harvest losses status and post-harvest losses status occurring in Kongwa and Kondoa Districts so as to detect which area experiences greater food losses than the other. The correlation between pre harvest losses and post-harvest losses affecting household food security parameters that is availability, utilization, accessibility and stability was confirmed by the Pearson Product-Moment Correlation Coefficient.

The study considered three aspect of food security that is food availability, food accessibility and food utilization as major facet that determine household food security as indicated by Chijioke*et al*. (2011). The influence of pre-harvest losses towards household food security was reflected more on limitation to food availability aspect, whereby the amount of crop losses as result of pre harvest losses was calculated as a difference between capacities of land to produce versus the actual amount obtained in kilogram. The estimation used during this process was that on average 1 acre produces 60 bags and 1 bag of maize equals to 100 kg as indicated by district agriculture officers at Kongwa and Kondoa districts. Conversely, the influence of post-harvest losses on household food security was reflected more on limited food utilization aspect. This was obtained as a difference between actual amounts of yield obtained in kilogram versus the capacity or amount in kilogram a household consumes per year at a satisfactory level. The difference was terms as consumption deficit which implies that loss food that was to be consumed. Lastly, the study also analyzed the limitation in terms of financial losses households incur after pre and post-harvest losses. The study argued that the amount of finances losses deprives capacity of household to purchase food from the market. This was obtained after converting the total amount of food losses incurs from both pre and post-harvest losses into Tanzanian Shillings whereby 1 kg of maize is sold at 390.07 Tanzanian Shillings. The correlation between pre-harvest losses influences on yield that is food availability and post-harvest losses influence on food utilization was confirmed by the Pearson Product-Moment Correlation Coefficient.

Conceptual Framework

The conceptual framework guiding this study was adopted and modified from the work of Harris-Fry *et al*. (2015) on socio-economic determinants of household food security and women dietary diversity in rural Bangladesh. According to Harris-Fry *et al*. (2015), food availability, access and utilization are the three major pillars that determine food security at the household. However, presence of influencing determinants within the food system environment affects household food security. This study modifies the framework by arguing that household food security is impaired by food losses occurring across the food system. That is presence of sustainable food system with zero food losses and wastes assures improved household food security. The food system comprises of

pre-harvest system and post-harvest system whereby the pre-harvest system produces crop while the post-harvest system performs the delivery of food through supply across different stages. Both the pre and post-harvest system functions to generate the household food security. Presence of food losses across the pre and post-harvest system limits and hinder achievement of household food security. Moreover, the continued food losses household experiences when compounded by other factors such as size of land a household cultivate, household size that is composition and age, financial resources and household consumption pattern further aggravates household food insecurity condition. Webb and Roger (2003) further highlight that since the food security pillars operates in a hierarchy nature then lack of food availability not only affects utilization but also limits access and stability in the long run. Therefore, understanding of the losses occurring across the pre and post-harvest system and their actual implication on household food security are important for improved household food security.

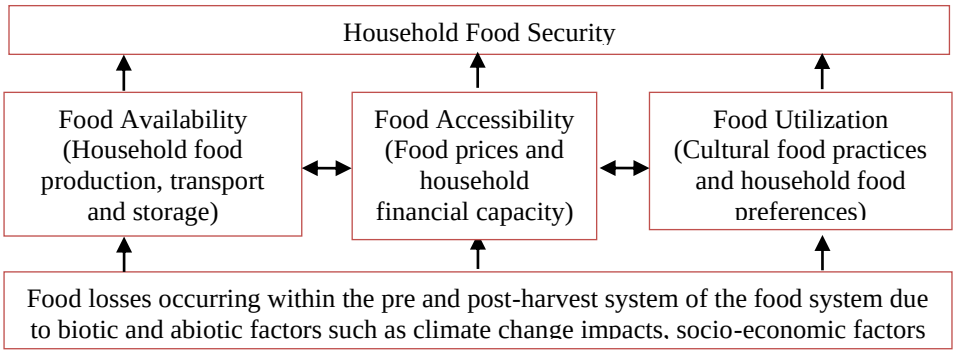

Figure 2: A conceptual framework for pre and post-harvest losses impacts on household food security

Source: Adopted and modified from Harris –Fryet al. (2015)

FINDINGS AND DISCUSSION

Status of maize pre harvest losses in Kongwa and Kondoa Districts

Table 4.1 presents the status of compiled maize pre harvest losses obtained for each individual household surveyed then compared against the global estimate of 31.2% of maize pre harvest losses provided by Oerke (2017). The aim was to establish the current status of maize in the study against the provided estimates done by previous studies. Results show that the majority of the households in the study area in both Kongwa and Kondoa districts are experiencing maize pre-harvest losses

at a status below 31.2% while relatively few households in Salanka and Bukulu experienced pre-harvest losses at a status above the 31.2%.

Table 2: Status of maize pre harvest losses at the household level in (%)

Responses	Kondoa District			Kongwa District		
	Salanka	Bumbuta	Bukulu	M'bande	Pandambili	Njoge
Below 31.2%	49	65	48	65	63	58
Above 31.2%	51	35	52	35	37	42
Total	**100**	**100**	**100**	**100**	**100**	**100**

Source: Fieldwork (2018)

This study argues that presence of majority of households experiencing maize pre harvest losses below 31.2% in Kongwa District is driven from the fact that in Kongwa District lies in the maize agro-ecological zone whereby maize crop is highly commercialized. Thus, farmers are motivated towards increased maize crop production with little pre-harvest losses. Conversely, this study argues that although Salanka and Bukulu villages in Kondoa District lies in the rainy agro-ecological zone, it experiences maize pre-harvest losses above 31.2% due to non-climatic factors. According to URT (2019), farming system in rainy agro-ecological zone is characterized by the shortage of land for extensive crop production with little use of improved seeds, fertilizers and pesticides. Shortage of land to cultivate attributes to land exhaustion and reduced soil fertility following repeated cultivation and lack of financial capacity to acquire fertilizers while cultivation of large land size causes difficulty in management as indicated by Conant (2010) and Pretty and Hine (2001).

Status of maize post-harvest losses in Kondoa and Kongwa Districts

Table 3 and 4 presents the results of complied percentage of individual household's status of maize post-harvest losses experienced during harvesting and storage against the provided status of 40% provided by Abass*et al*., (2013). The aim was to establish the status of maize post-harvest losses in the studied area against the provided estimates. Results in Table 3 indicate that majority of households in the studied areas are experiencing maize post-harvest losses during harvesting were below the 40% threshold. Conversely, results in Table 4 indicate that majority of the households in the studied areas are experiencing maize post-harvest losses below the threshold of 40% as compared to those experiencing losses above the 40% threshold.

Table 3: Status of maize harvesting losses at household level in (%)

Responses	Kondoa District			Kongwa District		
	Salanka	Bumbuta	Bukulu	M'bande	Pandambili	Njoge
Harvesting loss below 40%	96	94	97	94	88	82
Harvesting loss above 40%	04	06	03	06	12	18
Total	**100**	**100**	**100**	**100**	**100**	**100**

Source: Fieldwork (2018)

Table 4: Status of maize storage losses at household level in (%)

Responses	Kondoa District			Kongwa District		
	Salanka	Bumbuta	Bukulu	M'bande	Pandambili	Njoge
Storage loss below 40%	85	88	95	91	81	72
Storage loss above 40%	15	12	05	09	19	28
Total	**100**	**100**	**100**	**100**	**100**	**100**

Source: Fieldwork (2018)

Comparison of maize pre- and post-harvest losses status in Kondoa and Kongwa Districts

Although the variation on household percentage estimates on pre- and post-harvest losses in maize are shown in tables2, 3 and 4 above; it was important for the study to provide the statistically significant variation between pre and post-harvest losses of maize occurring in the study area. Table 5, below presents the results for the statistical significance difference between maize pre and post-harvest losses occurring in Kongwa and Kondoa district according to the two ways ANOVA analysis. It should be noted that prior to conducting the analysis, the homogeneity of variance was investigated using Levene test where the assumption of equality of variance was satisfied as shown in Table 5.

Table 5: Levene Test on Pre and Post-Harvest Losses Variability

Variables	Df	Sum of squares	Mean squares	F value	p-value
Districts	1	29078	29078	21.336	0.000
Type of Loss status	1	8142	8142	5.974	0.015
District: Type of Loss status	1	20554	20554	15.082	0.000
Residuals	583	794547	1363		

Source: Fieldwork (2018)

Findings indicate that there was a statistically significant main effect for district [F (1, 750) =21.336, p=0.000] such that the percentage of maize losses perceived by the farmers' household is statistically different between Kondoa and Kongwa Districts. The difference is denoted through mean percentage whereby Kondoa District has a mean percentage loss of 37.65 while Kongwa District has mean percentage loss of 51.76. This finding suggests that households in Kongwa District are experiencing higher percentage overall losses in both pre and post-harvest system than households in Kondoa District. This study argues that thepresence of significant high pre and post-harvest losses in Kongwa District than in Kondoa District is not only from lack of effective loss reduction but also continued loss influenced by climate change and variability. The ongoing ncreasing temperature trend in the semi-arid areas of Tanzania facilitates food losses through soil moisture reduction, drying of crops, and eruption of pest and diseases which further increases the susceptibility of maize contamination with aflatoxins (Suleiman and Rosentrater, 2015).

Results also indicate that there was a statistically significant main effect for the loss status [F(1,750) =5.974,p=0.015] such that the average percent of pre harvest loss is statistically significantly different from the average percent of post-harvest loss. This also implies that maize post-harvest losses had a higher mean percentage loss of 48.77% than maize pre harvest losses which had a mean percentage loss of 39.39%. This finding suggests that on average farmer's households in both Kongwa and Kondoa Districts experience more maize post-harvest loss than the pre harvest loss. This study argues that presence of high post- harvest losses in the study area is due to the fact that farmer's efforts are channeled on promoting resilient production system than resilient post-harvest system. This was also attested by Kader (2005) and WFLO (2010) that over the past decade's significant focus and resources have been allocated to increased food production than reducing food losses. Cooper et al. (2008) further indicated that most of the semi-arid are characterized by reduced rainfall and severe drought and as a result, farmers in these areas give more priority only to reduce crop risks during production (Cooper et al.2008). However, resilient production system alone without resilient post-harvest system cannot effectively address the prevailing rural household food insecurity conditions. Hence reducing post-harvest losses

remains the critical component in ensuring food security (Aulakh and Regmi, 2013).

Conversely, results also indicate that the interaction factor between district and type of loss was found to be statistically significant [F (1, 750) = 15.082, p=0.000]. This finding suggests that on average the percentage loss variability across different Districts (Kongwa and Kondoa) depends on whether the loss is pre harvest or post-harvest. This means that one cannot explicitly explain the variability of average percentage loss across different district without acknowledging which type of loss is being explained. Therefore, the status of pre and post-harvest losses variability depends on the District that is being explained.

Contribution of pre- and post-harvest losses to household food insecurity

This study argues that food availability, utilization, access and stability at the household level are reduced by pre- and post-harvest losses. However, in most cases, the three facet of food system that is; food availability, food access and food utilization are most needed in order for household food security to be realized (Chijioke*et al*. 2011). According to respondents in the study areas, a household is food secured when it consumes three meals a day comprising of maize meal. This study argues that food availability in the household is first determined by crop yield obtained. Pre harvest losses influences limited food availability in the household through reduced amount of crop production. It was revealed during discussion that a size of farm cultivated is proportional with the household size, so that obtained yield is able to cater for the household needs in terms of food availability.

Figures 3 and 4 present the proportion of the amount of maize household obtained after pre-harvest losses in relation to capacity of land to produce in tons in Kondoa and Kongwa Districts. Resultsin both Kondoa and Kongwa districts indicate that the amount of yield loss during production is comparable to the capacity of land to produce. This implies that households in the study areas obtained low maize yield compared to amount that is lost. The difference existing among villages in the two studied Districts is derived from the variation of the size of household sampled and the total size of land cultivated in each village. However, in general, the maize pre-harvest losses ranged from 428.2 tons in Bumbuta

village to 4925 tons in Njoge village. Therefore, a pre-harvest loss limit and hinders physical access to food through reduced crop yield.

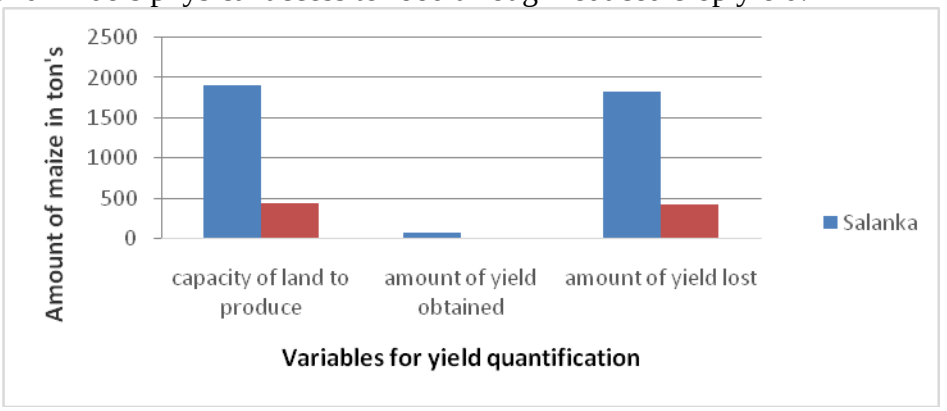

Figure 3: Amount of maize lost by tones in Kondoa District
Source: Fieldwork (2018)

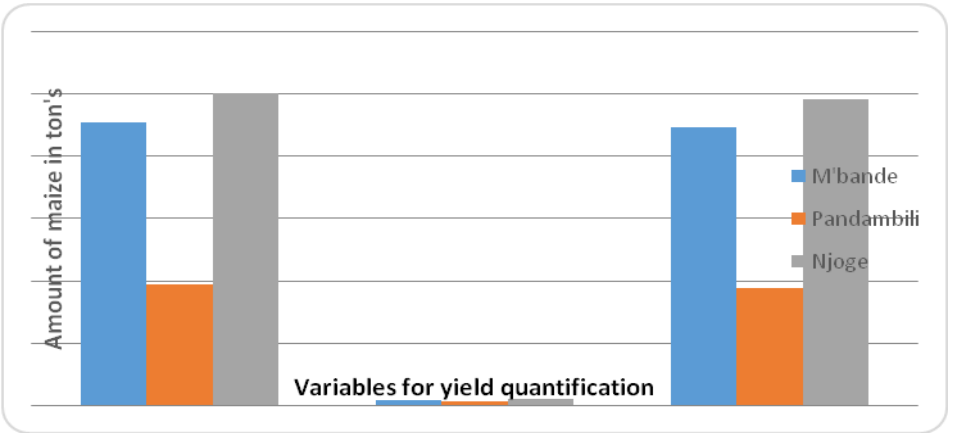

Figure 4: Amount of maize lost in Kongwa District
Source: Fieldwork (2018)

Conversely, the amount of food lost during pre-harvest system affects also the post-harvest system and hence limits household food utilization. However, food utilization in the household is not only determined by availability of food but also consumption amount and pattern at the households. It was revealed that food utilization was also proportional to household size. Parfitt*et al*. (2010) further indicated that household food utilization also depends on household composition, income, demographics and culture. Presence of large household size with high pre and post-harvest losses experiences exacerbates reduced household food

utilization. This may lead to skipping of meals or provision of meals to family members basing on priority needs such as the children and elderly. Figures 5 and 6 present the household maize consumption deficit in relation to amount of maize obtained from the farm and the amount of maize a household consume yearly. Result indicates that households in both Kongwa and Kondoa districts are experiencing household consumption deficit due to post-harvest losses. Comparison among the district show that Kongwa District is experiencing more household consumption deficit than Kondoa District. Finding further suggests and concur with previous findings that presence of high post-harvest losses in Kongwa District contributes to reduced household food utilization.

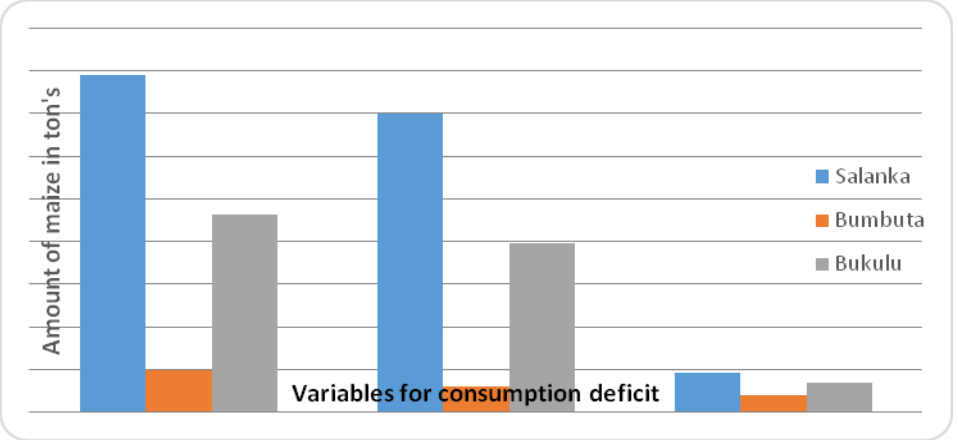

Figure 5: Household maize consumption deficit inKondoa District
Source: Fieldwork (2018)

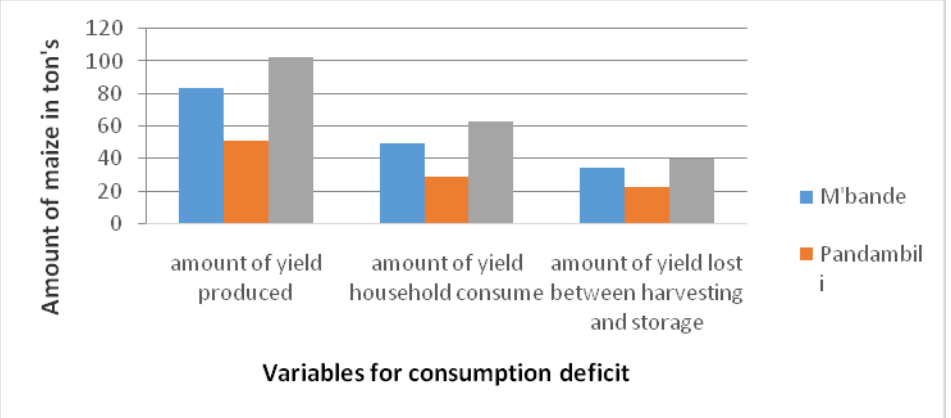

Figure 6: Household maize consumption deficit inKongwa District
Source**:** Fieldwork (2018)

This relationship between pre-harvest losses contribution to reduced household food availability and post-harvest losses contribution to reduced household food utilization or consumption was confirmed through Pearson Product-Moment Correlation Coefficient as indicated in Table 6. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity.

Table 6: Pearson Product-Moment Correlation Coefficient

Variables	Crop production loss		Consumption deficit	
	correlation	p-value	correlation	p-value
Pre-harvest loss	0.23	0.011		
Post-harvest loss			0.56	0.000

Source: Fieldwork (2018)

Findings indicate that there was a small but positive correlation between the two variables which was also statistically significant at [r=0.23, n=360, p<0.011], with high percentage of pre harvest losses associated with high levels of crop production loss. This finding implies that increase in pre harvest losses also increases crop production losses. Conversely, findings also indicate that there was a large, positive correlation between the two variables which was also statistically significant at [r=0.56, n=360, p<0.000] with high percentage of post-harvest losses associated with high levels of consumption deficit. This finding also implies that increase in post-harvest losses also increases consumption deficit at the household by limiting physical access to food. Therefore, this study asserted that the implication of pre harvest losses are more reflected in the limitation of food access through reduced food availability due to reduced crop yield while post-harvest losses limits food access through reduced food utilization due to consumption deficit.

Apart from hindering physical access to food through availability and utilization, it was also revealed during discussion that pre harvest and post-harvest losses also contribute to limited food access through financial losses household incur from pre and post-harvest losses. Figures 7 and 8 present the financial losses in Tanzanian Shillings households incurred or suffered due to pre and post-harvest losses. Findings indicate that majority of households in both Kongwa and Kondoa Districts experience financial losses from pre and post-harvest losses. Comparison between the districts indicates that cumulatively Kongwa District experience more financial losses than Kondoa District. This study argues

that presence of high pre and post-harvest losses in Kongwa District are associated with more financial losses. Presence of high financial losses hinders household's power to purchase food from the market. This is because increased pre and post-harvest losses influenced by climate change reduces food commodity availability in the market which causes increased food prices which are not affordable by the rural households. This also corroborates to Webb et al. (2006) that the purchasing power varies with market integration, price policies and temporal market condition.

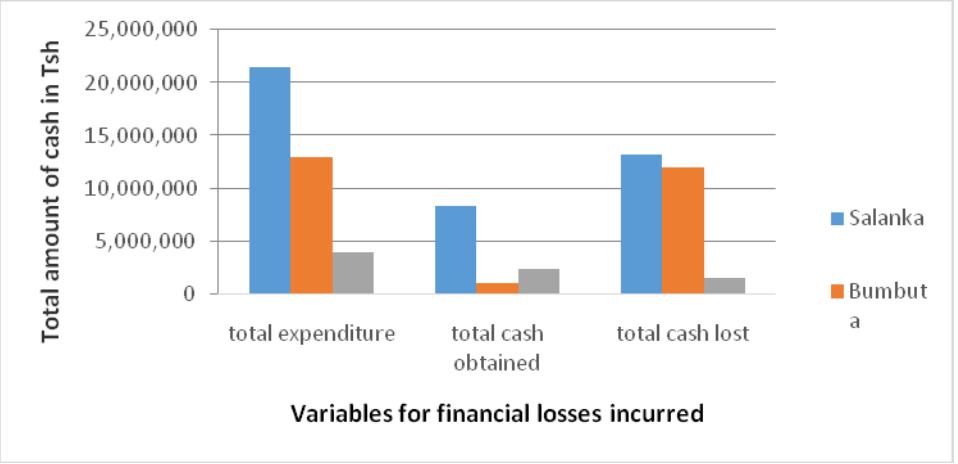

Figure 7: Financial losses incurred by households in Kondoa District
Source: Fieldwork (2018)

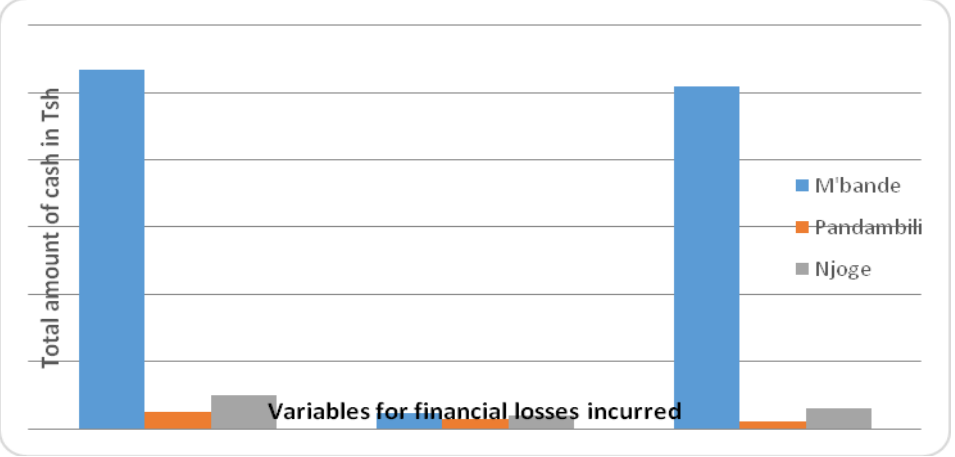

Figure 8: Financial losses incurred by households in Kongwa District
Source: Fieldwork (2018)

Most of households in the studied areas do not purchase foods from the market; they depend entirely on their farm produce and stored food. Therefore, presence of pre and post-harvest losses not only limits food availability but also causes households to incur financial losses which would have been used to purchase food from the market. The financial losses that households incur from pre and post-harvest losses results from the cost of renting of land for those who do not own land, purchase of seeds, hiring of labor for planting, weeding, harvesting, transportation, threshing and shelling and purchase of facilities used during storage. Limitation of access to food through purchase also limits consumption status in terms of amount and pattern (Ericksen*et al*., 2011). Although this study argues that there is relationship between amounts of finances lost through pre and post-harvest losses towards food access restriction in the market, Chakona and Shackleton (2017), report that there is no correlation between food losses occurring through pre and post-harvest with household wealth or food expenditure.

Conclusion and Recommendation

The status of both maize pre and post- harvest losses occurring in the studied area are relative low when compared against the threshold however they are huge to those who experiences losses above the threshold. The comparison between statuses of pre and post-harvest losses showed that post-harvest losses are higher than pre harvest losses, whereby Kongwa district is experiencing high pre and post-harvest losses than Kondoa district. The influences of pre and post-harvest losses on household food security are more reflected through food availability, utilization and accessibility. Pre harvest losses limit physical food access by reducing food availability which occurs as result of reduced food yield. Conversely, post-harvest losses limit physical food access hence reduces household food utilization. Moreover, occurrence of pre and post-harvest losses causes financial losses which also limit physical access of food in the market. Therefore, pre and post-harvest losses have a significant negative implication on household food security conditions by limiting access to food availability and utilization. The study recommends increased awareness on the food losses occurring across the pre and post-harvest system to household farmers and their associated implication on household food security through seminars and trainings on effective food loss reduction methods.

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