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The Contribution of Climate Smart Agriculture Practices in Mitigating Farmers against Maize Yield Losses, a Case of Bukembe ward in Bungoma County

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ABSTRACT

Over the years, the causes of climatic changes have been visible in the agriculture sector. It is noted that agricultural practices have the potential to mitigate climate change through climate-smart agricultural practices thus increases production and income of farmers. This study assesses how the effects of intercropping maize with legumes and using animal manure alongside planting of high yielding certified maize varieties mitigates farmers against maize yield losses in Bukembe ward of Bungoma County. A questionnaire set up in Open Data Kit (ODK) was administered to collect data from 250 randomly selected maize producing farmers. Ordinary least square (OLS) regression analysis was performed to ascertain if the climate-smart agriculture practices used in maize production increased maize yields hence mitigating the farmer against maize yield losses. The overall model was significant at $P < 0.05$ with an R – squared of 42%. Intercropping maize with legumes and adding manure to the maize crop was significant at $P < 0.01$; planting high yielding certified maize varieties was significant at $P < 0.05$. Few farmers planted high yielding certified maize varieties and added manure to the maize crop. This study recommends that farmers should be encouraged to add manure when planting maize and use high yielding certified maize varieties every season. Planting high yielding certified maize varieties, intercropping maize with beans and use of manure increases maize yields. Manure helps in the soil organic matter and soil moisture retention properties.

1. Introduction

Climate change forecast's estimates that there is going to be long-term changes in temperature and rainfall trends and an increase in the natural calamities, such as droughts, floods and storms (Schneider et al.,2001), which will result in a reduction in crop yields. Africa is subjected to the shocking effects of climate change and variability since it frequently has deficiencies in its adaptive capacity (Carter et al., 2007). Projections show robust transformations in regional climate features compared to the once currently happening and global warming of between 1.5°C and 2°C. The changes comprise rise in average temperature in most land and ocean, hot extremes in most populated regions, with heavy rainfall in several regions and the likelihood of rainfall and droughts in curtain regions (I. P. C. C. 2018). There are studies which shows that climate change will adversely affect agricultural and animal production through reduced production because of the changing rainfall patterns, increases in temperature and increases in animals and crop pests and disease incidence (Reynolds et al., 2015). Losses in staple crops production are due to environmental degradation, washing away of top fertile soil by running water, loss of nutrients, water reduction and environmental pollution, loss of the varieties of plants and animals and climate change impacts (Kurukulasuriya & Mendelsohn 2007). On other hand, the farming practices that farmers apply in order to produce and generate income have proved to be environmentally unsustainable (Debertin & Pagoulatos 2015).

Processes have been recognized by which agriculture systems can adjust to manage the variations and the potential of agriculture to mitigate against climate changes. Agricultural production systems need to tackle three challenges: building resilience to the impacts of climate change; sustainably increasing agricultural productivity and incomes and contributing to climate change mitigation (Palombi & Sessa 2013).

These can be achieved by embracing climate-smart agriculture (CSA) practices. CSA can facilitate a transition to agriculture and food systems that are more climate-friendly, productive and sustainable. These will be achieved by the promotion of the adoption of CSA practices that have been proven to be effective based on solid evidence and providing an enabling environment that includes conducive policies, finance and institutions.

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Climate-smart agriculture comprises three main components: increasing incomes and agricultural production, adapting and sustainability to climate change and greenhouse gas emissions reduction (Palombi & Sessa 2013).

If a farmer uses CSA practices in maize production, the farmer will be adapting and mitigating to the impacts of climate change and increasing yields and farm incomes sustainably. Maize is grown over a wide range of agro-ecological zones by many households. Maintaining maize production requires using environmentally friendly and sustainable practices and intensifying production and management to increase output on current cropland.

The rise of climate variability among the smallholder farmers in Bukembe ward is increasing each season. Climate change is an avenue for many blockages and projections for the agricultural sector to expand in Bukembe ward, so there is need to encourage and support sustainable agricultural land management (SALM) practices for agricultural yields to rise by helping farmers adapt and mitigate to the changing climate as defined in the Bungoma County Integrated Development Plan (CIDP) 2013-2017.

As 80% of its inhabitants rely on agriculture for income generation, the County Government of Bungoma has developed an agriculture strategy to take the value chain tactic at the same time factoring in climate change and land degradation effects on agriculture to increase food security and income generation (County 2013).

Climate change is the main cause reducing maize yields in Bukembe ward (Wabwoba 2018). The production of maize in Bukembe is a vital economic activity. The farmers will highly welcome a lasting solution to low maize yields caused by the changing climate (Wanyama 2017).

Through the Kenya Agricultural Carbon Project (KACP), Vi Agroforestry trains farmers in Bukembe ward on different sustainable agriculture land management (SALM) practices, e.g. use of cover crops, agroforestry, use of green manure and mulching, so that the organic content of the soil is increased (Renting et al., 2009).

Climate-smart agriculture practices in maize production cushions farmers against yield loss shocks and stresses in their production. When CSA practices are applied there is mitigation and adaptation to climate change. (Mbow et al., 2014) opportunities exists to transform the existing farming activities focused on climate-smart techniques that cope with and mitigate the negative influence of climate change.

Some agriculture practices and technologies have the potential of increasing the production of food and the adaptive capacity of food production systems, as well contribute to the reduction of greenhouse gas emissions and sequester carbon in agricultural biomass and soils (McCarthy et al., 2011). Organic fertilizer use rises soil fertility through the improvement of soil chemical and biological properties. Thus, applying manure shortens the soil humus process and accelerate the accumulation of humus carbon sources, improving its fertilityl (Zhao et., al 2020). Crop yields depend largely on the availability of nitrogen at critical stage of plant growth. Legumes form nodules on their roots that house nitrogen-fixing symbioses with rhizobia bacteria. Agricultural ecosystems have soluble nitrogen which is made available to plants by a process called biological nitrogen fixation (BNF) by legumes (Prévost & Bromfield2003).

The CSA practices that were assessed in this study were: maize-legumes intercrop and using animal manure alongside planting of high yielding certified maize varieties. The legume was beans, the dominant certified maize varieties planted were 6213, 6218 and 6210 and the manure was from livestock.

The effect of CSA practices in mitigate maize farmers against low yields is not well known. This study contributes more knowledge on how farmers can apply CSA practices to mitigate low yield shocks. The objective of this study was to determine the effect of CSA practices on mitigating farmers against maize yield losses. It was hypothesized that there are no increased maize yields when a farmer uses CSA practices.

2. Methodology

This study was conducted among maize farming households in Bukembe ward, Kanduyi Sub County in Bungoma County.

2.1 Sample size determination

Cochran 1963 formula was used to determine the sample size,

$$n = \left(\frac{\text{z} * \text{std dev}}{\text{Margin of error}}\right)^2 \quad (1)$$

Where,

n is the desired sample size from a known population.

z is the confidence interval of the known population divided by 2 and read from the z table (2.58).

The standard deviation of the known population which is 3.07.

The margin of error for the population at 99% confidence interval is 0.5.

Thus, n is approximately 250.

2.2 Sampling and data collection

The data for this study was collected from 10 villages of Bukembe ward in Kanduyi Sub-county of Bungoma County in Kenya. The area was purposively selected due to the efforts of Vi Agroforestry in training farmers on the benefits of adopting CSA practices.

The study adopted a multistage sampling as follows. In the first stage, 10 villages were selected through probability proportionate to size sampling procedure. In the second stage, 250 farmers were randomly selected from a list of maize farmers in the 10 villages.

Primary data was collected from the 250 randomly selected farms using a pretested semi-structured questionnaire set up in open data kit (ODK) by trained enumerators. The data analysis for this study was done in Stata 13.

The data were merged and cleaned in SPSS and analyzed in SPSS, Stata and Excel. This study adopted the OLS model used by (Wambugu et al., 2014) with some changes to the dummy variables.

The model in this study is specified as;

$$Yp = \alpha Xp + \delta\, IMLp + \beta HYMVp + \kappa MP + \breve{e}p \quad (2)$$

Where Yp is the number of 90 kilograms bags of maize yield on farm p produced in the long rain season of the year 2017 on an average of 1 acre piece of land, X is a vector of variables including household and farm characteristics; intercropping maize with legumes (IML), planting high yielding certified maize varieties (HYMV) and adding manure to the maize crop (M) are dummy variables indicating the practices that the farmer applies in the farm when producing maize and e is a normally distributed error term.

The dummy variables, table 1; intercropping maize with legumes (IML) indicates the farming practice that farmers intercrop their maize crops with legumes, planting high yielding certified maize varieties (HYMV) indicates that farmers use high yielding certified maize varieties in their maize production to get high maize yields, adding manure to the maize crop (M) indicates that the farmer uses animal or farmyard manure in fertilization of the maize crop. Percentages of farmers intercropping maize with legumes, using high yielding certified maize varieties and adding manure to the maize crop were analyzed and represented in a bar chart.

3. Results

3.1 Demographic characteristics of the respondents

From the results, 30% of the households were female headed and 70% of the households were male headed. The average age of the household head was 50.16 years. The mean number of years of schooling was 10 years. The main decision maker regarding farming activities in maize production in the household was the household head at 79%. The average size of land for planting maize in the long rains was 1 acre with a standard deviation of 0.5.

3.2 Climate-smart agriculture practices used in maize production.

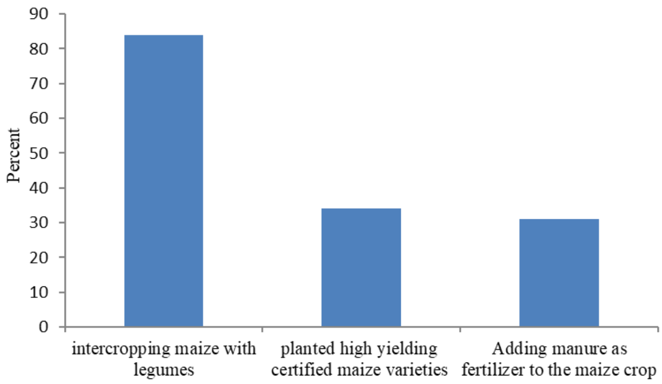

Figure 1. CSA practices used in maize production

The average number of maize yields in 90 kgs bags that were produced using the climate smart agriculture practices in the long rains season of the year 2017 on an average acre piece of land was 4 bags. The climate-smart agriculture practices that the farmers used to produce this maize were; intercropping maize with legumes and adding manure to the maize crop with planting high yielding certified maize seeds varieties. Among the households 84% intercropped maize with legumes, 34% planted high yielding certified maize varieties and 31% applied manure to the maize crop (Figure 1).
From the sampled farmers 81% classified the practices they used in maize production as climate-smart agriculture practices.

3.3 Effects of climate-smart agriculture practices used in maize production on yield

To achieve the objective of this study an ordinary least square regression (OLS) (Table 2) was estimated to determine the effects of CSA practices on maize yields. The goodness of fit, multicollinearity and specification test were done. The presence of heteroscedasticity was addressed by estimating a robust model (Arslan et al., 2014). All the explanatory variables had a variance inflation factor (VIF) less than 1.99 and a mean VIF of 1.35. The explanatory variables having a VIF of less than 1.99 then multicollinearity was ruled out. Multicollinearity exists if a model's VIF is greater than 10 (Press 2007). The coefficients of explanatory variables in the model were significantly different from zero this is because the chi-square value for log likelihood function was highly significant.

The household head age was significant at $P < 0.01$, if a household has a younger age there is a high chance that the maize produced will increase. This is because younger households look for technologies that increase crop productivity.

Table 1: Description of explanatory variables used in the model and their signs

Variable	Description	Expected sign
DTYM	High yielding certified maize varieties	+
IML	Intercropping maize with legumes	+
M	Adding manure to the maize crop	+
SLLR	Size of land under maize in the long rains	+
Age	Age of household head in years	+/_
Type of household	Dummy variable representing the type of household headship. 1 if male headed; 0 otherwise	+/_
Edcu	Number of years of formal education of the household head	+
Decision maker in the household	Dummy variable representing the decision maker in the household regarding farming activities in maize production. 1 household head; 0 spouse.	+/_

Table 2: Ordinary least square regression on the effect of climate smart agriculture practices used in maize production on maize yields produced in the long rain season of the year 2017

Long rains season of 2017 maize yield	Coefficient	Robust Std. Error	P>|t|
Type of household headship	-1.77**	.87	0.044
Age of the household head	-.08***	.025	0.001
Years of schooling of the household head	.41* *	.17	0.014
Decision maker in the household	2.38* *	1.01	0.02
Size of land in long rains season of the year 2017	6.63***	.70	0.000
Intercropping maize with legumes	4.72***	1.19	0.000
Planting certified high yielding maize	1.81**	.83	0.031
Adding manure to the maize crop	3.83***	1.00	0.000
Constant	8.41 ***	2.58	0.001

n = 250
Statistical significance levels ***1%, **5% and *10%
$R^2 = 0.4077$
Prob> 0.0000

Years of schooling of the household head was significant at P < 0.01 implying that farmers with a higher level of schooling have a higher chance of increasing the maize produced.

Size of acreage of land planted in the long rains was significant at P <0.01, farmers who planted maize on larger pieces of land in the long rains have a higher chance of increasing the maize produced.

Intercropping maize with legumes was significant at P < 0.01 implying that intercropping maize with legumes increases maize yields.

Planting certified high yielding maize was significant at P < 0.05 implying that when certified, high yielding maize seeds are planted there is increased yields. Adding manure to the maize was significant at P < 0.01 implying that adding manure to the maize crop increase yields.

The overall model was significant at P < 0.01 with an R – squared of 41% i.e. 41% of the variations in the dependent variable is explained by the independent variable.

4. Discussion

Using CSA practices i.e.; intercropping maize with legumes and adding manure to the maize plant with planting certified high yielding maize varieties had a significant effect on the maize yield produced during the long rains. Farmers can mitigate climate change effects by choosing agricultural practices that decrease greenhouse gas emissions, (Gujarati 2009).

The CSA practice in maize production increases maize yield which mitigates farmers against yield losses. The increased yield translates into increased incomes at the household level.

Healthy maize will also help in sequestering carbon from the atmosphere. Using manure increases the carbon content of the soil. When the carbon content of the soil is increased, the fertility of the soil increases hence increasing the yield produced when a crop is planted. From their manure and inorganic fertilizer long term application trails, found out a repeated improvement in maize yield with manure application (Wollenberg et al., 2012). The same study documented that the application of inorganic fertilizer on the same plot never increased maize yields significantly.

The importance of knowledge in decision making for CSA is very important. This was depicted in households with high educational levels. Farmer's awareness of CSA is relatively low. The study of (Abunyewa et al., 2007) found out that lack of awareness and information on climate change and coping approaches and low adaptive capacity delayed coping towards climate change. Low knowledge of climate change contributed to low adoption of CSA practices. According to (Gwambene et al., 2015) most smallholder farmers practice CSA in their field but they are not aware of the practices and the reason for practicing them.

With the model being statistically significant at 1%, this study rejected the null hypothesis and concluded that there is an increased maize yield when a farmer uses CSA practices in maize production.

Conclusions and Recommendations

The practices that the farmers use in maize production will increase or reduce the maize yield and at the same time have a positive or negative effect on the environment. Planting high yielding certified maize varieties was significant on the maize yield produced. These calls for efforts to make sure that the seed that is sold to farmers are certified and high yielding. This can be done when the maize seed systems i.e. producers and supply chains are strengthened. There should be increased sensitization on the importance and benefits of manure to the soil as carbon in the soil is increased when farmers use manure continuously and applying manure shortens the soil humus process and accelerate the accumulation of humus carbon sources, improving the fertility of the soil. Use of manure in maize production increases the maize yields and improves the adaptive capacity of the system to climate change shocks hence reduces greenhouse gas emissions and enhance carbon sequestration in agricultural soils and biomass. Farmers should be encouraged to continuously use manure and plant high yielding certified seed varieties. Training on CSA principles and practices is also important for increased uptake and practice. When farmers use CSA practices in their maize production, the triple wins of increased agricultural production and incomes, farm systems adaptation and mitigation being achieved hence contributing positively to the climate change discourse.

Further Research

There are very few studies that have been done focusing on how farmers mitigate against low crop yields when they use climate-smart agriculture practices. This study focused on how farmers mitigate low maize yield when they use climate-smart agriculture practices. More research needs to be done on how farmers mitigate against low crop yields when they use climate-smart agriculture practices in all the crops in their farms.

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