Impact of Rainfall Variability on Food production under Rainfed Agriculture in Homa Bay County, Kenya

Japheth O. Ogenga, Edward M. Mugalavai and Nicodemus O. Nyandiko

School of Disaster Management and Humanitarian Assistance (SDMHA)
Masinde Muliro University of Science and Technology, Kakamega, Kenya, P.O. Box 190-50100, Kakamega, Kenya
Department of Disaster Management and Sustainable Development (DMSD)

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Abstract: Rainfall variability exacerbated by frequent dry spell occurrences within the growing seasons is a common phenomenon in many regions of the world.. Homa Bay County located in the western part of Kenya in the Lake Victoria Basin is a sub humid region characterized by frequent dry spells resulting to poor yield in crops and livestock production in the County. This paper examines the impact of dry spells occurrence on food production under rainfed agriculture in Homa Bay County. The study used a sample size of 384 households. Primary data was gathered through use of questionnaires, interview guides, Focus Group Discussions and observation while secondary data including content analysis obtained from publications, journals, newspapers and internet sources. Data for evaluating dry spells and rainfall variability was obtained from Kenya Meteorological Department (KMD). Descriptive and inferential analyses were done for household data using statistical package for social scientists (SPSS) version 20. Results indicated that during dry spells, annual crop yield production for maize and beans fall below average of 1.44 tons/ha and 0.78 tons/ha while sorghum and millet were above average of 0.94 tons/ha and 1.61 tons/ha respectively. Livestock production (48%) was impacted upon greatly through weight loss and reduced milk output (23.8%). The findings revealed that rainfall variability and dry spells have serious impacts on food security in the Homa Bay County causing massive crop failure and reduced livestock production and death. It is therefore recommended that both national and county governments and other stakeholders put in place effective risk transfer strategies to ensure sustainability in rainfed agriculture in the area.

Key Words: Annual crop yield, dry spell occurrence, rainfall patterns, crop stages, food security

1. Introduction

Increasing crop production in semi-arid areas remains a challenging task due to rainfall that is low and erratic (Heng *et al*., 2007), since it is the primary source of water. The success or failure of crops under rain-fed conditions is determined by the rainfall patterns and amount received. Consequently rainfall amounts and seasonality are essential to an in-depth understanding of the biotic and a biotic environment. Rainfall trends are important for optimizing the spatial distribution and adaptability of different agricultural enterprises (Monadjem & Perrin, 2003).

Most parts of the world's agricultural systems are rainfed, and hence the occurrence of dry spells during the growing season greatly affects yield and productivity. Adamgbe *et al*., (2013) observed that in most of the tropics and equatorial regions of the world, and across large areas outside the tropics, the agricultural yield is determined more by the amount of rainfall received and stored by soil than by the air temperature. The amount of water transpired by the crops is also determined by air humidity with generally less matter produced in drier atmosphere (Parry *et al*., 1990). Therefore changes in rainfall and air temperature are likely to have a significant effect in crop yield and livestock.

Dry spells occurrence poses a great challenge to rainfed agriculture that hinders the constant supply of food needs for the increasing African population. For instance, rainfall in West Africa is characterized by high spatial and temporal variability for decades hence affecting the rain dependent agriculture (Nicholas, 2001). West Africa has experienced a decrease of 20 – 40% in annual rainfall amount in the last decade. This indicates the extent of loss in agricultural production hence putting the lives of population at risk of hunger and food insecurity in the region.

According to Parry *et al,* 2007, the climate variability has generated major phenomena in the Sahel by increasing the frequency and duration of occurrence of dry spells and droughts. This change in rainfed agriculture causes uncertainty in planting period and other farm practices. This in turn has greatly reduced agricultural productivity in many parts of the continent that are agriculturally viable.

The frequency of dry spells has increased in the recent years in Kenya and other nations in the horn of African. The increase has been attributed to the global climate change which has led to spatial and temporal reduction of rainfall (Gitau, 2012). Kenya has experienced some of the worst forms of dry spells that have claimed many lives in the present times due to hunger and famine (Gitau, 2010). Most of the socio-economic activities in Kenya are rain dependent. This may affect the status of food security in a place given that food security is defined by socio economic activities and climatic factors (Scoones *et al.,* 1996). Rainfall is therefore the most important climatic element over Kenya, yet it displays the largest variability in both space and time (Jaetzol *et al*., 2007).

Most parts of Kenya experience two rainfall seasons that alternate with dry seasons. The two rainfall seasons are the long rainfall season which is concentrated between March – May and the short season which occurs from September to Early December (Gitau *et al.*, 2008). The probability of these seasons getting interrupted by dry spells is very high mostly in the ASALs and sub humid regions such as Homa Bay County as opposed to wetter regions of the country (Awange *et al*., 2007). This is exacerbated by climate change that has influenced the climate in most regions during the last decade.

The required amount of rainfall for better agricultural yield and productivity is important however, the distribution in space and time plays a critical role in certain crops that are regarded as staple food crops in most parts of Kenya. According to Mugalavai and Kipkorir (2013), the impact of dry spells to rainfed crops like maize is felt most in the critical stages of crop development like flowering and grain filling.

The global climate shows an increasing trend in average air temperature (IPCC, 2008). In relation to the changes in temperature, the cropping period is expected to become shorter and even more irregular distribution of rainfall is expected. Increased frequency and prolonged duration of dry spells occurrences impact on; crops and livestock production, water access and market prices (Onchiri *et al*., 2016). In humid countries the success or failure of crops, particularly under rainfed conditions is highly related with the distribution of dry spells.

Adger *et al.* (2003), discussed adaptation to climate change related phenomena in developing countries while Barret (2002) described food assistance programs. The impact of climatic extremes in the context of climatic change in Lake Victoria basin has been assessed in Phoon *et al.* (2004), while Awange *et al.* (2007), has assessed the frequency and severity of dry spells and drought in the lake Victoria basin region (Kenya) and its effect on food security.

Dry spells affect not only agriculture but also other sectors such as fisheries, health, electricity etc. The fish productivity as the second major sector within the County from is likely to be stricken by longer dry spells (Odhiambo, 2013). Longer dry spells also interrupt generation of electricity from hydroelectric power as was experienced in 2011 in the areas bordering Horn of Africa. Information on dry-spell duration is useful in decision making with respect to supplemental irrigation and field operations in agriculture. Prior knowledge of dry spell studies can be applied to generate systematic sequences of rainfall and the estimation of the irrigation water demand, (Mathlouthi, 2008).

Crops are more likely to do well with uniformly spread ‘light’ rains than with a few ‘heavy’ rains interrupted by dry periods. The timing of breaks in rainfall (dry spells) relative to the cropping calendar rather than total seasonal rainfall is fundamental to crop viability (Usman, 2004). The longest period of several long spells is therefore of crucial importance in planning agricultural activities and managing the associated water supply systems but also the timing of dry spell occurrence in mostly in growing calendar plays a critical role in agricultural production.

A major challenge of dry spell research is to develop suitable methods and techniques for forecasting the onset and intervention points of dry spells, (Panu, 2002). Past studies done on dry spells in Sri Lanka and in Kano plains in Kenya highlighted the heavy losses in paddy production caused by prolonged dry spells and the importance of studying the temporal and spatial variability of dry spells (Ariyabandu and Hulanagamula, 2002) and (Ochola and Kerkides, 2003) . The objective of this study was to examine the impact of dry spells occurrence on rainfed agriculture in Homa Bay County.

2. Materials and Methods

2.1 Study area

The study was carried out in Homa Bay County which is located in the Western part of Kenya in the former Nyanza province with an area of 3,154.7 km square. It is bounded by latitude 0° 15' South and 0°52' South and longitudes 34° East and 35°" East (Figure 2.1). It has an altitude of 1146 m above the mean sea level.

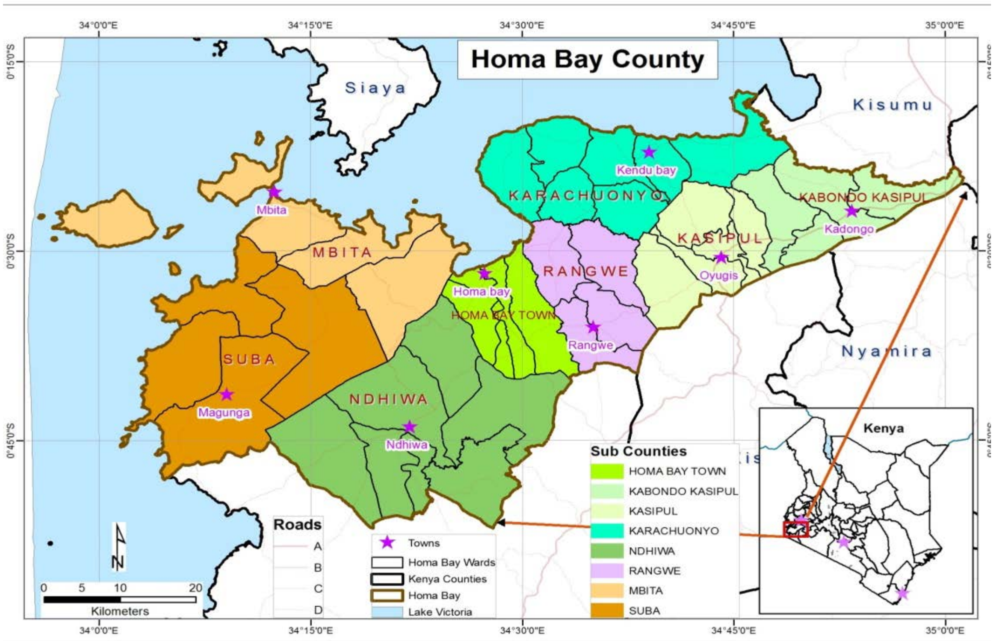

Figure 2.1: Location of the study area

Source: (Researcher, 2017)

2.2 Research design and sampling procedure

Descriptive research design was used to examine the impact of dry spells occurrence on rainfed agriculture in Homa Bay County. Additionally, the study utilized both qualitative and quantitative approaches. A sample size of 384 households was identified for this study. Homa Bay County was purposively selected due to the magnitude of the recurrent dry spells and droughts that reduce its huge potential as a food basket within the Lake Victoria region (GoK, 2013).

The study took a multistage sampling approach where 50% sampling units as supported by Mugenda and Mugenda (2003) were selected and two out of four sub counties were purposively selected for the large scale farming areas like Ndhiwa, Suba, Mbita and Karachuonyo; while another two out of four Sub Counties were selected for the small scale farming areas like Homa Bay Town, Rangwe, Kasipul Kabondo and Kasipul hence a total of four sub counties were selected for this particular study.

According to Awange et al., (2007), the most affected sub counties by dry spells and droughts were the peripheral ones neighbouring Lake Victoria, but for the wards that are located far away from the lake shores. These sub counties including Karachuonyo, Mbita, Homa Bay Town and Rangwe receive relatively low rainfall amount (KMD, 2015). The wards under these sub counties (Table 2.1) were purposively sampled given their proximity to the lake shores that defines the rainfall variability in the areas. The proportion of wards where the study was conducted were computed from the four sub counties based on 30 % sampling units as supported by Mugenda and Mugenda (2003).

Table 2.1: Proportion of wards Sampled

S/N	Sub counties (Wards)	Total number of wards	30% Sample of wards
1	Karachuonyo (Kibiri and Kanyaluo)	7	2
2	Mbita (Kanyamwa and Kolongi)	7	2
3	Homa Bay Town (Arujo)	4	1
4	Rangwe (Kagan)	4	1
	Total	**22**	**6**

Source: Field data, 2017

In-depth interviews were conducted using interview guides with 2 representatives (Table 2.2) from each organization including Ministry of Agriculture, Kenya Meteorological Department, Non Government Organizations and County disaster management committee totaling to Eight (8).

Table 2.2: Summary of study population units, sampling methods and sample size

Population Units	Sample size	Sampling strategy
Households	384	Multi stage
Ministry of Agriculture (MoA)	2	Purposive
Kenya Meteorological Department (KMD)	2	Purposive
Non Governmental Organizations (NGOs)	2	Purposive
County Disaster Management Committee	2	Simple random
FGD respondents	4	Quota

Source: Field (2017)

The key informants were identified through a combination of simple random sampling, purposive and quota sampling techniques. Appointments were scheduled by telephone with those respondents who were available and willing to speak to the interviewers about rainfall variability, dry spells occurrence and their impacts on the rainfed agriculture in Homa Bay County.

2.3. Analysis criteria of rainfall variability in Homa Bay County

Annual and seasonal rainfall patterns were analyzed from daily rainfall data and the variations illustrated using of graphs and trend lines. The study divided the years into four seasons (DJF, MAM, JJA, and SON) for comparison between the growing seasons and the non growing seasons in relation to rainfall variability. The main growing seasons in Homa Bay County are (MAM) and (SON) that is during the long and short rains respectively.

The trend line $y = mx + c$ was used to describe changes in rainfall amounts where "y" represented rainfall amount in millimeter (mm), "m" represented slope showing the rate of change of rainfall over the period under consideration while c represented the intercepts on y – axis. R^2 was used to determine the significance of change at 0.05 level in both seasonal and annual rainfall amounts over the years in consideration. Standard deviation (SD) was used to vary the magnitude of annual rainfall about the mean rainfall over the years. A time series analysis showing the long term mean rainfall, (mean + SD), (mean – SD) in order to describe the wet, dry and normal rainfall year for Homa Bay County. The graph demonstrated years regarded as wet (mean + SD) and dry (mean – SD) respectively under the years in consideration in Homa Bay County (Mugalavai and Kipkorir, 2015). The normal rainfall years were those falling between (Mean – SD) and (Mean + SD). Moving averages of 5 and 10 years were used to smooth the time series analyses of rainfall over the years in consideration in Homa Bay County in order to describe the climatic characteristics of the study area.

2.4 Analysis criteria of crop yield in relation to annual rainfall variability and dry spell occurrence (1950 -2017) in Homa Bay County

Crop yield data were obtained from the Ministry of Agriculture of the County Government of Homa Bay for the period (2007 – 2016). The crop yields were measured in tons/ha. A regression approach was used to establish relationship between the crops yield and annual rainfall variability in Homa Bay County.

Regression equation of $y = bx + c$ was used to describe the changes in crop yield against the annual rainfall amount. "y" represented annual rainfall amount in (mm), "b" = the gradient showing the rate of change in rainfall and crop yield while "c" represented the intercepts of y – axis.

Questionnaires for primary data were also subjected to descriptive statistical and inferential analysis, which gave the frequencies and proportions between the dry spells occurrence and the crop yield and livestock production. Descriptive statistical analysis was done to examine the relationships among different variables of the study. Inferential analysis obtained cross tabulation distributions with Chi square (χ^2) significance tests and single tailed analysis of variance. The (χ^2) statistics establishes the statistical association between variables both of which must be in nominal ordinal scales.

3. Results and Discussions

3.1 Annual rainfall variations for Homa Bay County: 1950–2017

The analysis in Figure 3.1 reveals that the annual rainfall mean for Homa Bay County is 1200 mm with a standard deviation of 230 mm (Table 3.1).

Table 3.1: Analysis of rainfall for the (1950 – 2017) period

Rainfall	**(1950 – 2017) Period**
Mean (mm)	1200
Standard Deviation (mm)	230
Trend (mm)	0.046
Total change calculated from the trend (mm/ 67years)	2.4

Source: Data from the Kenya Meteorological Department: 1950 – 2017.

*Total change is the difference between the trend line values of the last and the first year

In order to categorize rainfall characteristics into wet, normal and dry years, the standard deviation was used to vary the rainfall received about the mean annual rainfall over the period (Figure 3.1). Climate can be classified into below normal < (mean-SD), normal between (mean-SD and mean + SD) and above normal > (mean + SD) conditions based on the Kenya Meteorological Department (KMD) convention (Mugalavai and Kipkorir, 2015). Using one standard deviation as appoint of reference, the region above (mean + SD) is categorized under wet years. Rainfall data analyses for the period under consideration (1950 – 2017) reveals that 10% (7 out of 67) were wet years in Homa Bay County. The extremely wet years occurred in 1951, 1961, 1977, 1987, 2001, 2014 and 2016 causing Elnino in the various years. The normal annual rainfall years fall between the (mean + SD) and (mean – SD) considering the period under investigation. The analysis reveals that 67% (45/67) of the years received normal annual rainfall but with frequent dry spell seasons within the years in Homa Bay County.

Homa Bay County like many other parts of the Lake Victoria region experiences frequent and prolonged dry spells. The analysis reveals that the period under consideration had dry years with rainfall below the long term mean (Figure 3.1) that refers to the years falling below (mean – SD). The analysis reveals that 22.4% (15 out of 67) were dry years in Homa Bay County. The prolonged droughts occurred in 1953, 1956, 1959, 1960, 1965, 1967, 1973, 1981, 1984, 1993, 1996, 1999, 2005, 2007, 2009 and 2015. In line with the historical analysis of the weather, both Dry spells and extreme rainfall over the years have had a great potential of occurrence in Homa Bay County (GoK, 2016).

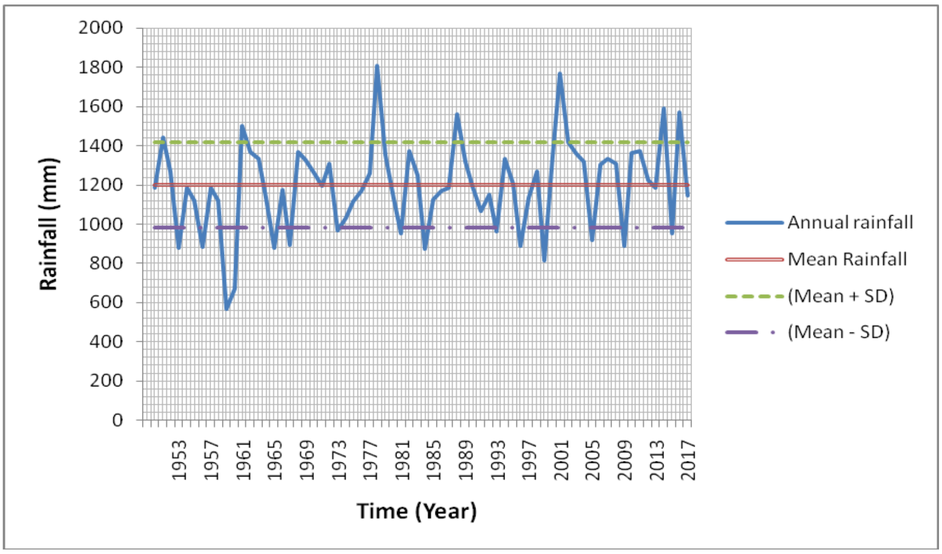

Figure: 3.1: Annual rainfall variations for Homa Bay County: 1950–2017
Source: Based on data from Kenya Meteorological Department (2018)

Many ASAL areas in Kenya are prone to rainfall variability but droughts have increased in frequency and are the major constraint to rainfed agricultural production (Huho and Mugalavai, 2010). This study findings resonates with a study by Awange *et al.*, (2007) who observed that many parts of Kenya including Lake Victoria region experienced drought in the years between 1983 – 1997 and Onchiri *et al.*, (2016) who observed frequent occurrence of drought in Mbita between the years 1983 – 2012. Within the 67 year period, 34 years had annual rainfall below the mean of 1200 mm that forms 57.7% of the entire study period. The duration of the prolonged droughts ranged from 1–2 years with the most affected years being 1959 – 1960 which had a 2 year span of prolonged droughts.

3.2 Impact of dry spells on different phenological stages of crops

The study sought to examine the impact of dry spell on different phenological stages of crops and in particular food crops that are regarded as staple food crops. The results in Figure 3.2 shows that maize which is cultivated by the majority of the residents of the County is most affected at the flowering at 44.3%, followed by grain filling stage at 42.2% and the germination that according to the respondents is not much affected at 30.2%. The impact on beans mostly affects flowering stage at 29.4%, pod filling at 30.2% and less at the germination stage at 24.3%. Sorghum in contrary is mostly affected at the germination stage at 23.8%, 15.5% flowering stage and 17.1% at the grain filling stage. Millet is affected more at 21.7% in the germination stage, 10.8% flowering and at 10.5% in the grain filling stage

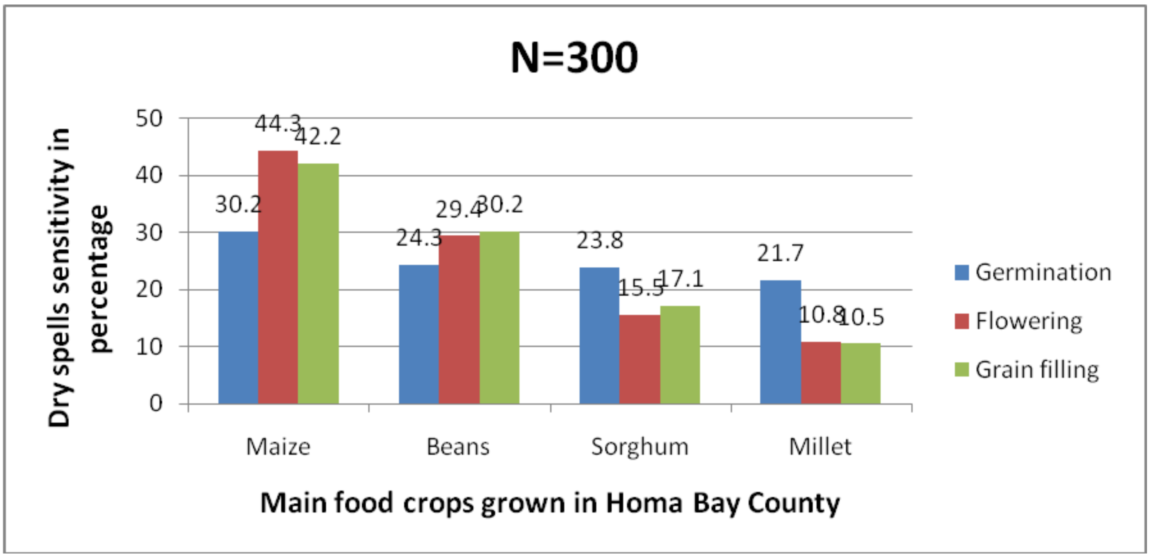

Figure 3.2: Impact of dry spells to different phonological stages on main food crops

Source: Field Data (2017)

Based on the distribution and cross tabulation analysis computed, χ^2 value of 179.8, with 3 degrees of freedom and a p- value of 0.052 at 0.05 margin error, suggesting higher chance that dry spells impact on different phenological stages of different crops thus impact were significantly different in terms of their consequences on food security in the study area. The most adversely affected by the extreme climatic conditions like prolonged dry spells is the agricultural sector and mostly the crop production which has obvious implications on food security (Ngaira, 2005). The respondents were asked to show which phonological stages of the most common cultivated food crops were affected by dry spells in Homa Bay County.

This question was asked with the intention of determining the most affected stage of growth and development in order to inform the best intervention to mitigate the dry spell effects on crops for food security. Biamah (2005) observes that food crops that are majorly rainfed dependent in the semi arid areas of Kenya have a 25 – 75% risk of crop failure due to the extreme climatic changes like dry spells. Therefore, it was meant to inform small scale farmers who are dependent on rainfall for their agricultural activities on the most suitable crops that are drought tolerant for increased food security in Homa Bay County.

Further analysis shows that the average percentage impact of dry spells on all food crops confirms that maize is the most sensitive to dry spells in virtually all critical stages of growth and development at 39% followed by beans at 28%, Sorghum at 19% and Millet at 14% respectively. Maize and beans are more affected at the mid season stage of flowering and grain filling and this increases their general percentage in sensitivity to water shortage. Nyandiko *et al*., (2013) observe that soil moisture condition during germination is of higher significance and determines crop performance. This is because it is the period of highest crop water need. If water shortage occurs during the mid season stage, the negative effect on crop yield will be pronounced (Bergaschi *et al.*, 2004).

Maize crop tends to experience extreme sensitivity to water deficit, during a short critical period, from flowering to beginning of grain filling phase (Bergaschi *et al*., 2001). Huho *et al.,* (2010) observe that maize crops are more sensitive to the drought related climatic factors than other crop types in water stressed regions yet in the eyes of the rural small scale farmers, lack of maize means hunger and famine. Farmers who have majored on maize and beans cultivation can therefore be advised on the most appropriate time and stages of development of different crops to mitigate the severity of the dry spells. Crop development stages are in the initial and mid season stages in regard to water shortage sensitivity (Adejuwon, 2004). During this time, some crops react favorably to water shortage by developing deeper rooting system which is helpful during the later stage when the crop is about to be harvested. The study therefore indicates that millet is the most suitable crop for Homa Bay County followed by sorghum in regard to their increased level of tolerance to drought than maize and beans for food crops. Homa Bay County that forms part of the Lake Victoria basin has been found to be an agriculturally potential zone as it has moderately favorable climate for both food crops and cash crops. Food crop farming is practiced to a large extent in the study area despite of the challenges regarding climate related hazards that affect the crops at different stages of growth and seasons of planting (GoK, 2013).

The findings of this study are hence supported by Mugalavai and Kipkorir (2013) on evaluation of dry spells during sensitive stages of growth of maize crop in Western Kenya which indicates that the dry spell severity during germination and flowering stages is highest towards the northern part of Lake Victoria Basin (Kenya) and around the Lake shores From the FGDs conducted it was revealed that grain filling stage is also impacted on by the dry spells but not to a larger extent as for germination and flowering stages.

The results indicate that the most vulnerable phenological stages to dry spells for maize crop which is a major food crop in the area are germination and flowering. Maize crop is very sensitive to water deficit in the critical stages due to its high water requirement in terms of evapotranspiration and high physiological sensitivity when determining its main yield components such as number of ears per plant and number of kernels per ear (Slingo *et al*., 2005). However, the impact on the initial stage (germination) highly depends on the crop variety, planting date and the climate, consequently the effective full cover for many crops including maize occurs at the initiation of flowering. Hence, lack of or insufficient rainfall during these stages retards the development of the crops and may lead to total crop failure.

3.3 Impact of rainfall variability and prolonged dry spells occurrence on crop yield

Studies carried out on the crop – climate relationship around the world have revealed that there is a considerable relationship between climatic condition and the crop yields (Bergaschi *et al*., 2001; IITA, 2004; Hulme *et al*., 2001). Based on the rainfall variability and prolonged dry spell occurrence experienced during drought years in Homa Bay County, it is prudent to investigate its impact on food crops and its relation to risk of food insecurity. Concerted efforts by various studies to investigate the effects of drought onset and duration on food security, gives a clear foundation of enquiring the rainfall variability and extreme dry spells conditions and years to their impacts on common food crop yields every year in Homa Bay County. Nyandiko *et al*., (2013) observes that in Lower Eastern Kenya region, inter annual rainfall variability has caused a major stress to farming and crop production that has only resulted to famine and hunger to the poor and vulnerable rural population.

The results from the analysis of food crop yield data were based on their availability from the County Government of Homa Bay County. An annual crop yields for ten (10) years from the years (2007 – 2016) were acquired and analyzed. The food crops that are mainly grown in Homa Bay County are maize, sorghum, millet and beans. According to the County Integrated Development Plan for 2013 -2017 for Homa Bay County, food crops majorly maize and beans take account of about 80% of the crops cultivated in the County while the rest with very minimal of the remaining percentage(GoK, 2013). This forms the back drop of its choice of evaluation in relation to drought years in Homa Bay County.

The analysis in Figure 3.3 shows that during the dry years, Maize and beans were mostly affected and did not achieve the minimum average yields of 1.44 tons /ha and 0.78 tons/ha respectively while Sorghum and millet were not so much affected and attained yields that were above average of 0.94 tons/ha and 1.61 tons/ha respectively. This suggests that despite the low acreage covered by sorghum and millet as compared to maize and beans that take 80% of food crops in Homa Bay County, the two crops can improve food security in the event of prolonged dry spells.

Maize and beans showed a high significance that was of no substantial increase in yield while Sorghum and millet indicated a low significance that showed substantial decrease in millet yield under the years in considerations. Due to overdependence on maize and beans that are drought sensitive, there is a substantial decrease in other food crops cultivation that has reduced their cumulative yield over the years in Homa Bay County hence exacerbating food insecurity (Daily Nation, 2016). The most affected years by droughts were 2007, 2009, 2011, and 2015 that indicated lower food crop production than the rest of the years under consideration. Yield of various crops were average during the years that were considered to receive normal amount of annual rainfall while during the wet years, the crops experienced reduced yields too.

Previous studies on the drought occurrences in the Lake Victoria region by Awange *et al*., (2007) and that of Onchiri *et al*., (2016) in Mbita Sub County revealed that Homa bay County experienced drought conditions in the years (1991/92, 1995/96, 1999/2000, 2004/05, 2008) with extreme drought in 2009/10. One of the years that experienced much lower crop production as a result of the extreme drought is 2009. Between July 2011 and mid 2012, a severe drought affected the entire East Africa region causing severe food crisis in Kenya (UN, 2012).

Mateche, (2011) observes that in 2015, prolonged dry spell affected over 1.6 million people in Kenya with marginal agricultural livelihoods subjecting them to famine. Ifabiyi *et al*., (2011) points that rainfall amount received in an area has a greater effect on the crop yields in a given year of production. The study finds out that the low annual rainfall amount in specific years contributed immensely to the low production of the specific food crops under investigation in Homa Bay County. These results therefore confirm the assertion that climate change is expected to increasingly impact on crop production and livestock in Busia and Homa Bay County (Luedeling, 2011).

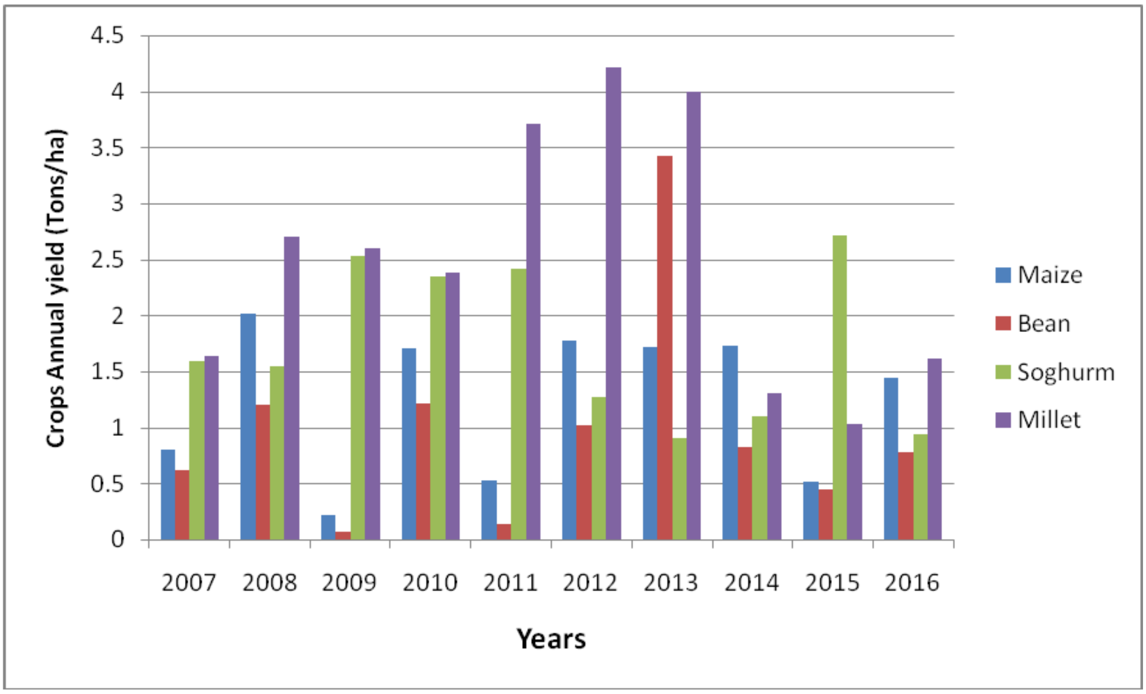

Figure 3.3: Impact of dry spell on main food crops in Homa Bay County
Source: Field Data (2017)

Variability in rainfall characteristics have a greater potential to crop failure and majorly in food crop yield and hence food insecurity in most Sub Saharan Countries in Africa (Adamgbe *et al*., 2013). However, the impact is exacerbated by the fact that a large proportion of these population depends on rainfed agriculture where there financial, technological, political and social capacities both at the national and local levels adaptability to the changing climatic conditions are slow (Ifabiyi *et al*., 2011). Rainfall variability worsened by prolonged dry spell occurrence within seasons and years of agricultural production therefore has serious repercussion to small scale farmers in food crop production. Evaluating crop response to the changing annual rainfall amounts received in a given area can hence inform the best mitigation strategies to reduce the impact of the prolonged dry spells and improve crop yields.

3.4 Impact of dry spell on livestock production in Homa Bay County

Livestock farming is also an important source of livelihood for the communities in Homa Bay County. This section presents findings on the impact of dry spells on livestock production which also affects food security (Figure 3.4). The results reveal that majority of the respondents at 48% indicated weight loss, reduced milk production was second at 23.8%, death of livestock was rated third at 18.3%, rise in disease cases indicated at 10.9% and 4% pointed at the loss in fertility during dry spells respectively.

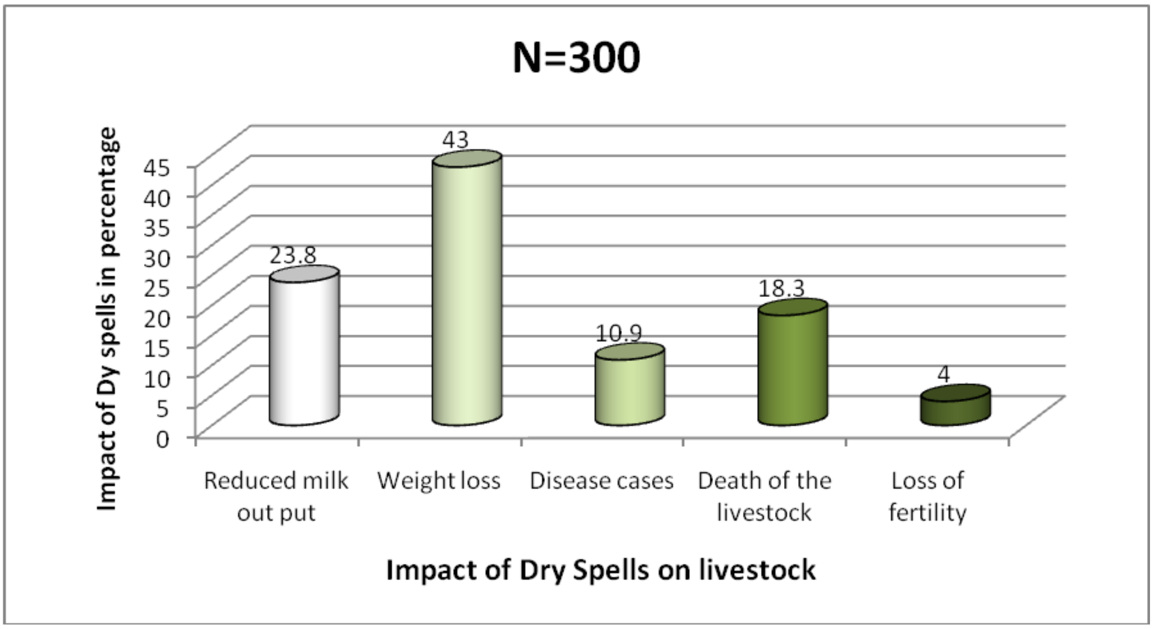

Figure 3.4: Impact of dry spells on livestock production in Homa Bay County
Source: Field Data (2018)

Based on the Chi-Square analysis obtained a computed χ^2 value of 119.9 with 4 degrees of freedom and a p- value of 0.082 at 0.05 margin error, which has less significance level, indicated variation in dry spells impacts on different aspects of livestock production and health that can negatively reduce production hence food insecurity. Livestock production is a major economic and social activity in many parts of Kenyan ASAL communities that account for nearly 90% of the employment opportunities and 95% of the family incomes (Huho and Mugalavai, 2010). Like many parts of ASALs globally, prolonged dry spells impacts on livestock in Homa Bay County causes reduced production hence food insecurity that results to starvation. Participants of the FGDs and face to face interviews of the household heads that during the dry spells accompanied by high temperature that characterizes the Lake Basin region, evaporation is high hence leaving the soil with moisture deficiency.

Dry spells make the fodder and pasture to dry up faster and thus causing insufficient feed for the livestock (GoK, 2004). Due to insufficient feed, it was evident as stated by the participants in the FGDs that animal weight is affected by the shortage of quality and quantity feed for livestock that accounted for the high number (48%) of respondents. Prolonged dry spells is pose a major constraint to livestock by lowering the quality and quantity of the feed that largely causes animal starvation and hence reduced productivity (GoK, 2004). Water is another important factor for the health of livestock. During dry spells, there is more water stress and the livestock are in dire need of safe and plenty of water for survival.

Water pans are impacted on through excess evaporation due to high temperature. Intense evaporation reduces the water levels in the water pans hence making it inaccessible. This is also attributed to the fact that at this time so many households have exhausted water stored at the homesteads and share on the use of water pans with the livestock as well as for supplemental irrigation mainly for small scale vegetable famers around the water pans. Though there are some water pans and ponds in the area, the scramble between livestock and human beings for water for both domestic and agricultural use is an indication that dry spells has adversely impacted on the area. The few water pans like Kobondo and Okii are insufficient, they evaporated and dry up very fast in the event of dry spells. This in turn impacts on livestock through reduced feed and hence reduced production. It was therefore revealed that reduced pasture and water stress affect the general health of the livestock that contribute to other impacts like reduced milk (23.8%) production. Reduction in milk production is one of the greatest economic impacts of dry spells. Nardone *et al*., (2010) observes that decreased synthesis of hepatic glucose and lower non esterified acids in blood during dry spells characterized with high temperature causes reduced glucose supply to the mammary glands resulting to low lactose synthesis hence reduced milk yield.

Reduced milk yield is further intensified by reduced feed consumption by the livestock. This is attributed to the high temperature caused by the dry spells that makes the pasture dry and of low nutrition. Generally, milk reduction due to prolonged dry spells is attributable partly to reduced feed intake. Rege and Tawah (2006) found out that approximately 35% of the reduced milk production is due to decreased feed intake while the remaining 65% is attributable to increased heat stress. However, other factors that are responsible for reduced milk production during dry spells are decreased nutrient absorption, effects in rumen function and hormonal status of the animal (Wheelock, 2010).

Temperature increase as high as 38 degrees Celsius due to prolonged dry spells in Homa Bay County is normally severer in the months of January and February and extents to early March (GoK, 2013). This causes severe depletion of natural pasture on which 99% of the livestock in the County depends on. Due to lack of or insufficient feed, there has been continued loss of livestock every time the dry spells occur (GoK, 2016). In this study, livestock deaths were rated third by the respondents in regard to impacts dry spells at 18.3%. Focus group discussions revealed that during the dry spells, the livestock sector is one of the sectors worst hit. This is characterized by weight loss due to lack of feed, followed by deaths when the dry spells persist. Some of the causes of deaths of livestock as stated by the residents are long distances travelled by the livestock in such of forage and water that continues to reduce their energy and weakens them more and more.

The other factor that has been the cause of livestock deaths during the dry spells in the area as indicated by the participants in a FGD is that due to lack of the usual feed, the livestock start eating other plants that may be poisonous to them. This was evidenced in Arujo village in Homa Bay where 18 cattle died as a result of consuming poisonous weed. This was also confirmed by a KII informant with the County chief officer for Agriculture that the cattle belonging to six farmers died after consuming poisonous weed known as bracken fern. He reported that the poisonous weed is drought resistant and remains the only surviving plant during drought and that is why the animals tend to consume it. During dry spells, pastures are short in forage but can be full of plants that are toxic and deadly to animals. In good pasture condition, animals avoid eating such plants unless accidental. The common toxic chemical to animals is prussic acid. Other plants with concentrated levels of nitrate and nitrite are found in Sudan grass, pigweed and ragweed (Knight *et al*., 2004). These plants should therefore be made known to farmers to be cautious in their pastures during drought situations.

Dry spells have high potential of increasing the livestock disease risks. In this study, 10.9% of the respondents indicated that there are increased cases of livestock diseases during dry spells. Livestock health majorly depends on the type, quantity and quality of feed it consumes but during drought, these important factors are reduced hence increased vulnerability to diseases. Drought conditions potentially affect all sources of water and specifically surface water (Abebe, 2009). It is of great importance to monitor the quality of water especially when the amount gets limited. It helps get track of the quality parameters of water like dissolved solids, sodium, sulfates and nitrates. Mendelson and Rober (2000) observed that blooms of blue or green algae are of great risk during dry spells. The Cyan bacteria produce toxins that can affect the liver and the nervous systems. Depending on the specific and quantity of toxins ingested, the animals will get weak, and sometimes die suddenly.

The effects of parasites and infectious diseases are often amplified during drought conditions. Admasu, (2005) observes that it is partly because of increased transmission in crowded places like the water points and pasture fields but also due to lower immunity resulting from poor nutrition. Diseases like Salmonellosis, fibrinous pneumonia and pinkeye are always devastating during prolonged dry spells in many parts of the world (Mochabo, 2005). This is therefore an indication of the number of respondents suggesting increase in livestock disease cases causing reduced livestock production hence increased incidences of hunger in Homa Bay County.

Prolonged dry spells generate a range of challenges to small scale livestock farmers when they occur. From the study, 4% of the respondents show that livestock farmers experience loss of fertility among their livestock during dry spells in Homa Bay County. Earnerson *et al*., (2014) observes that dry spells are always accompanied by high temperature that exacerbates heat stress which may decrease fertility in both male and female animals. Semen quality and vitality may also be negatively impacted on. In female animals, the heat may reduce expression of estrus and conception rate. Drought increases incidents of abortion due to reduced nutrients in feed and heat stress. In his study, it was however observed that on average pregnancy rate, 93% of the livestock was not significantly affected by drought but severe heat stress. From the Focus Group Discussions, the participants raised concerns on the rate of reproduction of the livestock during dry spells. It was mentioned that when the dry spells occur, the livestock stops conceiving and the poultry too stops laying eggs. It was mentioned that it is because of the stress experienced by livestock from low quantity of feed that lowers the bulls' energy.

Key informants revealed that Okii water pan is one of the most relied upon water source in the area serving many communities for both domestic and agricultural practices. Reports from a FGD conducted in Kobondo and Arujo concurred with the field observations that the few water pans and ponds dry up in the event of a severe dry spells. Field observations revealed that most areas where the water sources are located do not have either piped water or reliable bore holes. Owing to the perennial nature of the water sources and impact from dry spells, the households in this study area fall under the 3.5 billion continuously unsatisfied population with water scarcity world wide as established by United Nations World Water Assessment Program (2014).

3.5 Impact of dry spells on different types of livestock in Homa Bay County

The study sought to establish the types of livestock reared in the study area. It was established that the main types livestock reared in Homa Bay County are the zebu cattle, red Maasai sheep, the small East African goat and indigenous poultry (GoK, 2013). The livestock are bred on subsistence basis and not for commercial purposes. This is due to the limited grazing land in the County hence hindering commercial practice. The study sought to determine the impact of dry spells on different types of livestock and the results are as shown in Figure 3.5. The results in Figure 3.5 reveal that majority of the respondents 59% (177) indicated that cattle are the most affected when the dry spells occur. Sheep were the second most affected at 30% (90), followed by goats while poultry were the least affected during dry spells at 9% (27) and 2% (6) respectively.

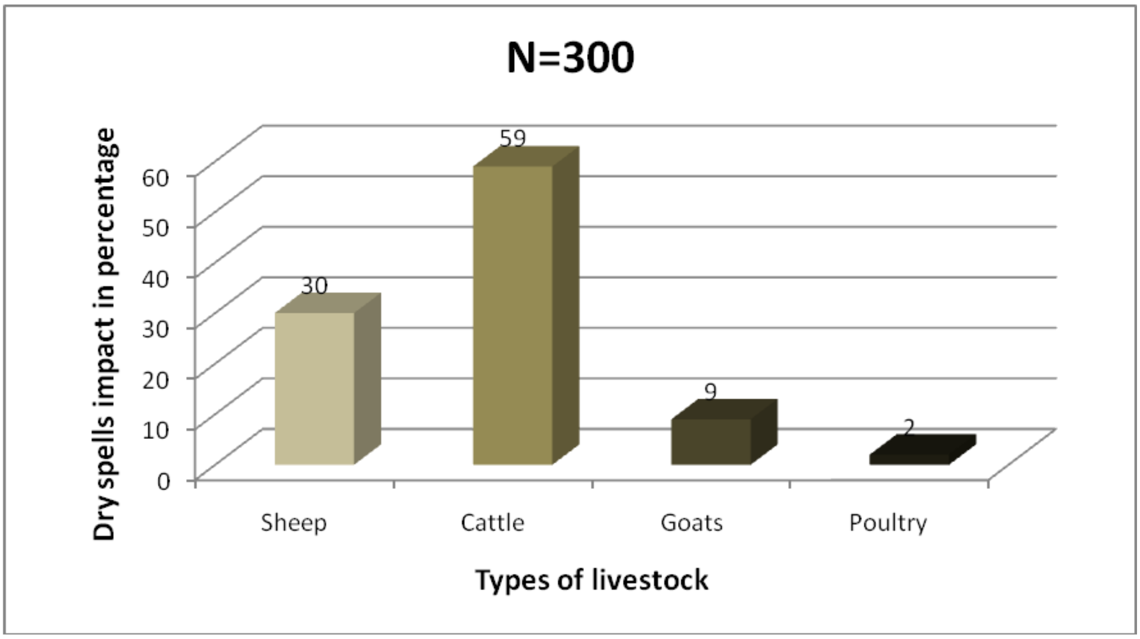

Figure 3.5: Impact of dry spells on different livestock in Homa Bay County
Source: Field data (2018)

The Chi–Square value ($\chi^2_{3,0.005}$ = 38.9) of the varriation in household heads of the respondents was significant at (P>0.05). This suggests that the dry spells impacts are varried on cattle, sheep, goats and paoultry when it occurs. Livestock rearing as one of the main sources of livelihood experiences different forms of impacts hence food insecurity based on the livestock mostly bred and impacted on by dry spells in Homa Bay County. Small scale farmers attest to the continued change and varriation in climate that has increased chances of long dry spells and drought that has impacted on livestock in Homa Bay County. The major challenges facing livestock in Homa Bay County are drought, malnutrition due to low quality feed and tsetse fly infestation specifically in Lambwe valley (GoK, 2016). Malnutrition, pests infestation and low quality and quantity of feed are exercabated by dry spells and drought (De La Rocque *et al*., 2008).

Death rate during of prolonged dry spells is ussually high among particular species and types of livestock. Cattle, donkeys and horses are generally less resistant to drought than sheep, goats and camels (Musimba *et al*., 2004). There are other livestock that can endure drought impacts than others. This may be based on different characteristics encountered in different environments for easy adaptability and survival in different environments with different characteristics. This means that there are other livestocks that are drought tolerant than others. From the Focus Group Discussions, participants tended to agree more that cattle are the most vulnerable to dry spells than any other livestock like goats in the County. The cattle and sheep tend to highly depend on grass than any other edible plants. The natural pasture are affected so easily by dry spells than other plants hence they suffer more than other types of livestocks like sheep and goats. Other factors which were mentioned by the participants were that cattle consume and require more feed and water than the other livestock so in the event of dry spells, due to lack of quality and quantity feed they die or get diseased easily.

During dry spells, there is increased temperature that induces heat stress in the livestock. The heat stress therefore has numerours effects on livestock from reduced energy due to low feed consumption and increased vulnerability to diseases. GOK (2016) observes that livestock have different mechanisms to dissipate heat and maintain the normal temperature. These mechanisms include conduction, radiation, convection and evaporation. However, the cattle have limited ability to sensibly lose heat through conduction, radiation and convection but only through evaporation. This explains the increased vulnerabilty to dry spells as indicated by majority of the respondents in Homa Bay County by 59% in agreement that they are the most impacted on during dry spells.

Sheep were secondly rated at 30% as the most impacted and vulnerable to dry spells after cattle in Homa Bay County. It was established that like cattle, sheep also to a higher percentage depend on grass that is more vulnerable to dry spells than other plants. During dry spells there is increased disease and parasite occurrences. Due to the fact that sheep graze close to the ground, they easily pick up worm larvae. Sheep and specifically lambs take long to develop immunity hence they easily succumb to secondary bacteria infection that may lead to death (Salem, 2010).

Both external and internal worms are a big problem to sheep production than any other animal during the dry spells. However, it was established from the County Agricultural Officer that sheep fall under the category of drought tolerant livestock naturally due to the fats that helps the sheep to take long before being affected by intense dry spells. It is therefore clear that the main cause of vulnerability to sheep in Homa Bay County is disease and parasite infestations.

Goats bred in Homa Bay County are basically indegenious. Findings shows that they are the least vulnerable livestock to dry spells in Homa Bay County. It was rated by the respondents as third most vulnerable at 9% among other livestock bred in the County. From a focus group discussion, one participant explained that goats consume less compared to other livestock and are not easily affected by diseases during dry spells. Given the fact that goats eat any vegetation availlable, it therefore confirms why they survive longer than other various livestocks that solely depend on grass in Homa Bay County. Abella (2005) observes that in semi arid areas, goats have comparative advantage over cattle and other livestocks because they are more tolerant to drought and are increasingly used to augment cash income and enhance food security. Due to there resistance to drought, goats use a wide range of plants and their high reproductive rate enable them to recover quickly even during drought situations (Alamer, 2009). During prolonged dry spells, sheep and goats are under stress. Maria *et al*., (2007) observes that the stress increases their susceptibility to the out break of coccidiosis and other related diseases. Frequent inspection is therefore recommended to the heard to reduced the disease cases. This will hence increase production of the livestock for small scale farmers.

Majority of the respondents in Homa Bay County do not agree that poultry farming is not much affected by dry spells as compared to other livestock. It is rated at 2%, the lowest impacted by dry spells among other livestock. Dry spells that manifest into a cute shortage of water and reduced feed availlabilty has affected the poultry farming among the small scale famers. It was established from the focus group discussions that majority of small scale farmers in Homa Bay County practice free range poultry farming “kienyeji” farming. Local poultry production is found in all AEZs in the County. The indegenious poultry are reared for mainly food security and for income generation to pay school fees and other expenses (GoK, 2016). However, there are other economically enriched farmers who can afford to supplement their stocks to improve the local breeds productivity during drought situations. Due to the fact that most of the stocks greatly rely on free range for their feed, they stand to be more resistant to dry spells conditions even without suppliments than exotic breeds.

3.6 Dry spells impact on the different agricultural commodities available and market prices

Besides the impact of dry spells on crop and livestock, respondents also reported on the impacts on market prices of the agricultural products and yields that distablizes the food accessibility as one of the pillars of food security. Based on this, respondents were asked to indicate if the crop and livestock products market prices increase or decrease in the event of dry spells in the study area. The results in Table 3.2 show that 98.3% (295) of the respondents strongly indicated that fodder and pasture for livestock feed price increase in the event of a dry spell; 99% (297) indicated that food crops prices increase; on livestock products, 35% (105) indicates that the prices increase while 65% (195) disagreed by showing that the prices decrease; and 98% (294) strongly indicated that the livestock prices in the market decreases while only 1% (3) shows that prices increase.

Table 3.2: Level of impact of dry spells on different agricultural products market prices

Impact on Market Price	**Increase**		**Decrease**	
	Frequency	Percent %	Frequency	Percent %
Pasture/fodder	295	98.3	5	1.7
Food crops	297	99	3	1
Livestock products	105	35	195	65
Livestock prices	3	1	294	98

Source: Field data (2017)

Cross tabulation of the data obtained gives a χ^2 value of 0.860, with 3 degrees of freedom and a p – value of 0.09, which was less significant at 0.005 error margins. The results there for show variation that there are change in market prices of different agricultural commodities during dry spells. According to the United Nations world summit, 1996 definition, food security is a situation where all people at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (Gaus, 2012). In the event of a dry spell, the accessibility that is informed by availability, stability and utilization becomes compromised.

The study reveals that crop failure to achieve the expected yield and livestock production, reduces to a higher percentage availability of safe food that can satisfy the dietary need of the community and the unavailability may have impact on the food prices. Most households get access to food by purchasing (93%) followed by own food production (4%) in most African countries (Mjonono *et al.*, 2009). From the FGDs, livestock solely depend on water and grass to produce milk and other quality products but has not been the case in different seasons. Increased temperatures as high as $38^0 c$ around January to February lead to depletion of natural pastures on which 99% of livestock depend on as well as loss of livestock. Around January and February, the communities experience water scarcity because the rivers dry up. Increased incidences of crop and livestock diseases in the County were also reported, (GoK, 2013). Increased disease incidence on livestock during dry spells therefore explains the reason for 65% decreased livestock product prices. This is due to the low quantity and quality feed for livestock providing low quality products like meat, milk, hides and skins that many regard as unhealthy for human consumption.

During prolonged dry spells, many livestock are rendered unhealthy and that is the time when many farmers rash to sell them to slaughter houses at throw away prices or some are slaughtered at home and sold cheaply to the residents due to their low quality. The low quality of livestock products in return compromises the principle of food security and healthy food which threatens the health of many residents in Homa Bay County. From a FGD, the participant added that the dry spells in other cases push the cost of production materials high hence reduced production. This makes the affordability high affecting many households in the County. However, it depends on the type of products from the livestock where the participants indicated that there are other products like skins and hides whose quality will reduce in the event of a dry spell. This reduces the prices of livestock products in the markets and can account for the 35% who indicated that prices reduce when dry spells occur. Food crop prices have also shot up due to the dry spells that reduce their production hence scarcity in the stores and markets. The situation hence impact on the access and availability of the food that affect the food security situation of the study area. From the FGDs, livestock market prices are determined by the health of the livestock. Healthy livestock fetch higher market prices compared to unhealthy livestock. From key informant in the ministry of agriculture, the health of the livestock is primarily determined by the prevailing environmental conditions and quality and quantity of the feed.

In the event of the dry spells, the feed quantity and quality reduce. This impact on the health of a good percentage of the livestock in the study area hence reduced market prices. The farmers are hence enabled to sell their livestock at throw away prices $.150 from $. 200 for a mature cow to get money to buy other commodities like the staple feed such as maize, beans, and vegetables. This observation supports the large percentage of 98% of the respondents that indicated the reduced market prices for livestock during dry spells. Food security is hence destabilized when there is no sustainability in production and consumption.

4. Conclusions and Recommendations

Annual Maize and beans production for the years that were affected by prolonged dry spells (2007-2016) were below average of 1.44 tons/ha and 0.78 tons/ha respectively while Sorghum and millet were above average of 0.94 tons/ha and 1.61 tons/ha respectively hence sorghum and millet are suitable for increased food security in this region. Livestock production was impacted greatly at 48% through weight loss and 23.8% reduced milk output respectively. Homa Bay County residents are therefore susceptible to agricultural production failure hence food insecurity.

The findings revealed that rainfall variability and dry spells impact on food security in the County through mass crop failure and reduced livestock production and death. It is therefore recommended that both national and county governments and other stakeholders put in place effective risk transfer strategies to ensure sustainability in rainfed agriculture in the area.

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