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Impact of Climate Change on Maize Production and Adaptation Strategies in East Shoa Zone, Oromia Region, Ethiopia

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ABSTRACT
Climate change has tremendous impact on crop growth and productivity. This paper reviews effects of Climate change on maize yields, trends of maize production under the prevailing environmental condition, coping mechanisms to adapt climate change and the perception of farmers towards climate change. Semi-structured questionnaires were used to collect data from 166 sample respondents randomly selected from designated locations in East Shewa Zone. A stochastic production frontier function was fitted to the sample households. As the study result revealed that, 95.78% of farmers perceive climate change availability within the last ten years of crop production. In the meantime 98.80 % of farmers perceive climate change have impact on maize production and productivity. About 72% of smallholder farmer though decline of maize yields was due to rainfall decline and temperature increased. The sum of the partial elasticity of all inputs was 1.17 for Maize indicates an increase in all inputs at the sample mean by one percent increase by 1.17% maize. The average maize yields before ten, five and current years were 54, 31 and 24 qt/ha respectively. Percentage change in maize yield due to climate change 0.06 whereas its coefficient of variability 0.24 in East Shoa Zone. The variable included in the model have been used in their logarithmic form in order to provide convenient interpretation (elasticity) and to reduce heterogeneity of the variables. The time trend (year) has been used as a proxy for technical change in maize production technology such as development of new variety and farm management practices which general increases maize yield overtime. The main growing season rainfall has negative but statistically insignificant effect on average maize yields. As the results of research analysis indicate that, the cumulative sum of farmer's perception towards the impact of climate change were 1.9 which is below the mean suggesting farmers perceive climate change have negative impact. Adaptation to climate change requires cross-disciplinary solutions that include the development of appropriate germplasm and mechanism to facilitate to farmers access to germplasm. In addition using drought - tolerant maize varieties, early mature variety, using compost and improving agronomic management and Crops other adaptation strategies to climate change variability. So the adaptation strategies to climate change in the zones were; the development and cultivation of more drought-tolerant maize varieties; the adjustment in the planting days of maize; the use of irrigation facilities in the cultivation of maize; farmers must engage in crop diversification and Improved agronomic management and Crops.
Keywords: Climate Change, Maize, Drought, Impact and Adaptation, East Shoa Zone
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1. INTRODUCTION

1.1. Background and Justification

Ethiopia is one of the fastest growing non-oil economy countries in Africa. The country is heavily reliant on agriculture as a main source of employment, income and food security for a vast majority of its population. In GTP-II period, agriculture will remain the main driver of the rapid and inclusive economic growth and development. It is also expected to be the main source of growth for the modern productive sectors. Therefore, besides promoting the productivity and quality of staple food crops production, special attention will also be given to high value crops, industrial inputs and export commodities (NPC, 2016).

The impacts of rising average temperature, rainfall variability and increase in the frequency and intensity of droughts are more severe in the tropics than temperate regions (Bekele, 2013). Agriculture is the most susceptible sector to climate change related hazards. This is due to the fact that climate change affects the two most important direct agricultural production inputs and these are precipitation and temperature (Philip et al., 2014 and Birhan, 2017). The change in rainfall distribution and pattern had contributed to the change in cropping pattern and crop yield (Kassa, et al., 2012).

The impacts of climate change are adverse in low and middle-income countries, where millions of people depend on agriculture and are vulnerable to food insecurity (FAO, 2017). The majority of the rural people in developing countries in general and in Ethiopian in particular depends rain fed subsistence agriculture and the daily exploitation of natural resources (Alebachew, 2011 and Kassa, et al., 2012). Variability of weather conditions, particularly of precipitation, is a key climatic characteristic of Ethiopia (IFAD, 2016). Because of changes in the patterns of the local climate, this region is exposed to chronic food shortages, degradation of natural resources, unstable livelihoods and distress migration (Alebachew, 2011 and Kassa, et al., 2012). The farming technology in the central rift valley of Ethiopian is basic and incomes are low, suggesting that farmers will have few options to adapt (Mendelsohn, 2000). Adaptation enhances the capacity of people and governments to reduce climate change impacts (Kassa, et al., 2012).

Agriculture is extremely vulnerable to climate change (Birhan, 2017). Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. The overall impacts of climate change on agriculture are expected to be negative although there will be gains in some crops in some regions of the world (FAO, 2008).

Agriculture, and especially crop growing, is heavily dependent on weather events in SSA, where 97% of agricultural land is rain fed (Birhan, 2017). The impact of climate change on crop yields is a major concern in this region (Deressa, 2006). Ethiopia is not an exception to the adverse impacts of climate change as its economy is highly dependent upon climate sensitive rainfed agriculture. The country is among the most vulnerable nations to climate and ecological change, given that only a small proportion of its cultivated land is irrigated and food production is dependent mainly on traditional rain fed agriculture (NMA, 2007 and Birhan, 2017).

The dependence of Ethiopia on agriculture makes vulnerable to adverse impacts of climate change on crop and livestock productions. The frequent droughts and floods negatively affect agricultural production, shows agriculture's sensitivity to climate change (Yesuf, et al., 2013). Some scholars have conducted research to measure expected impacts of climate change on agriculture in developing nations (Deressa, 2006 and Birhan, 2017). For example, the studies in pastoralist and agro-pastoralist are found out impact of climate and adaptation mechanisms to reduce vulnerability to climate change, regarding crop production (Temesgen, 2008; Woldeamlak and Conway, 2009; Kassa, et al., 2012; Birhan, 2017). In different parts of Ethiopia, climate change is affecting the yield of crop production because they are exclusively dependent on rainfed agriculture with little or no adaptive strategies to cope up with climate. The magnitude of climate change related problems have been intensifying both spatial and temporally. The increase in frequency of extreme weather events such as droughts and floods accompanied by the difficulty in predicating growing seasons create a considerable endanger for the achievement of food security. This phenomenon is also the real manifestation of East Shoa Zone where this study has conducted.

1.2. Objective of the Study

- To identify the trends of maize production under the prevailing environmental condition
- To analyze the impact of climate change on maize yields
- To identify coping mechanisms to adapt climate change
- To identify the perception of farmers towards climate change

1.3. Expected Output

- Farmers coping up mechanism towards climate change identified
- Climate variability trends identified
- Impacts of climate change on maize yield quantified and
- Farmers' perception towards climate change identified

2. METHODOLOGY

2.1. Description of the Study area

The study was conducted in East Shoa Zone which found in central part of Oromia National Regional State, Ethiopia. East Shoa Zone lies between 60º 00' N to 70º 35'N and 380º 00'E to 40^0 00'E. East Shoa Zone has different agro-ecologies which categorized as highland, midland and lowland agro-ecologies. In the Zone, 18.70% of the agro-ecology is high land, 27.50% is midland and 53.80% is lowland. The Zone received 350mm-1150 mm annual rain fall and has uni-modal nature of rain fall pattern. This Zone was received 12ºC-39ºC annual temperature per year (Farming System Report, 2018).

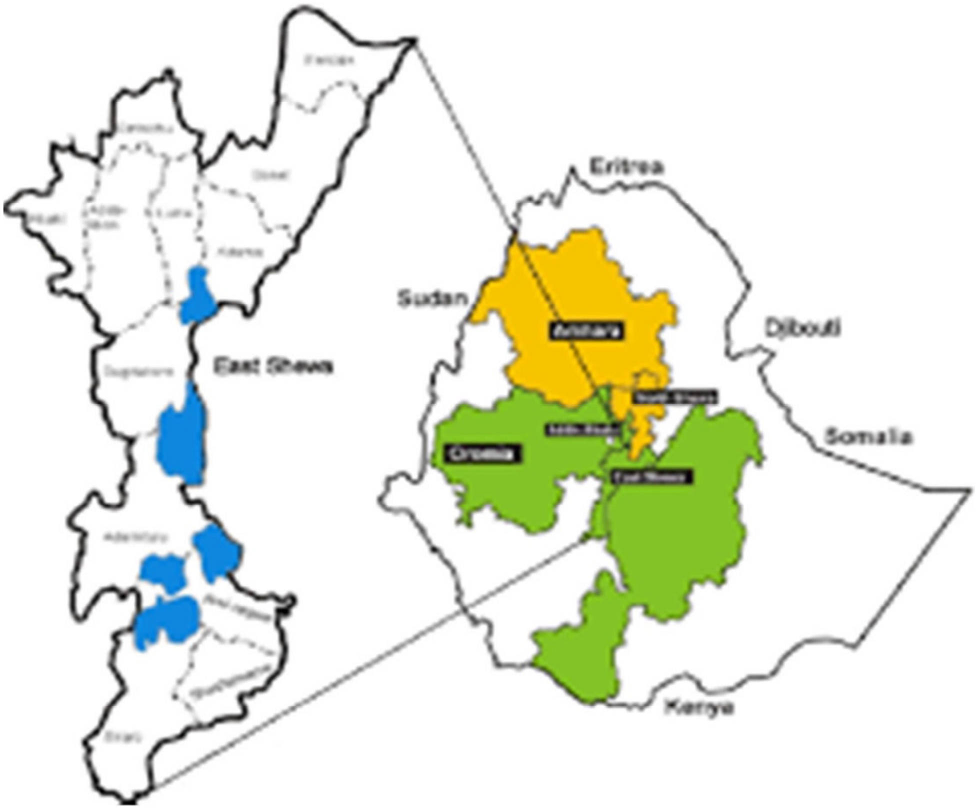

Fig: map of East Shoa zone

2.2. Sampling Procedure and Sample Size

The target population for this study was the Maize producer farmers in East Shoa Zone of Oromia National Regional State. Maize was dominantly produced in lowland areas of East Shoa Zone (Farming System Report, 2018). In order to have a representative sample in achieving the stated objectives, the sampling procedure was covered the major Maize producing Districts in the Zone. Accordingly, multi-stage sampling procedure was employed to select sample respondents.

First stage: Purposive sampling method was employed to select three major maize producing districts based on maize production volume

Second stage: Purposive sampling was applied to select two major Maize producing kebeles from three selected districts

Third stage: Simple random sampling was used to select 166 Maize producers from selected kebele by using Yamane formula, (1967)

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

Where,

n = is the sample size of sampled producer households, N= total number of maize producer households farmers, e= level of precision

2.3. Method and Type of Data Collection

Both primary and secondary data sources were used in the study. The primary data sources was semi-structure questionnaire, interview, discussion, and observation while secondary data sources was collected from government documents, Metrological data and crop production data.

To examine the impacts of climate change on crop production, agricultural product yields data with climatic parameters (i.e. Temperature and Rainfall) were employed in this research. Ten years climate data (rainfall, maximum and minimum temperature) were collected from Adama Meteorological Agency (AMA) and National Meteorological Agency (NMA) while crop yield data such as Maize, Teff, Haricot Bean, and Chick Pea were gathered from East Shoa Zone of Agricultural Development and Natural Resource Management Office.

2.4. Method of Data Analysis

Both descriptive and inferential statistical techniques were employed to analysis the collected data. Descriptive

statistical techniques such as mean, standard deviation, and variance was computed whereas using inferential statistical technique such as Cobb–Douglas stochastic production frontier approach was used to estimate the production function and determinants of maize production, Auto regression, correlation analysis and analysis of variance (ANOVA) was computed to see the relationship between climatic parameters with maize yield data.
The trend analysis model is formulated as:
Ci=f(T,e),
Where:
Ci=climate variables,
T=time and
e= error term
Thus, to estimate a Cobb-Douglas production function, it needs too log all of input and output data before the data is analyzed (Coelli, 1995).
lnY=B0+B1lnLi+B2lnFi+B3lnSi+B4lnTi+B5lnPi+B6lnDi+Ui
Where:
Yi= maize yields (Quintal/ha) for farm i, Li is labor hours per hectare; Fi is fertilizer application per hectare (Kg); Si is the quantity of seed cultivated per hectare (Kg); Ti is mean summer temperature (degrees Celsius) that is experienced by farm i; Pi is mean precipitation (millimeters per month) that is experienced by farm i; Di is irrigation used of farm i ; Bk is the vector of the ki parameters to be estimated; and variables which affect maize yield, and Ui= disturbance term
The MELE and GME models were applied avoid correlation among some of the inputs, yield inconsistent and biased estimates since the application of ordinary least square may yield inconsistent and biased estimates (Golan, et al, 1996a)
Vector Auto regression Model
This model was also be used to estimate maize yield response to changes in temperature and rainfall using this model variable that fitted into model to co-integrate.
$$Yt = \alpha_1 Tt + \alpha_2 Rt + \alpha_3 y$$
Where
Yt = maize yield produced at time t;
Tt = temperature at time t;
Rt = Rain fall at time t;
y = change in output of maize
The data collects from the Meteorological agency and agricultural development office was analyzed using version 15 STATA software and Microsoft Excel.

4. RESULTS AND DISCUSSION

This chapter presents the findings of the study and discusses in comparison with the results of earlier similar studies. It is organized under five sections. The first section presents results of descriptive characteristics of sample respondents the study area. The second section is about the trends of maize production under the prevailing environmental condition. The third section is about the impact of climate change on maize yields. The fourth section is about coping mechanisms to adapt climate change and the last fifth section is about the perception of farmers towards climate change.

4.1. Descriptive Analysis Results

4.1.1. Socio-demographic characteristics of sampled households

Age of Household head (HH) has the source of good farming experience and able to participate risk involving farm activity than older farmers. The average age of the sample households during the survey period, was about 41.042 years having farming experience 17.81 years which was less than 65.97 year of average life expectancy for both sex in Ethiopia (WPP, 2017). Based on Strock et al., 1991 (as cited in Ermiyas, 2013) this average value of age included in the most economically active age group of 17-50 year.

The average education level of literate sample household heads during survey period was about 6.5 years with the minimum of zero years (illiterate) and maximum of 12 years. Family size plays an important role in crop production and most farmers depend mainly on family labor. The average family size of the sample households was 7 persons per household (Table 2) which is greater than 4.6 person per household as Ethiopia, based on household size and composition around the world in 2017.

Cultivated farmland land is land used by sample farm households to undertake agricultural production. The own average cultivated land holding size of the sample households was 2.03 hectares, which is greater than national average of 0.95 hectares (CSA, 2015). The average areas covered by maize during the year 2020 cropping season were 1.084 ha.

Livestock is one of the major assets for the farmers and also indicates their level of wealth in the study area.

Types of livestock owned by households are oxen, cows, heifers, calves, horses, donkey, sheep, goat and poultry. Livestock provides traction power, manure, and is a source of cash that can be used to purchase goods for household consumption and production inputs. The average livestock holdings measured in terms of tropical livestock unit (TLU) were found to be 7.79. This is relatively a large number in the crop-livestock mixed farming system (Table 2). This indicates that the farming system in Ethiopia is mainly based on plough by animal draught power that has created complementarity between crop and livestock production. Income from crop, off-farm and non-farm income was 45,464.24; 86,766.83 and 54,625 birr respectively.

Table 2: Socio-demographic characteristics for continues variables

Demographic characteristics	Sample respondents (n=166)	
	Mean	**Std. Dev**
Age of HH head	41.042 years	12.34
Experience in maize production	17.81years	9.940
Family size	7.19	3.297
TLU	7.799	3.009
Grade level	6.528	2.840
Land cultivated/individual	2.03ha	1.80
Area under maize/ha	1.084ha	0.958
Income from crop	45,464.24 birr	6798.4
Off-farm income	86,766.83 birr	2454.5
Non-farm income	54,625birr	3562.5

Source: Survey result, 2020

4.2. Maize Production and its trends in East Shewa Zone

4.2.1. Maize production (Supply) and Demand in the zone

As survey result indicate, 55.90% of sample respondents think supply of maize within the last ten years was decreasing suggesting the production of the maize is decline due to different factors from which climate change took lion share, in the meantime its demand highly increasing due to shortage of maize production exist which accounts about 93% of sample respondents thinking (Table 3). To complement the survey result indicated under below table taken from smallholder farmers, secondary data taken from East Shewa zone agricultural office indicate that price of maize within the last ten years increased confirming the supply shortage and high demand (Fig: 1).

Table 3: Supply and demand of maize within the last ten years

	Supply of maize within ten years		**Demand of maize within ten years**	
	Freq.	Percent	Freq.	Percent
Increasing	63	39.13	150	93.17
Decreasing	90	55.90	16	6.83
No change	13	4.97	0	0
Total	166	100	166	100

Source: Survey result, 2020

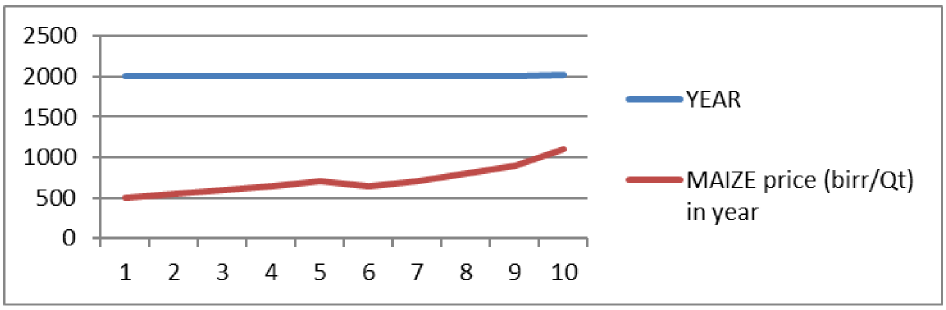

Fig 1: Price of maize within the last ten years

Source: Secondary data taken from East Shewa zone agricultural office

4.2.2. Cropping system in the zone

The majority of cropping system of maize production in East Shewa zone is sole cropping which accounts 98.18% suggesting the other reason of maize yield decline.

Table 4: Cropping system

Cropping system	Freq.	Percent
Inter cropping	2	1.21
Sole cropping	162	98.18
Mixed cropping	2	1.21
Total	**166**	**100**

Source: Survey result, 2020

4.2.3. Trends of Maize Production within the last ten years

As survey result indicate, 57.23 and 59.51% of sample respondents think trends of maize production within the last ten and five years were decreasing respectively, suggesting the production of the maize is decline due to different factors from which climate change took lion share (Table 5). To complement the survey result indicated under below table taken from smallholder farmers, secondary data taken from East Shewa zone of agricultural office indicate that productivity of maize within the last 12 years was decreased confirming the reason of production trends decline (Fig: 2 and 3). In addition to the above information gained from secondary data of zonal agricultural office, the zonal metrological office data indicate that within the last ten years rainfall was declining whereas the temperature was increasing that cause the zonal maize yield decline (Fig 3). The average annual rainfall of 30 years was 735.86 ml with SD of 262.80.

Table 5: Farmers perception on Trends of maize production within the last ten and five years

Trends of maize production	During last ten (10) years		During last five (5) years	
	Freq.	Percent	Freq.	Percent
Increasing	66	39.76	60	36.81
Decreasing	95	57.23	97	59.51
Fluctuate	5	3.01	9	3.68
Total	**166**	**100**	**166**	**100**

Source: Survey result, 2020

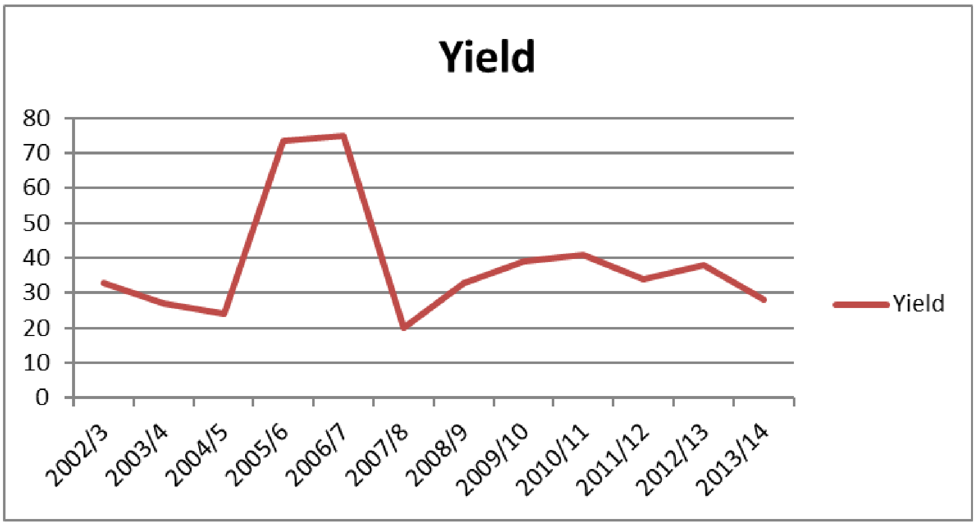

Fig 2: Productivity of maize within the last 12 years
Source: Secondary data taken from East Shewa zone agricultural office

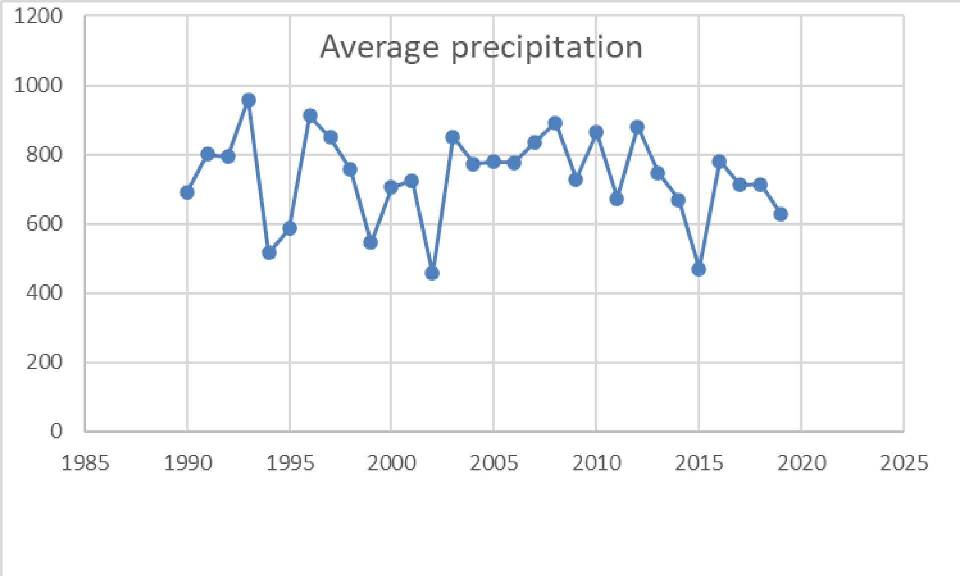

Fig 3: Productivity of maize within the last 12 years in line with RF and Temperature
Source: Secondary data taken from East Shewa zone agricultural office

4.2.4. Productivity/yields of Maize

There was variability in technical inputs and output among maize producing farmers (Table 6). This is economic process of producing output from these inputs or uses resources to create output that are suitable for users. The productivity of Maize per hectare was 54.159, 31.619 and 24.033 quintal before ten, five and current, respectively suggesting productivity of maize was decreasing. To complement the survey result indicated under below table taken from smallholder farmers, secondary data taken from East Shewa zone of agricultural office indicate that productivity of maize within the last 12 years was decreased confirming the reason of production trends decline (Fig: 2 and 3). In addition to the above information gained from secondary data of zonal agricultural office, the zonal metrological office data indicate that within the last ten years rainfall was declining whereas the temperature was increasing that cause the zonal maize yield decline (Fig 3).

Table 6: Productivity/yields of Maize from sample respondents and metrological office collected

Maize yields/ha across year	Mean/quintal	Std. Dev.
Current maize yield	24.03	20.06
Maize yield before 10 years	54.16	22.29
Maize yield before 5 years	31.62	20.62

Source: Survey result, 2020

Table 7: Productivity/yields of Maize from secondary data collected

YEAR	ATJK	DUGDA	LIBAN	EAST SHEWA ZONE
2010/11	21	43	40	38
2011/12	33.87	60.52	54	42.61
2012/13	35.877	60.12	50	44.27

Source: Secondary data taken from East Shewa zone agricultural office

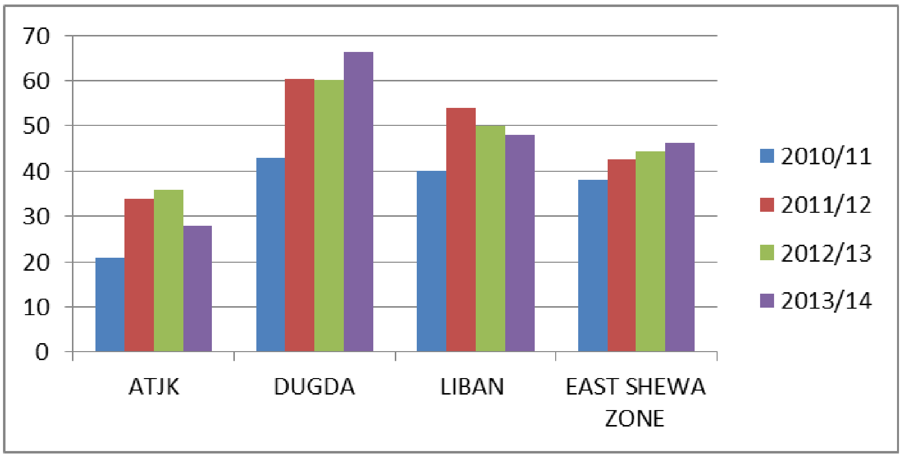

Fig 4: Productivity of maize across three selected districts
Source: Secondary data taken from East Shewa zone agricultural office

4.3. Perception of farmers towards Climate Change

As the study result revealed that, 95.78% of farmers perceive climate change availability within the last ten years of crop production from which rainfall accounts about 92%. In the meantime 98.80 % of farmers perceive climate change have impact on maize production and productivity from which about 99 and 93% perceive it have negative impact on maize yields and cost of production, respectively (Table 8). About 72% of smallholder farmer though decline of maize yields was due to rainfall decline and temperature increased. To support the above information gained from survey result of smallholder farmers secondary data of zonal metrological office data indicate that within the last ten years rainfall was declining whereas the temperature was increasing that cause the zonal maize yield decline (Fig 3).

Table 8: Perception of farmers towards climate change

Is there any climate change within the last 10 years of crop production	Freq.	Percent	If yes/climate change, which one?	Percent	Reason of maize yield change %
Yes	159	95.78	Rainfall	92.45	21.29
No	7	4.22	Temperature	7.55	6.45
Total	**166**	**100**		**100**	**Both** 72.26

Source: Survey result, 2020

Do you perceive climate change have impact on maize production and productivity?		If yes, does it have negative impact on maize yields?	Do you perceive climate change have impact on cost of maize production?
Yes	98.80	99.39	93.37
No	1.20	0.61	6.63
Total	**100**	**100**	**100**

Source: Survey result, 2020

According to the survey result shown in Table 9 climate change have negative impact for all attributes of reduce maize yield, consumes a lot of labour force, demands intensive management practice, requires high overhead cost per farmer and ecological adaptability were 1.9, 1.9, 1.95, 1.92, and 1.92 respectively suggesting the mean below the average indicating negative impact of climate change.

Negative attitude towards impact of climate change is one of the factors that can speed up the change process. Positive attitude formation is also a prerequisite for behavioral change to occur. Therefore, it was hypothesized that favorable attitude towards impact of climate change negatively influences the likelihood of farmers to produce maize. This was measured using a summated rating (Likert) scale.

In this study, weighted average of individual positive (advantages) was calculated. As the results of research analysis indicate that, the cumulative sum of farmer's perception towards the impact of climate change was 1.9 which is below the mean suggesting farmers perceive climate change have negative impact.

Table 9: Distribution of respondents per perception category (%)

Farmers perception on impact of climate change	Distribution of respondents per perception category (%) (N=166)				Average score
	Strongly Agree	**Agree**	**Undecided**	**Disagree**	Mean SD
Reduce maize yield	15.06	81.93	0.60	2.41	1.9 0.5
Consumes a lot of labour	15.24	80.49	1.83	2.44	1.9 0.5
Demands intensive management practice	10.43	85.28	2.45	1.84	1.95 0.4
Requires high overhead cost per farmer	11.66	85.89	1.23	1.23	1.92 0.4
Ecological adaptability	11.04	87.12	1.23	0.61	1.9 0.38

Source: Survey result, 2020

4.4. Impact of Climate Change on Maize Yields

4.4.1. Model testing for appropriateness

Hypotheses stated in the model specification part and validity of the model which is used for analysis has to be tested before estimating the parameters of the model.

The appropriateness of the stochastic frontier model over the convectional production function can be tested using the statistical significance of the Stochastic Production Frontier Ordinary Least Square parameter gamma, Ý. The estimated value of gamma is equal to 99.86 for production of maize which is statistically significant at 1% level of significance. The estimated value of gamma signifies that 99.86 % of the variation in output is due to the variability of climate and technical efficiency. This indicates that climate have impact on maize production and productivity. Hence, the production function estimation using SPF analysis is more appropriate than convectional production function.

The other hypothesis testing is the test for returns to scale. The results of the estimation made under model specifications, constant and variable return to scale, show that the value of log-likelihood functions equal to -85.60 for maize production. Thus, the log likelihood ratio test is calculated to be 5.28 and when this value is compared to the critical value of $\chi 2$ at 4 degrees of freedom with 1% level of significance equals to 12.483(given by kodde and palm, 1986). Therefore the null hypothesis of climate change have no impact on maize yields was rejected. The sum of the partial elasticity of all inputs equals to 1.17. This means an increase in all inputs at the sample mean by one percent will increase maize by 1.17% in the study area. This reveals that the production function is characterized by increasing returns to scale for maize production. This shows that the elasticity of mean value of output is estimated to be an increasing function of inputs for maize production. The gamma (γ) of the MLEs of stochastic frontier production is 0.9986. This value is statistically significant implying that 99.86% of variability output from maize production is attributed to the technical efficiency of maize production technic where as 0.14% due to random shocks in production which could be climate change. As the study result suggest that, as rainfall increased by 1mm maize productivity increased by 3% whereas as temperature increased by 1^{o}c maize production/productivity declined by 1% suggesting climate change have impact on maize production and productivity.

The results of the estimated parameters revealed that all the coefficients of the physical variables confirm to a priori expectation of a positive signs whereas from coefficients of the random shocks variables rainfall have positive sign but temperature have negative sign. The positive coefficient of land, labor, seed, Fertilizer, rainfall and agro chemical implies that as each of these variables is increased, ceteris paribus, maize output increased however negative coefficient of temperature increment reduce maize output. The coefficients of the variables; land, seed, fertilizer, rainfall and temperature are significant even at 1% level of significance. Therefore these are factors explaining maize production in study the area.

The estimated value of gamma signifies that 99.76% of the variation in output is due to the variation in allocative inefficiency among the farmers and remaining 0.24% of output variation is due to due to variation output. Hence, the production function estimation using SPF analysis is more appropriate than convectional production function (Table, 10).

Table 10: Estimated Maize stochastic production and cost frontier function

Variables	**Production frontier** ML estimate Coefficient	Std.Err	**Variables**	**Cost frontier** ML estimate Coefficient	Std.Err
Intercept	1.836 ***	0.6093	**Intercept**	2.380***	0.2883
LnLand	0.601 ***	0.1158	***LnLandcost***	0.290***	0.0268
LnLabor	0.104	0.0723	***LnLaborcost***	0.163***	0.0257
LnSeed	0.196 ***	0.0663	***LnSeedcost***	0.248 ***	0.0232
LnFertilizer	0.230 ***	0.0652	***LnFertilizercost***	0.163***	0.0249
LnChemical	0.037	0.0866	***LnChemicalcost***	0.063***	0.0217
	$\sum\beta$= 1.167				
$\sigma^2=\sigma^2_u+\sigma^2_v$	124.612			12.014	
$\lambda=\sigma_u/\sigma_v$	27.062	22.708		20.420***	8.239
γ (gamma)	0.9986 ***			0.9976	
Log likelihood	-85.6014			25.5278	
LR test	5.29			9.35	

***, Significant at 1% significance level,
Source: Own computation, 2020

4.4.2. Returns to scale Maize production

The return to scale (RTS) analysis, which serves as a measure of total resource productivity, is given Table 11. The maximum likelihood estimates (MLE) of the Cobb-Douglas based stochastic production function parameter of 1.167 is obtained from the summation of the coefficients of the estimated inputs (Elasticities) including rainfall and temperature from random shocks. It indicates that maize production in study area is stage I of increasing returns to scale where resources and production were believed to be efficient.

Table 11: Elasticities and returns to scale of the parameters of stochastic frontier

	Maize
	Elasticities
LnLand	0.601
LnLabor	0.104
LnSeed	0.196
LnFertilizer	0.230
LnChemical	0.037
Returns to scale	**1.167**

Source: Survey data, 2020

Unit root test Result

P			
(drift, lag(1), demanded, N=30			
Maize	**149.90***	**Chi-square (30)**	**24.28**

Annual Rf	SD	F	Coefficient of maize yield	Coefficient of variability
735.86	262.8	2.8	0.06	0.24

Percentage change in maize yield due to climate change 0.06 whereas its coefficient of variability 0.24 in east shoa zone.

The variable included in the model have been used in their logarithmic form in order to provide convenient interpretation (elasticity) and to reduce heterogeneity of the variables.

The time trend (year) has been used as a proxy for technical change in maize production technology such as development of new variety and farm management practices which general increases maize yield overtime.

The estimated coefficient of trends (technical change in maize production) i.e. 1.167 revealed that, technical change in production has a significant effect on the variance and yield of maize.

Table 12: Estimated coefficient from mean of maize yield regression

	Mean	se
Kiremt	-0.0159	0.05171
Belg	0.1050*	0.06181
Trend	0.0017	0.0094
$Trend^2$	0.0005*	0.0003
Intercept	2.1258***	0.5106

Source: Secondary data

- ✓ The main growing season rainfall has negative but statistically insignificant effect on average maize yields
- ✓ The *belg* precipitation have positive and significant effect on maize average yield
- ❑ Technical change or improvement in maize production technology increases mean maize yield at increasing rate

5. CONCLUSION AND RECOMMENDATIONS

This paper reviews effects of climate change on maize yields, trends of maize production under the prevailing environmental condition, coping mechanisms to adapt climate change and the perception of farmers towards climate change in East Shewa zone. To meet this objectives primary data was collected from 166 sample households by using semi-structured questionnaire

The most dominant crop produced in East Shewa zone was Maize.

As the descriptive analysis result indicates that; the average age of the sample households during the survey period, was about 41.042 years having farming experience 17.81 years and 6.5 years of educational level. The average family size of the sample households was 7 persons per household. The own average cultivated land holding size of the sample households was 2.03 hectares, which is greater than national average of 0.95. The average areas covered by maize during the year 2020 cropping season were 1.084. The average livestock holdings measured in terms of tropical livestock unit (TLU) were found to be 7.79. Income from crop, off-farm and non-farm income was 45,464.24; 86,766.83 and 54,625 birr respectively.

55.90% of sample respondents think supply of maize within the last ten years was decreasing suggesting the production of the maize is decline due to different factors from which climate change took lion share, in the meantime its demand highly increasing due to shortage of maize production exist which accounts about 93% of sample respondents thinking. The majority of cropping system of East Shewa zone is sole cropping which accounts 98.18% suggesting the other reason of maize yield decline. About 57 and 59% of sample respondents think trends of maize production within the last ten and five years were decreasing respectively, suggesting the production of the maize is decline due to different factors from which climate change took lion share.

The productivity of Maize per hectare was 54.159, 31.619 and 24.033 before ten, five and current, respectively suggesting productivity of maize was decreasing. The gamma (γ) of the MLEs of stochastic frontier production is 0.9986. This value is statistically significant implying that 99.86% of variability output from maize production is attributed to the technical efficiency of maize production technic where as 0.14% due to random shocks in production which could be climate change. The maximum likelihood estimates (MLE) of the Cobb-Douglas based stochastic production function parameter of 1.167 is obtained from the summation of the coefficients of the estimated inputs (Elasticities) including rainfall and temperature from random shocks. It indicates that maize production in study area is stage I of increasing returns to scale where resources and production were believed to be efficient. This means an increase in all inputs at the sample mean by one percent will increase maize by 1.167 % in the study area. However, variable from random shocks i.e. rainfall and temperature; as rainfall increased by 1mm maize productivity increased by 3% whereas as temperature increased by $1^{o}c$ maize production/productivity declined by 1% suggesting climate change have impact on maize production and productivity.

As the study result revealed that, 95.78% of farmers perceive climate change availability within the last ten years of crop production from which rainfall accounts about 92%. In the meantime 98.80 % of farmers perceive climate change have impact on maize production and productivity from which about 99 and 93% perceive it have negative impact on maize yields and cost of production, respectively. About 72% of smallholder farmer though decline of maize yields was due to rainfall decline and temperature increased.

As the results of research analysis indicate that, the cumulative sum of farmer's perception towards the impact of climate change were 1.9 which is below the mean suggesting farmers perceive climate change have negative impact. Adaptation to climate change requires cross-disciplinary solutions that include the development of appropriate germplasm and mechanism to facilitate to farmers access to germplasm. Seed production and deployment, effective policies and management strategies at the country, regional and international levels will all be required to ensure that the technologies reach the community.

Different types and varieties with increased resilience abiotic and biotic stresses will play an important role in adaptation to climate change. While this challenge is immense, the advancement in molecular and phenol typing tools combined with the vast accumulated knowledge on mechanisms responsible for yield loss will provide a solid foundation to achieve increases in productivity within maize systems.

The main growing season rainfall has negative but statistically insignificant effect on average maize yields. The *belg* precipitation have positive and significant effect on maize average yield. Technical change or improvement in maize production technology increases mean maize yield at increasing rate.

Adaptation to climate change requires cross-disciplinary solutions that include the development of appropriate germplasm and mechanism to facilitate to farmers access to germplasm. Seed production and deployment, effective policies and management strategies at the country, regional and international levels will all be required to ensure that the technologies reach the intended beneficiaries and make the desired impacts. Smallholder and subsistence farmers will suffer more of the impacts of climate change resulting from small farm sizes, Technologies for the development of improved germplasm, however the first step in the process of reducing the impact of climate changes on Maize growth and production.

The adaptation strategies to climate change in the zones were;

- ✓ A primary measure is the development and cultivation of more drought-tolerant maize varieties
- ✓ A second measure is adjustment in the planting days of maize
- ✓ The use of irrigation facilities in the cultivation of maize
- ✓ Farmers must engage in crop diversification
- ✓ Improved agronomic management and Crops

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