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Effects of Climate Variability and Change on Household Food Sufficiency among Small-Scale Farmers of Yatta District, Kenya

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Abstract

The overall objective of this study was to understand the impacts of climate variability and change on the food security of small-scale farmers in Yatta District, Kenya. Study participants, included 510 small-scale farmers were randomly sampled in all the 17 administrative locations while the district departmental heads from the Ministries of Water, Agriculture, and Environment formed the key informants. Participatory Vulnerability Profiles (PVP) approach was employed, focusing on the small-scale farmers' current vulnerability to climate change. Questionnaires, interviews, Focus Group Discussions (FGDs), stakeholder analyses, field observations, and desk research techniques and tools were used to generate the data. Qualitative and quantitative data analysis techniques were used while the results were presented in tables, figures and charts. Findings of the study indicate that climate variability has negatively affected food availability, food access and food adequacy which leads to food insecurity in Yatta District. Pearson correlation coefficients for annual precipitation Coefficient of Variation (CV) against crop yield for the period 2004 to 2010 revealed negative correlations for maize (r = -0.614), beans (r = -0.579), sorghum (r = -0.328), cow peas (r = -0.568), and pigeon peas (r = -0.221). Recommendations were made for farmers' awareness and the Ministry of Agriculture to formulate policies to improve the situation about climate change and its effects on food production in Yatta District.

Keywords: *Climate Variability and Change, Small-Scale Farming, Food Security*

1. Introduction

Agriculture provides livelihoods for about 60% of Africa's active labour force, contributes 17% of Africa's total gross domestic product and accounts for 40% of its foreign currency earnings (Harsch, 2004 and Sharma, 2005). Agriculture is highly dependent on climatic conditions, and being one of the most sensitive activities to the negative effects of climate change i.e. its performance depends directly on climate variability (Clements et al, 2011). The effects of global warming are already visible in much of the world. In some areas, moderate warming can slightly increase crop yields, though negative impacts increasingly dominate. Although the effects of changes in climate on crop yields are likely to vary greatly from region to region, anticipated changes, however, are expected to have large and far-reaching effects predominantly in tropical zones of the developing world with precipitation regimes ranging from semiarid to humid (Cline, 2007). Droughts and floods in these areas have been reported to become more frequent and severely causing failure and damage to crop and livestock leading to chronic food shortages (Kangalawe & Liwenga, 2005 and Liwenga et al, 2007). This has also lead to increased risk of conflicts over land and water. Climate change also influences patterns of spread of pests and invasive species and may increase the geographical range of some diseases (Green Facts, 2008).

The fourth Intergovernmental Panel on climate change report indicates that all the four dimensions of food security identified by the Food and Agriculture Organization (FAO), namely food availability (i.e. production and trade), stability of food supplies, access to food and food utilization will likely be affected by climate change. Importantly, food security will depend not only on climate and socio-economic impacts, but also, and critically so, on changes to trade flows, stocks and food-aid policy (IPCC, 200). Various studies show that as a result of climate change, there is a reduction in the production potential of tropical developing countries, many of which have poor land and water resources, and are already faced with serious food insecurity, adding to the burden of these countries (Hitz & Smith, 2004; Fischer et al, 2005 and Parry et al, 2005).

In Africa, climate exerts a significant control on the day-to-day economic development, particularly for the agricultural and water-resources sectors, at regional, local and household scales. Observed global temperature patterns have indicated a greater warming trend since the 1960s (IPCC, 2007). Although these trends seem to be consistent over the continent, the changes are not always uniform. For instance, decadal warming rates of 0.29 °C in the African tropical forests (Malhi & Wright, 2004) and 0.1 to 0.3 °C in South Africa (Kruger & Shongwe, 2004) have been observed. In South Africa and Ethiopia, minimum temperatures have increased slightly faster than maximum or mean temperatures (Conway et al, 2004 and Kruger & Shongwe, 2004). Between 1961 and 2000, there was an increase in the number of warm spells over southern and western Africa, and a decrease in the number of extremely cold days (New et al, 2006). In eastern Africa, decreasing trends in temperature from weather stations located close to the coast or to major inland lakes have been observed (King'uyu et al, 2000).

Variability in precipitation in Africa has also been reported. In the tropical rain-forest zone, for instance, declines in mean annual precipitation of around 4% in West Africa, 3% in North Congo and 2% in South Congo for the period 1960 to 1998 have been noted (Malhi & Wright, 2004). A 10% increase in annual rainfall along the Guinean coast during the last 30 years has, however, also been observed (Nicholson et al, 2000). In different parts of Southern Africa (Angola, Namibia, Mozambique, Malawi and Zambia), a significant increase in heavy rainfall events has also been observed (Usman & Reason, 2004), including evidence for changes in seasonality and weather extremes (New et al, 2006). During recent decades, Eastern Africa has been experiencing an intensifying dipole rainfall pattern on the decadal time-scale. The dipole is characterized by increasing rainfall over the northern sector and declining amounts over the southern sector (Schreck & Semazzi, 2004). It is projected that crop yield in Africa may fall by 10-20% by 2050 or even up to 50% due to climate change (Jones & Thornton, 2003), particularly because African agriculture is predominantly rain-fed and hence fundamentally dependent on the vagaries of weather (Enete & Amusa, 2010).

Over the past decade, the incidence and intensity of hunger and malnutrition has increased significantly and food availability has not kept pace with the rapidly growing population in Kenya (Shori, 2000). The regions that are associated with hunger are mainly the arid and semi-arid lands. Decreased food production, drought and famine are very regular in these areas despite the involvement of the largest proportion of population in agriculture. Increasing temperatures and frequent droughts have worsened the already fragile situation of the small-scale farmers who rely on rain-fed agriculture for survival. Yatta District lies in these arid and semi-arid areas characterized by frequent droughts and food insecurity. Drought and famine are very regular in Yatta District and the communities in this district are quite vulnerable to the changes in climate. Agriculture is the most important sector in this district contributing 70% of the district's household income (Republic of Kenya, 2009).

Climate variability and change act as a multiplier of these existing threats to food security by making natural disasters more frequent and intense. Natural disasters such as prolonged drought is one cause of the breakdown of the balance maintained in natural resource use leading to a breakdown of a traditional mechanism of self-insurance against food insecurity that places the poor households to greater famine risks. Small-scale farmers in Yatta District are reporting more frequent crop failures and water shortages, and food relief has become a permanent feature of their life (Rocheleau et al, 1995).

While geography and climate largely explain Kenya's exposure to drought, the root cause of the country's vulnerability is its dependence on rainfall for its economic and social development (Kandji, 2006), which makes prone its high exposure to natural hazards, their direct dependence on climate sensitive resources such as plants, trees, animals, water and land, and their limited capacity to adapt to and cope with climate change impacts (IASC, 2009). Climate variability and change directly affects food security and nutrition and exacerbates this fragility (UNICEF, 2008). Climate variability and change is one of the greatest environmental, social and economic challenges facing humanity today and it is a phenomenon that undermines the drive for sustainable development, particularly in Sub-Saharan Africa (Tadesse, 2010).

The objective of this study was to determine the effects of climate variability and change on household food sufficiency among small-scale farmers of Yatta District, Kenya.

2. Materials and Methods

2.1. Study Area

Yatta District is situated between longitudes 37° 20' and 37° 55' east, and between latitude 0° 50' and 1° 30' south. Part of the district falls on Yatta Plateau, which is a long, flat-topped ridge formed by a stream of lava flow from Ol Donyo Sabuk Mountain. It covers a total area of 2,469 Km^2 and has a population of 299,435 inhabitants (Republic of Kenya, 2009). The population density is influenced by land productivity and water availability. People tend to be concentrated around water sources and fertile lands.

The district receives about 450-800 mm of rainfall per year. The rainfall pattern is bimodal and starts from March until May in the first season and from October to December in the second season. Average temperatures range from 29 °C to 36 °C. The main soil groups are Acrisols, Luvisols, Ferralsols, alfisols, ultisols, oxisols, and lithic soils (Lezberg, 1988). These soils are all generally of low fertility, and many are highly erodible. The dominant vegetation is dry bush. These conditions result to very low yields or even at times, no harvest is realized at all. Thus, poverty levels are very high in the area.

The main ecological zones are the agrimarginal Lower Midland Zones LM4 and LM5. These are zones characterized by short to medium and short cropping seasons respectively (GoK, 2012). The main food crops grown in the district include maize, beans, sorghum, pigeon peas, cowpeas, cassava, green grams, millet, mangoes and bananas (Figure 1).

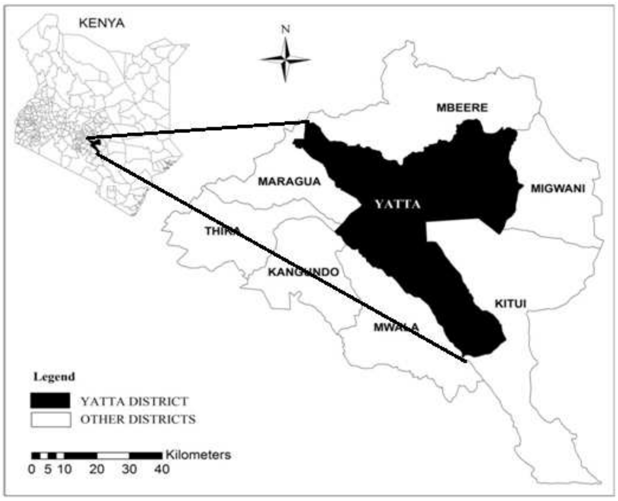

Figure 1. Study Area Location

2.2. Data Collection and Processing

The study being primarily a survey research employed several methods for data collection including the use of questionnaires, interviews schedules, Focus Group Discussions (FGDs), desk research, and observations from the field. The study adopted the Participatory Vulnerability Profiles (PVP) approach as used by Haan et al (2001). The PVP focused on current vulnerability, risk of present and future climatic variations, and responses to reduce present vulnerability and improve resiliency to future risks. This approach placed the stakeholder at the centre of the research, which is important because the people in the region have developed indigenous knowledge systems that have enabled them cope so far with the climate variability and change phenomenon.

Crop production data was obtained from the District Agricultural Offices whereas climatic data (1963-2010) was obtained from the Kenya Meteorological Department. A representative sample size for the survey was determined by using Krejcie & Morgan (1970) formula commonly used to calculate a sample size from a given finite population (P) such that the sample size will be within plus or minus 0.05 of the population proportion with a 95 per cent level of confidence.

$$s = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P(1-P)}$$

Where:

X^2 = table value of Chi-Square for 1 degree of freedom at the desired confidence level (in this case 3.84)
N = the population size, in this case 299,435
P= the population proportion (assumed to be 0.5 since this would provide the maximum sample size)
d= the degree of accuracy expressed as a proportion (0.05)

Computing the desired sample size using this formula gave 384 as the minimum number of respondents that should be used in the study. A larger sample size than 384 was, however, considered to cater for non-responses. Since sampling was farm based, to cover as much area as possible, one sub-location was randomly selected in each of the 17 administrative locations. From each of the sub-location, 30 farmers were randomly selected, giving a sample size of 510 farmers in total. District heads of agriculture, environment and water departments were also interviewed. Four single sex FGDs comprising of eight to twelve farmers were conducted.

The collected data was analysed using both quantitative and qualitative techniques. Frequency counts, means and percentages were computed for all quantitative data and results presented using frequency distributed tables and bar graphs. Focus group discussion results were transcribed and translated and then analysed qualitatively which basically involved establishing the categories and themes, relationships/ patterns and conclusions in line with the study objectives (Gray, 2004). The Coefficients of Variation (CV) were computed for annual precipitation (1964-2010) and then correlated to crop production using Pearson Correlation Coefficient, at the 0.05 level of significance.

3. Results and Discussion

3.1. Food Sufficiency in Yatta District

In order to establish the status of food sufficiency in relation to climate variability and change, the farmers (n=486) were asked to describe the adequacy of food in their households for the last 5 years (2006-2010). In response, 81.3% of the farmers indicated that sometimes they did not have enough to eat, with only 0.6% indicating they had enough of the kinds of food they wanted to eat (Table 1). The study established that most of the farmers in Yatta District were experiencing food insecurity. FAO (2003) defines food security as access of all people at all times to sufficient, nutritionally adequate, and safe food, without undue risk of losing such access. In this study, only 7.8% of the farmers in Yatta District were enjoying food security for the period 2006-2010. These comprised of those who had enough kinds of food they wanted to eat and those who had enough but not always the kinds of food they wanted.

Table 1. Sufficiency of Food in the Households (2006-2010)

Food Sufficiency	No. of Farmers	Percent
Sometimes not enough to eat	395	81.3
Often not enough	53	10.9
Enough but not always the kinds of food we want	35	7.2
Enough of the kinds of food we want to eat	3	0.6
Total	**486**	**100.00**

Majority of the farmers were worried whether their food would run out before the next harvest, adding that the food harvested did not last and they did not have money to buy more. Majority of the farmers also indicated that they could not afford to eat balanced meals, which is an indicator of food insecurity (Table 2). Indeed only 3.5% of the farmers could afford to eat a balanced diet.

A number of factors could influence food security. According to IPCC (2007), food security is dependent on climate and socio-economic impacts, changes to trade flows, stocks and food-aid policy. The farmers in the study gave a number of reasons why their households did not always have enough to eat. As shown in Table 3, most of the farmers indicated that insufficiency of food was mainly due to insufficient harvests from previous seasons (92.2%) and lack of enough money to buy food (58.6%). Lack of firewood and inability to cook or eat due to health problems were also cited as reasons by a few farmers. The results imply that climate variability and change had affected food security among farmers in Yatta District. The farmers in the district did not have other stable sources of income other than farming, and therefore could not afford to buy sufficient food when crop failures were experienced. Droughts are increasingly becoming more frequent in the area with serious consequences to food security as these small-scale farmers depend on rain-fed agriculture. Food accessibility was at times a serious issue even to those with money. A good example is the 1983/85 drought christened "*nikua ngwete*" by the farmers. This literally meant the farmers had the money but absolutely no food in the market to buy. Climate variability and change has affected food availability, food access and food adequacy in Yatta District. Indeed it is ironical that farming households in Africa constitute 50% of the food insecure in Africa (Heidhues et al, 2004) and Yatta farmers constitute part of this proportion.

3.2. Causes of Food Insecurity

The study established that 88.9% of the farmers had on several occasions missed meals because there was not enough food. Food insecurity is associated with a number of effects, such as diseases and school dropout. As it turned out, 37.4% of the farmers indicated that members of their households had fallen sick due to lack of enough food. In addition, 38.9% of the farmers indicated that their children had dropped out of school due to lack of enough food.

The main causes of food shortages in Yatta District, as reported by the farmers, were changes in weather patterns (94.2%), poor farming methods (50.6%), land degradation

Table 2. Status of Food Security among Households in Yatta District

Statement	Often True		Sometimes True		Never True		Don't Know	
	F	%	F	%	F	%	F	%
We were worried that food would run out before the next harvest	148	30.5	322	66.3	15	3.1	1	0.2
The harvested food did not last	129	26.5	327	67.3	30	6.2	0	0.0
We couldn't afford to eat balanced meals	173	35.6	296	60.9	17	3.5	0	0.0

and soil exhaustion (35%), reliance on rain-fed agriculture (23.7%), pests and diseases (22.6%), high cost of inputs (6.2%), poor access to credit facilities (3.1%) (Table 4).

Table 3. Reasons for Food Insecurity in Yatta District

Reasons for Food Insecurity	Yes		No	
	F	%	F	%
Insufficient harvest from previous season	448	92.2	0	0.0
Not enough money to buy food	285	58.6	163	33.5
No firewood available	5	1.0	443	91.2
Not able to cook or eat because of health problems	12	2.5	436	89.7

Table 4. Main Causes of Food Shortage in Yatta District

Main Cause	Yes		No	
	F	%	F	%
Changes in weather patterns	458	94.2	28	5.8
Poor farming methods	246	50.6	240	49.4
Land degradation and soil exhaustion	170	35.0	316	65.0
Reliance on rain-fed agriculture	115	23.7	371	76.3
Pests and diseases	110	22.6	376	77.4
High cost of inputs	30	6.2	456	93.8
Poor access to credit facilities	15	3.1	471	96.9
Others	20	4.1		

The other factors (4.1%) cited by respondents as causes of food shortage included poor market prices; low demand for drought tolerant crops, inflexible dietary lifestyles, policies and poor food distribution networks. Small-scale farmers in Yatta District rely on rain-fed agriculture which is quite sensitive to changes in weather patterns. The farmers observed that the rains have become so erratic and unpredictable nowadays leading to poor timing of planting and consequently poor harvests. They noted that April long rains season can onset as early as February when farms have not yet been prepared.

Furthermore, should the rains fail even after the maize crop has flowered; the yields turn out to be very poor. This is unlike in the older days when the maize crop would proceed to give reasonable harvests. This can be attributed to land degradation and soil exhaustion that are other causes of food shortage highlighted by the farmers. Agricultural production and productivity is highly influenced by rainfall availability and distribution, which ultimately controls the length of the growing period and thus crop yields (FAO, 2010). In Yatta area, rainfall distribution has become very poor compared to the older days leading to declining yields.

3.3. Rainfall Trends in Yatta District

As shown in Figure 2, the total annual rainfall in Yatta District has been fluctuating between highs of 1388 mm in 1968 and lows of 477 mm in the year 2000. Linear regression analysis shows a gentle decline of the total amount of rainfall over the years (Y=2339.11-0.745t). For the period 1964-2010, the mean annual rainfall in Yatta decreased by 34.27 mm.

Rainfall variability in the area was also observed to be on the rise. The farmers reported increasing unpredictability of seasonal rainfall onset. The rainfall coefficient of variation (CV) for the duration 1964-2010 was calculated to give an indication of variation. The coefficient of variation basically measures variability in relation to the mean and it is a dimensionless number that is useful for comparing the relative dispersion between data sets with different units or widely different means. The CV, calculated as the standard deviation divided by the mean is often used to make comparisons of rainfall variability.

Figure 3 shows the coefficients of variations for the period 1964-2010. It shows that there has been a steady increase in CV for this period (Y= -2.429 + 0.0019t). This shows that monthly rainfall variance has been increasing over the years. This is corroborated by analysis of rainfall and river flow records in the headwater regions of the Nile during the 20th century which demonstrated high levels of inter-annual and inter-decadal variability (Conway et al, 2004).

3.4. Relationship between Crop Yield and Rainfall

Pearson Correlation Coefficients for annual precipitation CV against crop yield (2004-2010) revealed negative correlations for maize (r = -0.614), beans (r = -0.579), sorghum (r = -0.328), cow peas (r = -0.568), and pigeon peas (r = -0.221). Therefore, crop yield was negatively correlated with CV for the seven years (2004-2010) whose yield data was available. The negative correlation coefficients for these crops implying that the larger the CV the less is the yield. Consequently, it is evident that rainfall variability had significant effects on crop yield among farmers in Yatta District. Other researchers (Southworth et al, 2000 and Moriondo et al, 2011) have also established that climate variability is a major determinant of crop yield and consequently, food security.

Comparing total annual rainfall and crop production in Yatta District revealed that some years with low rainfall still recorded higher crop harvests than other years with higher rainfall amounts (2009 and 2006 respectively) (Figure 4). This could be attributed to rainfall distribution patterns or variability.

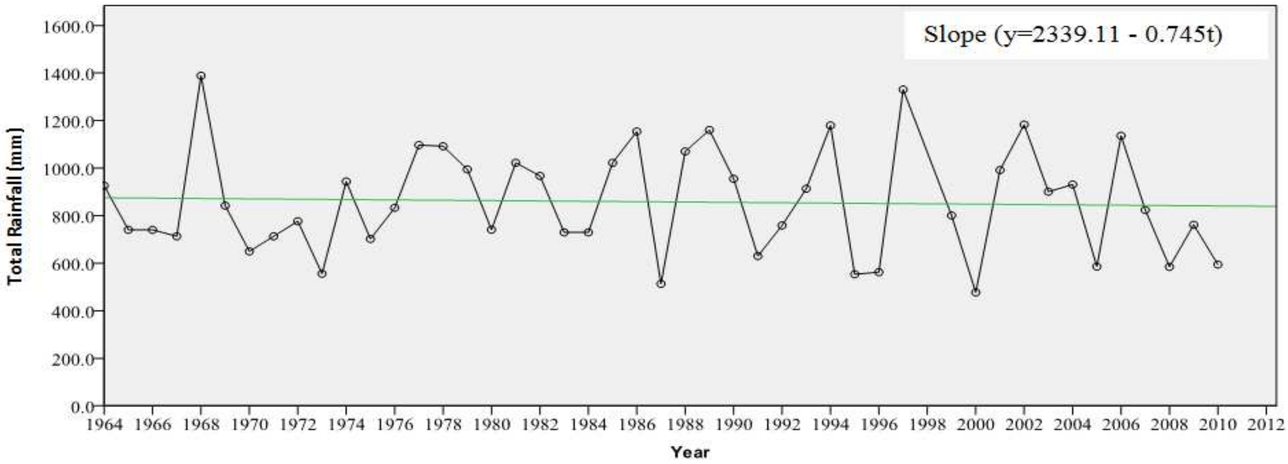

Figure 2. Total Annual Rainfall in Yatta (Yatta Furrow Station)

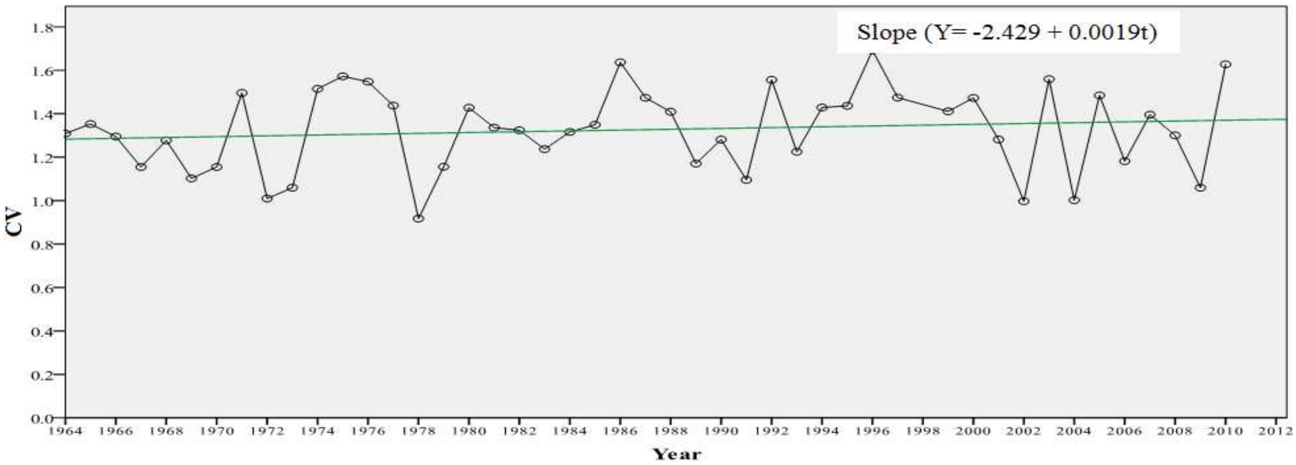

Figure 3. Coefficients of Variation (CV) of Annual Rainfall in Yatta District (1964-2010)

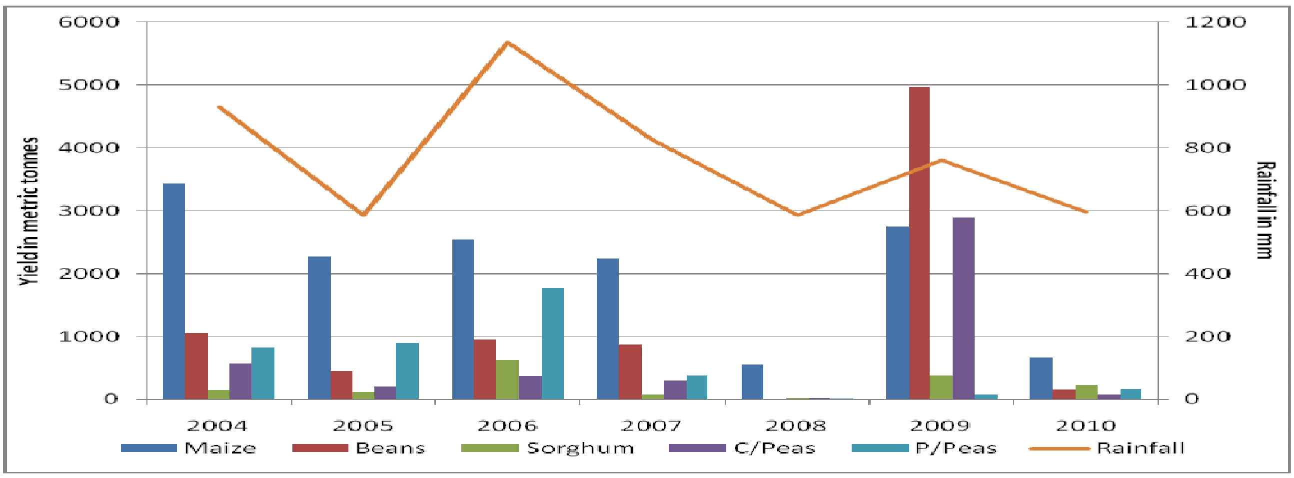

Figure 4. Total Rainfall and Crop Production in Yatta District (2004-2010)

Contrasting crop production between year 2005 and 2008, it is evident that year 2005 had better yields than 2008 even though both years had the same amounts of total annual rainfall. This difference can be attributed to better rainfall distribution in the year 2005 which experienced a total of 34 rainy days (MoA, 2005). Year 2008 had only 14 rainy days (MoA, 2008) with a good amount of rainfall falling in the months of January and February which are off season. This was confirmed by the farmers during focus group discussions who observed that the rains can no longer be predictable, unlike in the past when there was a clear sequence of seasons. As one elderly farmer in Kithyoko Location put it:-

"The rain does not fall as it used to. We used to know the time it will rain, but these days it can rain even during harvesting time and it is confusing people. Once you plant the rain goes and the seeds dry up. So the rain is confusing people".

Another farmer observed that:-

"Climate has changed because when I was young there was plenty of rain and good harvests of cowpeas, beans, millet etc. and in that time there used to be stores known as "Kiinga" (granary) which used to be filled with harvests. The food was in plenty. But nowadays, the climate has changed because the rain comes during harvesting time or when maize plantations have already withered and dried up. We wait for rain but it does not fall".

Crop-yield-variability is a significant characteristic of agriculture which is strongly influenced by fluctuations in weather. Studies show that the year-to-year variations in crop yields are normally associated with the fluctuations in weather (Edeh et al, 2011). Water availability is one of the most critical factors for sustaining crop productivity in rain-fed agriculture. Rainfall variability from season to season greatly affects soil water availability to crops, and thus poses crop production risks. In Yatta District, rainfall variability has been steadily increasing over the years as indicated by the increasing CV. This poor dispersal of rainfall over the years has had a direct negative impact on food production. Even with high amounts of rainfall, food production is not good due to poor distribution of the rains. This leads to the conclusion that climate change has contributed to food insufficiency in Yatta District.

4. Conclusion and Recommendations

The objective of this study was to determine the effects of climate variability and change on household food sufficiency among small-scale farmers of Yatta District, Kenya. The study established that climate variability and change is a reality in Yatta District, where it has negatively affected food availability, food access and food adequacy. Most of the farmers are experiencing food insecurity as a result of insufficient harvests from previous seasons occasioned by changes in weather patterns. This study established that rainfall has been decreasing and becoming more unreliable. Different forms of changes on rainfall have been identified including late onset of long rains that come in April and short rains that come from September. Variances in precipitation patterns are already observable as there has been a steady increase in rainfall coefficient of variation. Pearson correlation coefficients for annual precipitation against crop yield revealed a negative correlation for the five major crops. This is likely to intensify with additional warming implying that small-scale rain-fed agriculture in Yatta will continue to suffer with serious negative consequences to food security. Thus, further changes in precipitation patterns (both in intensity and variability) will require communities to devise sustainable adaptation measures to climate change.

In order to improve food security in Yatta District, rain-fed agriculture needs to be complemented with the development of irrigation schemes. Water harvesting needs to be enhanced and promoted. This is because climate change is expected to have serious environmental, economic, and social impacts on small scale farmers whose livelihoods depend on rain-fed agriculture. Considering the importance of rain-fed agriculture in Yatta, and Kenya in general, and the fact that ambitious mitigation efforts can only lessen, but not prevent, future climate change, the Ministry of Agriculture needs to formulate policies specifically focused on small-scale farmers' adaptation to climate change so as to improve food security. The farmers should be sensitized on the need to engage in sustainable adaptation strategies such as planting drought resistant crops and home gardening.

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