

## **Factors Affecting Maize Yield in Machakos County**

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### **ABSTRACT**

*Maize is the main staple crop for many people in Kenya. It is a high yielding cereal grown almost in all parts of the country mainly under rain fed environmental conditions. However, despite the fact that maize is the main subsistence crop there has been structural maize deficit in Kenya which has pushed the prices of maize and maize products up beyond affordable level of many households leading to food insecurity. This forced the country to import maize from other countries to cover the shortage and also provide subsidized maize flour at ksh 90 per 2kg packet. There are various factors that affect maize yield and therefore research was aimed at assessing the factors that affect maize yield in Machakos County. The research targeted mainly small-scale and large-scale farmers in Machakos County. The study sought to achieve the following objectives: To examine the maize production and yield trends for the last 10 years in Machakos County. To find out the factors that constrain realization of high maize yield in the county. The research was conducted between July and November 2017 and involved random selection of farmers by visiting them and receiving direct responses from them as they answered the questionnaires. Through the field visits; The questionnaires, interviews and field observations provided the study with primary data. Secondary data was obtained from the Ministry of Agriculture (MOA), National Cereals and Produce Board (NCPB) in Machakos and Kenya agricultural research Centre (KARLO) in Machakos. After data collection, the research findings were analyzed using graphs, frequency tables and percentages and also in regression to establish the relationship between maize yield and the explanatory variables. The research found that maize yield in Machakos county is affected negatively by prolonged droughts and shortage of rainfall due to weather variability, poor soils most of which are very acidic and others are highly alkaline (MOA 2014), lack of agricultural advisory services, lack of essential inputs. The research shall greatly benefit the farming communities comprising of both small scale and large-scale maize producers and also traders of either maize products or farm inputs. The study shall help the farmers to identify the relationship between output and variables that affect the yield they get from their farming activities.*

**Key words:** Maize yield, yield trends, Food policy, Food security, Small and large Scale farmers, Machakos county

### **INTRODUCTION**

#### *Background Information*

Agriculture is the mainstay of Kenya's economy and it accounts for approximately 27% of Kenya's gross domestic product (GDP). It is the main source of livelihoods for about 80% of the population in rural areas (MOA 2009). Maize (*Zea mays*) is the main food crop in Kenya. It is a high yielding cereal grown almost in all parts of the country mainly under rain fed environment and requires minimal capital. It is also used as animal feed especially the maize stalks, can be

stored after harvesting and fed to animals at a later period of time. Maize is not only a subsistence crop but also an industrial crop, it is used to make corn oil, flour, beer, quicker oat among others. Maize has a great potential to meet human food requirement because it has a great significance as human food, animal feed and is also an industrial crop hence it is important to analyze the factors that relate to maize yield to ensure that those that affect the yield negatively can be monitored and worked on to ensure improved yield and sustainability. It does well in a wide range of agro-ecological zones and hence the most widely produced crop. Crop yield projections of maize vary widely depending on region and specified climate scenario. Most models predict declining maize yields in large parts of ASALS and in lowlands where Machakos County is not an exemption. Kenya has undergone a transformation from a maize exporting country to maize importing and has lost competitiveness in maize production to the neighboring regions (Nyoro et al,2004). This is being witnessed in the current situation in Kenya where prices of maize and maize products have increased until the government started to provide subsidized maize meal costing sh 90 per 2kg packet. Based on the IFPRI analysis 4 out of 6 climatic scenarios predict an overall decline in rain fed maize yields. Therefore, the research will focus more on factors constraining maize production with much emphasis on the climatic changes, production technologies used, seed varieties, fertilizer, manure and other inputs used. Other variables will also be considered and these include the social and economic characteristics of maize farmer such as education level, gender among others. All these will be geared towards achievement of the objectives listed below.

### *Problem Statement*

Despite the fact that maize is the staple food of many people in Kenya, there has been rise in price of maize and maize products such as flour not only in Machakos but all over Kenya rendering many households both in rural and urban areas to be food insecure. According to the food security assessment report from the ministry of agriculture that was done in march 2013, The cyclonical droughts experienced in many counties especially those on the lower eastern part of Kenya for example Machakos county have severely hampered efforts to improve the food security situation in the county. House hold crop production is currently of little significance to house household food security as over 98% of cereals are imported from high potential neighboring counties of Machakos such as Kiambu and this drives the prices of food up to cover transportation costs. Most small-scale farmers in Machakos County are almost giving up on maize production and shifting to production of drought tolerant crops such as green grams so that after harvesting the green grams which normally fetch much better prices in the market they will sell them then buy maize. This is after continuous failure of maize crops which has left many of them without food after incurring so many production costs only to get losses.

Following the increase in maize yield from 39 million 90kg bags on 2014 to 42.5 million bags on 2015 the food was projected to sustain the country all through the year of 2016 and 2017 and prices were expected to remain fairly constant around ksh 100-120 per 2kg packet (FAOSTAT, Economic survey 2016), however contrally to this, Kenya is Currently suffering from structural deficit of maize production that has culminated to price rise to even ksh 200 per 2kg packet until lately when the government started to import and provide subsidized maize flour at ksh 90 per 2kg packet. This does not fully contribute to food security since as soon as that flour arrives in the supermarkets

and shops people buy it all and even some do not find it due to the high demand for the same relative to the supply.

### *Research Objectives*

This study sought to examine and analyze production and yield trends of maize in Machakos county for the last 10 years and examine the factors that affect maize production and yield in Machakos county.

### *Significance of the Study*

It is important to undertake a study on maize yield since yield is an aspect of sustainability according to the agricultural transformation agenda some of the reasons for targeting maize as an ideal crop for intensification in rural areas include: high yield potential of maize, diversified uses, ease in transporting, processing and marketing and most importantly its contribution to food security. Understanding the factors affecting maize yield will make it easy to address most of the challenges that are constraining maize production not only in Machakos county but also to the entire lower eastern region of Kenya and all over the country hence curb the issue of importing maize and encourage sustainable production.

### *Justification of the Study*

The researcher chose this topic of study following the maize crisis that we were then facing in the country, Kenya. As a result of maize shortage, the prices of maize and maize products such as flour have increased beyond affordable levels putting both rural and urban populations at risk of being food insecure. If this shortage persists then almost everyone in the country will be vulnerable to food insecurity. The research will contribute to efficient and sustainable production of maize to curb the prevailing maize insecurity situation in Kenya. This was achieved through interaction with the maize farmers both small and large scale producers in the selected research sites, and helping them to identify the key factors that constrain maize production and find a way out.

## **LITERATURE REVIEW**

Maize belongs to the family of grasses and is scientifically name *Zea mays*. It is a high yielding, easy to process crop and a good source of carbohydrate and survives in a wide range of agro ecological zones although it does best in warm climate. It has a short life cycle making it the first crop to harvest for food during hunger periods in Kenya.

Most agricultural production in Kenya is dominated by maize which is comprises 38.2% and dry beans (18.7%), and the two together make a half of the total cropped area. Maize production accounts for approximately 80.3% by volume of Kenya total grain output and it is packed and marketed in 90 kg bags, however yields for small holder farmers are generally low since most of their production are dependent on rainfall. (FAO 2010)

According to Byerlee and Eicher, 1997, maize is the most important and widely consumed cereal in Kenya. It is the staple food of 96% of Kenya's population with 125kg per capita consumption and provides 40% of the calorie requirements. About 70-80% of maize is produced by smallholder farmers. Self-sufficiency in maize production was achieved in the 1970s when production was high and the surplus was exported.

In MY 2015/2016, Kenya's corn production increased due to effects of higher rainfall in the marginal corn growing areas attributed to the El Niño weather phenomenon. However, current trends show that the country is struggling to achieve self-sufficiency in major staples including maize. Kenya's corn production remains constrained by underlying factors such as soil acidification due to continuous multi-year use of Di Ammonium Phosphate (DAP) fertilizer, lack of access to improved seeds, and the impact of maize lethal necrosis (MLN). The Government of Kenya (GOK) and the county governments in the corn growing areas have initiated measures to increase yields including distribution of certified seeds and alternative fertilizers to farmers.

According to GOK 2010, Kenya has experienced years of heightened food insecurity and dependence on imports and emergency humanitarian assistance in the last one decade where in 2009 Kenya imported 16.8 million bags of maize. Even in the current period Kenya is still importing maize. Maize demand in the country has been on increase outstripping supply thereby necessitating imports.

Maize consumption in Kenya whose population is currently over 40 million is projected to be about 3.2 million bags per month which amounts to 40 million bags per year. Despite the overall positive food security outlook in the non-ASALS, the situation in the Kenyan arid and semi-arid lands has deteriorated due to poor performance of rains in 2016, whereby there was delay in short rains. These ASALS which comprise of but not limited to the counties in the lower eastern region, especially Machakos are most susceptible to food insecurity due to low yields realized after receiving little or no rains (MOALF 2016).

Retail prices for corn and corn products have decreased after Kenya's National Cereals and Produce Board (NCPB), a GOK agency, lowered the purchase price for the strategic reserves in 2015 from Ksh 3,000 per 90 kg bag to Ksh 2,300. Some of the farmers in key maize growing areas reacted to the price changes by diversifying to other crops. NCPB's corn purchase price is still far higher than the prices offered to farmers in the neighboring EAC countries, creating an incentive for imports from these countries. Thornton et al. (2009) predicts a maize production decline of 8.4% in ASALs. This decline is very dangerous since it threatens food security situation for the residents of these areas.

### *Conceptual framework*

The conceptual framework is a summary of the factors that affect maize yield in Machakos County. It is comprised of independent variables, moderating variables and the dependent variable. The independent variables are those factors that affect the dependent variable or maize yield. They include demographic characteristics of farmers such as gender; male or female, age of the farmer

in years, education level, years of farmers experience in maize farming and membership in farmer organizations or cooperatives;

Characteristics of the farm like size, inputs used such as fertilizer, manure and seeds varieties Sources of labor either family labor or hired and other economic activities of the farmer such as casual jobs, livestock keeping; rainfall trends and prices of maize. Moderating variables include government policies such as input policy, credit policy and food policies and culture. The dependent variable is maize yield in tons.

## RESEARCH METHODOLOGY

### *Site Selection and Description*

The research was carried out in Machakos County, a county in the lower eastern region of Kenya. The county has a population of 1098584 people (as at 2009) and is about 6208.2km. The county borders Nairobi and Kiambu Counties to the west, Embu to the North, Kitui county to the east, Makueni county to the south Kajiado to south west Murang'a and Kirinyaga to North West. The climate of the county is semi-arid with a hilly terrain and an altitude of 1000-2100M above sea level. It experiences a bimodal rainfall mode with the long rains expected to start from march to May and short rains fall from October to December hence two cropping seasons per annum; the temperature ranges between a minimum of 15.50C and a maximum of 31.50C per annum. (Kwena et al., 2011)

### *Demographic characteristic of the county*

The population is approximately 1.098583 million as per 2009 Kenya population housing census where 49% are male and 51% female. Age distribution is 0-14 years 39%, 15-29 years is 28%, 30-64 years 27.7%, above 65 years 5% (GOK 2010). Agriculture is practiced with maize and other Drought resistant crops such as sorghum and millet being grown due to areas semi-arid nature. The land has generally been underutilized for agricultural production. The ASALS which cover 84% of the total land are also underutilized.

The study was conducted in the following sub counties

**Table 3.1. Description of study districts**

District	Area km <sup>2</sup>	No. of respondents
Masinga	1402.8	20
Yatta	1057.3	20
Machakos central	925.5	10
Mwala	1017.9	10
Kathiani	207.1	10

Source : county commissioner offices Machakos ,2013

### *Research Design*

The study used explanatory and descriptive research design that involved field visits and

administration of questionnaire to understand how different variables affect maize yield. The study also involved exploration of secondary data on maize yield trends and weather patterns specifically rainfall trends.

#### *Target Population and Scope of the Study*

The target population included the small and large-scale maize farmers who were picked at random from different constituencies. The study was only limited to Machakos county in the following five districts; Masinga, Machakos central, Yatta, Mwala and Kathiani.

#### *Methods and Tools of Data Collection*

The study used both primary data and secondary data. Secondary data was obtained from the ministry of agriculture, Machakos. The study used the following tools to collect primary data; questionnaire, interviews and field observations provided primary data. Questionnaires consisting of printed questions were issued to the farmers in Machakos County. The questionnaires are more economical to use due to their lower cost .it is also through questionnaires that a large number of farmers was reached over a wide geographical area. The research used both open ended and closed ended questionnaires though the closed ended questionnaires were more dominant since they gave farmers choices of all possible answers where they could only tick. Open ended questionnaires were also included even though they are few farmers were allowed to write answers in their own words.

The researcher conducted interviews during the issuing of questionnaires since it was just a short dialogue between the farmer and the researcher. The research was more interactive since the researcher just dealt with individual farmer at a time and this made the research also confidential.

#### *Validity of Data Tools*

The research questions were presented to the supervisors to check the objectivity of questionnaires that were used to collect the data and they gave a go ahead.

#### *Data Analysis and Presentation*

The data from questionnaires was recorded in excel tables and the response rate was analyzed using descriptive statistics such as frequency and percentages then it was presented using bar graphs, line graphs and pie charts.

#### *Ethical Consideration*

The research provided the dignity and privacy of every individual by ensuring that personal details were limited to general information and no names, identification number or telephone number was enquired from the respondents. The information was used in fulfillment of the researcher's academic requirements only.

## **FINDINGS AND DISCUSSIONS**

### *Maize Yield Trends*

*Table 4.2 maize yield trends in Machakos county*

	Secondary Data Maize Trends In Machakos County		Prices of maize	Price of fertilize
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			Long Rains	Short Rains		Buying price	Selling price	
YEAR	area in ha	yield in tons	in mm	in mm	Station	90 kg bag	90kg bag	50kg bag
2000	162000	58320	143	575	Katumani	980	1150	2000
2001	163880	78034	229	276	Katumani	1000	1250	2400
2002	153580	87685	356	398	Katumani	1050	1600	2350
2003	145000	59850	404	231	Katumani	1450	1800	2450
2004	152000	27765	238	357	Wamunyu	1500	1850	2430
2005	170000	15300	145	178	Wamunyu	1350	1800	2000
2006	167225	119330	302	367	Wamunyu	1350	1500	2200
2007	145500	71295	238	337	Wamunyu	1455	1700	2550
2008	138750	78578	202	262	mikuyu farm	1500	1850	3500
2009	170000	142800	53	327	mikuyu farm	1800	2000	3550
2010								
2011								
2012	117600	140000						
2013	117600	140000						
2014	152000	80000						

Source : ministry of agriculture, Machakos

As shown in figure 4.2 above Machakos county has been having fluctuating trends in maize yield over years from 2000-2014. The highest yield was realized in in the year 2009,2012 and 2013 with production of 140000 tons of maize and the lowest in 2005 15300 tons .In the years 2003,2004,2005,2007,2008 and 2014 the maize yield in the county was below the trend line and this is very dangerous since it increases vulnerability to food insecurity.

Yield is not significantly affected by the size of land, this is because there are some years when the land size was big but the yield was very little. For example, comparing between 2005 and 2009 the land size was almost equal but maize yield in 2009 was very high compared to 2005 which was too low. This indicates that there are other factors rather than land size that affect the maize yield for example drought. The productivity of land depends on availability of water or rainfall, inputs and agronomic technologies used.

The equation for maize yield is

$$Y = 106.59R + 1.0 L - 2705.9A - 27569M - 53460.8F + 6.89BP - 51.41SP + 44.21PF$$

Where: R - Rainfall, M- male F- female BP-Buying price of maize, A – age of farmers  
SP- selling price of maize, L is land size, PF- price of fertilizer

Age is also significant in determining the yield of maize.

From the questionnaires many farmers are aged between 51-60 years. This shows that they are the

ones who participate mostly in maize farming and the main reason for this could be because they are the only ones who own land hence most young people cannot do maize farming due to lack of land.

There's significant difference in yield between male and female farmers. This indicates that there is gender gap in agriculture.

The price of fertilizer doesn't affect maize yield very much, this is possibly because farmers use manure instead of fertilizer.

The selling price does contribute significantly to maize yield. This is because an increase in price of maize motivates more farmers to produce maize since out of it they can make some sensible income. However, the coefficient for selling price of maize is -51.41, this indicates that the NCPB has been buying maize from farmers at poor prices and this has a negative effect on maize production since farmers will shift from maize production to producing other crops that fetch higher prices like green grams.

The  $R^2$  is 0.99 which indicates that 99% of variation in maize yield in Machakos county is due to the variable factors such as weather variability particularly rainfall, limited agricultural land expansion, prices of maize, high cost of fertilizer, gender inequality in agricultural and age of farmers. The other 1% is due to other factor that were not included in regression such as education level, pest and diseases, declining soil fertility, poor quality seeds and diversion of farmers from maize production to other enterprises.

The P-values for annual rainfall, area under maize, age, gender, selling price of maize and price of fertilizer as shown in the table above indicate that they are significant in determining maize yield in Machakos Count

**Table 4.5 Data Variables**

Table 4.5	VARIABLES		Total Frequency	Percentage
	No. Of Respondents		70	
A	Background Information Of Farmers			
	VARIABLES	Description		
1	Gender	Male	34	48.57%%
		Female	36	51.43%%
				100%%
2	Marital Status	Married	50	71.43%
		Single	20	28.57%
				100.00%
3	Educational level	Adult education	7	10%

		Primary	18	26%
		Secondary	26	37%
		Higher level	19	27%
				100%
4	Age in years	20-30	12	17.14%
		31-40	14	20%
		41-50	16	22.86%
		51-60	23	32.86%
		Above 60	5	7.14%
				100.00%
5	Experience in maize farming	1-5 years	12	17.14%
		5-10 years	17	24.29%
		10-15 years	21	30%
		over 15 years	20	28.57%
<b>B</b>	<b>Information On Maize Production</b>			100
1	Mode of land acquisition	Inherited	19	27.14%
		Purchased	11	15.71%
		Rented	9	12.86%
		Family land	31	44.29%
				100.00%
2	Cropping system	maize mono crop	17	24.00%
		maize intercrop	53	76.00%
				100.00%
3	crop rotation	Yes	42	60%
		No	28	40%
				100%
4	seeds used	local varieties	31	44.00%
		improved varieties	39	56%
				100%
5	Time of planting	Before rains	21	30%
		onset of rain	39	56%
		later after onset	10	14%
				100%
6	Input use	Fertilizer	8	11%
		Manure	37	53%
		Both	25	36%

				100%
7	Farm uses of maize	Consumption and seed	57	81%
		for sale	13	19%
				100%
8	Agric extension services	Yes=1	18	26%
		No=2	52	74%
				100%

### *Gender*

As shown in table 4.5 above more than half of the respondents were female that is 51.43% and less than half was male that is 48.57%. This is a clear indicator that the study was gender sensitive and both genders were well represented. It also shows that both men and women participate in maize farming.

### *Marital Status of Respondents*

The researcher only decided to use two choices for marital status i.e married and single. Both divorced and widow statuses were combined as married. As shown in table 4.5 above more than half, 71% of the total study population is comprised of married people while less than half comprise of unmarried people that is 29%. Marital status also affects maize yield.

### *Educational level of respondents*

The research analyzed the educational level of the respondents and found that the highest percentage of respondents that is 37% had learnt up to secondary level, 27% had higher level of education, 26% primary level and 10% had adult education see table 4.5. The education level of a farmer affects the level of yield due to ability to read, interpret and respond to new information and this also determines their adoption on information on use of improved and appropriate technologies and other activities. Farmers who are less educated find it hard to receive and adopt new farming technologies.

### *Age in years*

The study sought to establish the age of the maize farmers and as shown in table 4.5 above a high percentage of the farming population is aged between 51-60 years with 33% of the total number of respondents, followed by those aged between 41-50 years 23%, then 31-40 year with 20%, 20-30 years with 17%. Those aged above 60 years have the least percentage with 7%. This indicates that most of the maize farmers are aged between 51-60 years and 41-50 years because they are the ones who own land hence can do farming.

### *Years of Experience in Maize Farming*

The study also sought to find out the respondents' years of experience in maize farming. As shown in Table 4.5 above, a high number of respondents had experience of 10-15 years of experience in maize farming, 28.57% had above 15 years of experience in farming, 24.29% had 5-10 years and

17.14% had 1-5 years of experience in maize farming. Experience in maize farming is significant in maize yield because as years pass on with continuous maize farming farmers' capacity to make improvements in maize farming increases hence increase yield. As time goes on with continued farming, farmers gain skills and knowledge necessary to make choice of the best farming technologies to use.

#### *Mode of land acquisition*

The study also sought to find out the mode of land acquisition and from the results as shown in table 4.5 , 44.29% cultivated their maize on family land,27.14% use inherited land,15.71% purchased their land and 12.86% rented land

#### *Size of land*

The researcher presented an open-ended question to farmers on the size of their land and most of the farmers own a land that is less than 10 hectares hence they do small scale farming.

#### *Proportion of land under maize*

Most farmers have set aside almost a half proportion of their total land to maize planting. This indicates that they value maize as their main food crop that can solve food security problem.

#### *Cropping system*

A great percentage of the sampled farmers use intercropping system that is 76% while less than half, 24% plant maize as a mono crop. Most farmers gave reasons why they use intercropping system such as small size of farm land and since they want to maximize use of that small land then they intercrop maize with many other crops such as beans, cowpeas, peas. And green grams. The study also indicated that most of farmers who plant maize as a mono crop are only doing maize farming for commercial purposes while those who intercrop maize with other crops, grow it for consumption purposes.

#### *Crop rotation*

The study also sought to find out whether the farmers practice crop rotation and found that more than half of the respondents that is 60% practiced crop rotation while 40% did not practice crop rotation and the main reason they gave is still on small size of land. Common crops rotated with maize include legumes such as beans, cow peas, green grams and cereals like sorghum, millet.

#### *Maize varieties and their Sources*

The study classified maize varieties used as either local varieties or improved varieties. As shown in table 4.5, the study found that more than half of the respondents that is 56% use improved varieties while less than half that is 44% still use the local varieties commonly known as kikamba in the local language. Improved varieties include Katumani, Duma 42,43.Pioneer,Dekalb as given by the farmers during the study. Those still using local varieties gave reasons for using them due to their high productivity in the region, high cost of the improved varieties in the market where a

packet of 2kg maize like Duma 43 costs over ksh 300 compared to local varieties which they would buy from the local shops at most sh 35 per kilo. The varieties of maize use affect yield because some of the varieties are designed to suit the rainfall patterns of the area for example Katumani is a drought resistant variety.

### *Time of planting*

The study established the time of planting and found that more than half of the respondents that is 56% plant on the onset of rainfall, 30% plant before the onset of rains and 14% plant later than one week after onset of rainfall. The time of planting affects maize yield because of the rain pattern and high sensitivity of maize to water availability (rainfall). Planting later after onset is brought about but not always by lack of oxen to plough the shamba on time where those farmers who don't have their own oxen usually wait for those who have oxen to first plough their own farm then they plough for them later when time has already passed by, this in turn makes their maize unable to produce because sometimes the rain season is too short. Other farmers who plant before onset also face a challenge because the rain patterns are unpredictable and in most of the times, the onset delays when the farmers have already planted this is a loss to them because once the seeds fail to germinate, no one compensates them for the loss.

### *Input usage*

Input usage was only based on fertilizer, manure or both. According to the study more than half of the respondents 53% use manure, 36% use both manure and fertilizer, and 11% use fertilizer only. The large number of farmers using manure is because of its ready availability compared to fertilizer which is attributed with high costs. The question on type of fertilizer use was open ended hence farmers listed them such as Ammonium phosphate (DAP), Calcium Ammonium nitrate (CAN) and urea. Of the manure users 85% use cow dung while 15% use green manure. Input usage affects yield because they supply the plant with the important nutrients.

### *Farm uses of maize*

The study sought information about the uses of maize and the result indicated that more than half of the respondents 81% use maize for consumption and seeds while 19% grow maize for sale.

### *Agricultural extension services*

A great number of respondents, 74% don't receive agricultural advisory services and those that receive those advisory services 26% said that the delivery is also done poorly. Agricultural advisory services are important in yield through these services the farmers are taught on the best agronomic practices and also dissemination of agricultural technologies to farmers.

*Table 3.20 Maize pests and diseases encountered by maize farmers*

Pests include

Pests	How farmers manage them
Squirrels	Scare away Use of scarecrows Some use poison
Birds	Chase away
Stalk borers	Chemicals
Cutworms	
White ants	Use of wood ash by pouring it at the base of the maize plant. Use of chemicals
Diseases	
Maize smut	Destroy and burn infected plants
MLND	“

*Other variables used in the study*

The study also assessed those farmers who have organized themselves into cooperatives and other organizations, land preparation before planting, other economic activities that the farmers are involved in rather than farming and sources of farm labor.

*Farmer organizations.*

From the interviews, The research found that only a few farmers have organized themselves into groups and these few are mostly women who usually have merry-go-round usually termed by locals as 'Mwethyia'. Many women have grouped themselves into different saving groups where they can save money and share after a given period of time, others save and when it approaches rain season they buy things like fertilizer, seeds and other farm inputs in bulk at a cheaper cost and they share amongst themselves. This helps solve input constraints by farmers. Being in these groups also saves farm labor constraints since as most farmers responded during the interviews when the time to cultivate comes they can help each other in eliminating the weeds by visiting each members' farm and helping each other to cultivate.

*Land preparation before planting*

Land preparation is also a very important determinant of yield because it's through land preparation that one clears weeds and bushes that might have grown and also ploughing land during the dry season reduces soil compaction hence facilitate easy water infiltration into the soil once it rains. Farmers gave different ways through which they prepare their shambas before planting. Some use ox plough others use jembes to hand dig their farms.

*Farmers other activities rather than maize farming*

Farmers in Machakos county undertake many other activities rather than maize farming. Some are

livestock keepers, keeping a wide range of livestock such as cattle, goats, sheep and poultry. Keeping livestock while you are a maize farmer is very economical since the stocks from maize can be fed to the animals and in turn the animals provide manure in form of cow dung. Other farmers have donkeys that help them do some activities such as fetching water from the river and selling it in the local market hotels and also selling to those people who are far away from the river; this gets them a good source of income especially during the dry seasons which are usually very long in the county.

There are other farmers who also do some formal casual labor employment, others do small businesses like retail shops, small hotels, selling vegetables in the market and others charcoal burning when life gets hard.

#### *Sources of farm labor*

Many farmers use family labor to cultivate their farms, others hire labor. In most cases the family labor is inefficient especially where the family household is small hence little yield. Those farmers who are in groups may not have some labor constraints since they may decide to help each other to cultivate by setting dates to visit each member farms in turns.

## **CONCLUSION AND RECOMENTATIONS**

#### *Summary of Key Findings*

The study found that over the last ten years there has been fluctuating trends in maize yield and weather pattern trends and prices of maize. According to Kenya agricultural sector risk assessment report 2015 maize production in Kenya is dependent on rainfall and is vulnerable to drought and year to year fluctuations, this is also in line with a study by La Rovere et al 2014 which suggest that nearly a fifth of maize production takes place in areas with high rainfall variability. The area under maize has not changed very much and this indicates that there are other factors rather than land size that affect maize yield, This is also in line with Stephen et al 2015 that increase in maize production since 1990s is driven by nearly 40 percent growth in land under cultivation it is only that this expansion is done in marginal areas where the soils and rains are less favorable to maize production. More than half of the respondents were female that is 51.43% and less than half was male that is 48.57%. This is a clear indicator that the study was gender sensitive and both genders were well represented. It also shows that both men and women participate in maize farming there is also gender gap in agriculture according to Malapit et al 2014 hence need for gender empowerment in agriculture.

According to the findings, 71% of the total study population is comprised of married people while less than half comprise of unmarried people that is 29%. The research analyzed the educational level of the respondents and found that the highest percentage of respondents that is 37% had learnt up to secondary level, 27% had higher level of education, 26% primary level and 10% had adult education. The education level of a farmer affects the level of yield due to ability to read, interpret and respond to new information and this also determines their adoption on information on use of improved and appropriate technologies and other activities. Farmers who are less educated find it hard to receive and adopt new farming technologies. The study established the age of the maize

farmers and found that high percentage of the farming population is aged between 51-60 years with 33% of the total number of respondents, followed by those aged between 41-50 years 23%, then 31-40 year with 20%, 20-30 years with 17%. Those aged above 60 years have the least percentage with 7%. This indicates that most of the maize farmers are aged between 51-60 years and 41-50 years because they are the ones who own land hence can do farming.

The respondents' years of experience in maize farming As shown in Table 4.5, a high number of respondents had experience of 10-15 years of experience in maize farming, 28.57% had above 15 years of experience in farming, 24.29% had 5-10 years and 17.14% had 1-5 years of experience in maize farming. Experience in maize farming is significant in maize yield because as years pass on with continuous maize farming farmers capacity to make improvements in maize farming increases hence increase yield. As time goes on with continued farming, farmers gain skills and knowledge necessary to make choice of the best farming technologies to use.

The mode of land acquisition from the results as shown in table 4.5, 44.29% cultivated their maize on family land, 27.14% use inherited land, 15.71% purchased their land and 12.86% rented land to farm.

#### *Size of land*

The response from the open-ended question on the size of the land indicates that most of the farmers own a land that is less than 10 hectares hence they do small scale farming.

Proportion of land under maize. Most farmers have set aside almost a half proportion of their total land to maize planting. This indicates that they value maize as their main food crop that can solve food security problem. The research indicate that a great percentage of the sampled farmers use intercropping system that is 76% while less than half, 24% plant maize as a mono crop. Most farmers gave reasons why they use inter cropping system such as small size of farm land and since they want to maximize use of that small land then they intercrop maize with many other crops such as beans, Cowpeas, peas pumpkins and green grams. The study also indicated that most of farmers who plant maize as a mono crop are only doing maize farming for commercial purposes while those who intercrop maize with other crops grow it for consumption purposes

The study also found that more than half of the respondents that is 60% practiced crop rotation while 40% did not practice crop rotation and the main reason they gave is still on small size of land. Common crops rotated with maize include legumes such as beans, cow peas, green grams and cereals like sorghum and millet.

The study found that more than half of the respondents that is 56% use improved varieties while less than half that is 44% still use the local varieties commonly known as kikamba in the local language. Improved varieties include Katumani, Duma 42, 43, Pioneer, Dekalb as given by the farmers during the study. Those still using local varieties gave reasons for using them due to their high productivity in the region, high cost of the improved varieties in the market where a packet of 2kg maize like Duma 43 costs over ksh 300 compared to local varieties which they would buy from the local shops at most sh 35 per kilo. The varieties of maize use affect yield because some of the varieties are designed to suit the rainfall patterns of the area for example Katumani is a drought resistant variety.

The study established the time of planting and found that more than half of the respondents that is 56% plant on the onset of rainfall, 30% plant before the onset of rains and 14% plant later than one week after onset of rainfall. The time of planting affects maize yield because of the rain pattern and high sensitivity of maize to water availability (rainfall). Planting later after onset is brought about but not always by lack of oxen to plough the farm on time where those farmers who don't have their own oxen usually wait for those who have oxen to first plough their own farm then they plough for them later when time has already passed by, this in turn makes their maize unable to produce because sometimes the rain season is too short.

Other farmers who plant before onset also face a challenge because the rain patterns are unpredictable and in most of the times, the onset delays when the farmers have already planted this is a loss to them because once the seeds fail to germinate, no one compensates them for the loss. According to the study more than half of the respondents, 53% use manure, and 36% use both manure and fertilizer and 11% use fertilizer only. The large number of farmers using manure is because of its ready availability compared to fertilizer which is attributed with high costs. The question on type of fertilizer use was open ended hence farmers listed them such as Ammonium phosphate (DAP), Calcium Ammonium nitrate (CAN) and urea. Of the manure users 85% use cow dung while 15% use green manure. Input usage affects yield because they supply the plant with the important nutrients.

The study indicated that more than half of the respondents 81% use maize for consumption and seeds while 19% grow maize for sale. According to Kirimi et al 2011 three out of every five smallholder farmers are net maize buyers. According to the study, most respondents; 74% don't receive agricultural advisory services and those that receive those advisory services 26% said that the delivery is also done poorly. Agricultural advisory services are important in yield through these services the farmers are taught on the best agronomic practices and also dissemination of agricultural technologies to farmers.

### *Conclusion*

The study found that maize yield is affected by many factors. Decline in maize production in the past years has been as a result of the unpredictable weather patterns especially variability of rainfall in Machakos county, lack of agricultural advisory services, limited agricultural land expansion, low producer prices, lack of access to inputs such as fertilizer due to their high cost declining soil fertility, poor quality seeds and pest and diseases infestation. Farmers are also involved in other activities such as small businesses, casual employments that destruct their farming activities this also reduces yield since they concentrate more on those activities and forget to work on their farms. Despite the fact that maize production is cheaper than buying, production is still below average leading to poverty and food insecurity and also making maize a rich man's product, necessitating imports. This calls for government to implement agricultural policies such as input policy like subsidizing the prices of fertilizer and other inputs and credit policy.

### *Recommendations*

based on findings and conclusions the study suggests the following;

Input policy to be implemented in rural areas to ensure that farmers can access the key inputs like

fertilizers at subsidized prices.

Encourage farmers to join cooperatives since they will be able to get credit facilities at low interest rates. They can also form merry go rounds and other associations. Farmers should be encouraged also to form farmer organizations where it will be easy for them to have better access to inputs like fertilizers, improved maize varieties and also when in groups or organizations farmers can share information among themselves and get information on improved farming activities.

Encourage the educated youth to take up agricultural farming as a business.

Early warning mechanism should be implemented by the Kenya meteorological department to keep farmers informed on the rainfall expected and onsets because the weather has become unpredictable.

The government should Encourage appropriate agricultural advisory service delivery by deploying more agricultural extension officers to reach many farmers and disseminate agricultural technologies in rural areas.

Encourage farmers to use manure by training them how to make farm yard manure or compost manure using local materials at their disposal since most of them use only cow dung because they do not know how to make other types of manure. Encourage farmers to plough their land before planting to increase water infiltration into the soil to reduce run offs that cause soil erosion. Implementation of all these will lead to an increase in maize yield by a bigger margin.

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