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Analysis of Household Response Farming Techniques to Climate Change in Southeast Ethiopia

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General Note
Article is recommended to print as color version in recycled paper. *Save Trees, Save Climate*.

ABSTRACT

Response farming to climate change work towards reducing the vulnerability of the agricultural sector to climate change. Therefore, the objective of this research was to assess the response of farmers towards climate change in the target districts of bale zone. Thus, cross-sectional research design having multi stage stratified sampling procedures was followed to achieve the study objectives related with farmer's response towards climate change. Sinana, Ginir and Dallo Mana were purposefully selected from each strata of Bale zone based on the presence of meteorological station. Two kebeles from each district and a total of 370 households for this study and for each kebele it was proportionally calculated. Different research approaches were used to collect data from primary and

secondary sources. Quantitative data was analyzed by using descriptive statistics and inferential statistics using SPSS 20 version software. Response farming practices like soil and water conservation, irrigation practices and crop diversification of the community to climate change and adjustment of crop water requirement scenarios was observed in the study districts. Therefore, emphasis on maintenance and conservation of response farming to climate change practices, improve extension service, information availability, and credit saving institution should get attention by all stakeholders.

Keywords: Farming; Household; Climate change; global warming

1. INTRODUCTION

Back ground of the study

Global temperatures have already increased by approximately 0.6°C (1°F) over the last century, and the Intergovernmental Panel on Climate Change (IPCC) concluded that the human-made environmental warming contribute most proportion since last 5-decades (IPCC, 2001). In addition, the IPCC projects that average global temperatures will increase by 1.4 to 5.8°C (2.5 to 10.4°F) this century. According to reports growth of crop and successful farming practices such applications of fertilizers or pesticides is dependent on climate Furthermore rise of production cost which implies a decrease in farm revenue due to period of drought is primarily caused by climate variability. Persistent disruption of climate resources induces farmers to substitute more reliable resources for riskier ones (William *et al.,* 2004).

The water used by different crops for cooling and growth process is referred as crop water use or evapotranspiration (ET). Furthermore, crop water requirement or water use is the amount of water needed by the crop from planting to harvest crop growing stages in a specific climate in a specific climate, when adequate soil water is maintained by rainfall and/or irrigation so it does not limit plant growth and crop yield. Only a small fraction of the water a plant takes in is used for growth, often only about 1 percent; the majority of water is needed to allow the plant to cool itself. The movement of water into the plant is important, since this water carries essential nutrients needed by the plant for growth processes (Danny *et al.,* 2015).

Knowing crop water requirement in a given area can be important to plan certain irrigation projects. To determine the crop water requirement climatologically data as rainfall, maximum and minimum temperature, relative humidity, wind speed etc., are needed. According to Hajare et al. (2008) computing the water requirement of different crops in a given area can be utilized for planning of irrigation scheme, irrigation scheduling, effective design and management of irrigation system and also for midterm planning when drought happens in between the season. In order to have optimum irrigation and water management schedules computations of crop coefficient and potential evapotranspiration are important tool for assessing irrigation water requirements of different crop types (Falguni, 2013).

Reference and crop evapotranspiration (ETo and ET_C) is higher for crops with longer growing season than for those with shorter ones. Also ETo and ET_C were more during the dry season than the rainy season (Adeniran *et al.,* 2010). According to the projection of Samiha *et al.* (2016) climate change condition in 2040 is expected to increase ET and consequently, water requirements will also increase. In semi-arid regions, more pressure will be put on water resources distribution between economic sectors under climate change, especially agriculture.

Under changing climate food security situations can be worsen via application of reduced allocation of water for irrigation, final yield reduction and increased need or crop water requirement.

Thus, it is very important to revise and fix the production system for cultivated crops, in terms of the used cultivars, fertilizer, irrigation application, etc.

Climate change is already taking place now, thus past and present changes help to indicate possible future changes. According to report temperature was increased by 0.2°C per decade in Ethiopia. Studies with more detailed regional climate models also indicate that the sign of the expected precipitation change is uncertain. The temperature will very likely continue to increase for the next few decades with the rate of change as observed. The projected increases in the interannual variability of precipitation in combination with the warming will likely lead to increases in the occurrence of droughts (Marius, 2009).

Furthermore, heavy rains and floods are projected to increase as well. According to research reports the current and projected climate change and variability patterns has an effect socio-economic and natural systems. These impacts include: Agriculture, Food Security, Water, Health, Ecosystems, biodiversity, and infrastructure. Furthermore, the changing climate has an impact in water scarcity, pollution and soil degradation and fertility beyond food security. When the aforementioned problems in relation to resource scarcity and environmental quality problems addressing these challenges need to be prioritized. Crop and livestock production systems in most regions of the world is expected to negatively impacted by climate change (OECD, 2015).

According to Burke and Lobell (2010) report, an adapted world in 2050 will have some key characteristics to look for: specific to temperate regions planting of improved crop varieties; area expansion of crops and shifts in planting dates are needed; furthermore, expansion of irrigation, water harvesting and effective institutions for anticipating and responding to droughts and local food production shortfalls are expected. Understanding this adapted world, however, will necessitate difficult decisions on the part of public and private sector organizations.

However, in responding to climate change is a challenge for global agriculture in general Ethiopia in particular. This is due to differences in rainfall, temperatures and the ranges of plants and pest species will transform agriculture. Therefore, developing countries are predicted to experience stronger impacts than others (IPCC, 2007).

Statement of the problem

Agriculture being the major recipient of climate changes will continue to suffer and farmers continue to lose their investments due to lack of knowledge about climate change to set appropriate adaptation options. In order to tackle impact of climate change on natural and human systems proper attention should be given. Due to changing climate the environment is becoming hotter and drier, rainy seasons are getting shorter and unpredictable, more violent and increasingly erratic and different variations have been observed (Kok *et al.,* 2008).

On the other hand, a manageable solution to the problem of estimating monthly water requirements for supplementary irrigation and dryland crops is complicated by the numerous factors which interact to form the water demand. The requirement is primarily a function of the rainfall amount and frequency in association with evapotranspiration, soil type, crop-type, time of planting, as well as the stage of growth of the crop and its rooting depth. An estimate of the probabilities of occurrence of these water requirements is also essential in risk management planning. The agricultural planner is often faced with a large number of possible crop, soil and risk management options which must be considered. Comprehensive planning therefore requires appraisals of the many combinations of the aforementioned variables.

In Bale Zone in general and study areas in particular scientific studies were not carried out which quantifies crop water requirements for all crops grown in target districts whether in the highland or lowland areas. This situation will result in unplanned farming activity for those performing rain fed agriculture, especially in dryland farming districts. For the present and future small scale or large scale irrigation practices designed in country wise if there is no crop water requirement outline, it is very difficult to be economical in water use and for successfully achieving of the goal.

According to WFP (2015), in the lowlands of Bale Zone, only 18 percent of average planted area is under crops due to the late start of summer rains, hence taking into consideration climate change agenda in to development is a must. Despite this tragedy, pastoralist, agro-pastoralists and farmers follow the previously existing trend of farming system in which their response were not as expected as required, which is disastrous for their future life. Thus, finding adaptation solutions is critical for those who engaged in agricultural sector for their livelihood so as to minimize the recurrent risk. Therefore, adaptation measures must work towards reducing the vulnerability of the agricultural sector and increasing the resilience of rural areas from an environmental and an economic perspective.

Significance of the Study

Evidence is accumulating that the Earth's climate is undergoing change, and observations are consistent with scientific expectations concerning the increasing concentrations of greenhouse gases in the atmosphere. Agriculture is an economic sector directly influenced by climatic conditions, thus any change in the climate patterns will have immediate effects on it. Reliable predictions and an understanding of climate change impacts on water use, irrigation requirements and yields of crops are necessary to plan adaptation strategies, especially in dryland agriculture.

In order to anticipate, avoid and react climate related shocks by the farmers' knowledge of risk management is an important tool which in return improves living standard, strengthen the viability of farm businesses, and provide an environment which supports investment in the farming sector. Furthermore, high risk of crop failure due to drought and dry spells leads to reluctance by smallholder farmers to invest on cropland, which suggests that drought and dry spell mitigation through better on-farm and off farm management activities could be the key to improved crop production in the current farming systems of potential areas where agriculture is hampered by periodic droughts. To this end this end Knowledge of exact amount of water required by different crop in a given set of climatological condition of a District is great help in planning of irrigation scheme, irrigation scheduling, effective design and management of irrigation system and also for midterm planning in case of mid-season drought occurrences. In addition, this study will initiate other researchers to make further study about the issue.

General Objective

- To determine the crop water requirement for major crops and asses the response of farmers towards climate change in Dallo Mana, Sinana and Ginir districts of Bale Zone

Specific Objectives

- To determine crop water requirement for major crops in Dallo Mana, Sinana and Ginir districts of Bale Zone
- To simulate crop water requirement for major crops up to 2049
- To assess the response of Farmers towards Climate Change in the selected

2. METHODOLOGY

Description of the study Area

Dello Mena is located in the south western part of Bale Zone and located at 555km south east of Addis Abeba., it is bounded by Madda Walabu District in the south, Goba District in the North, Harena Buluke District in the West and south west, Berbere District in Northeast and Guadahamole in the East. It has a total area of 1339km^2 which ranked the district 14th largest among the districts. The area has minimum and maximum temperature record of 21^{o}c and 38^{o}c with respectively and annual mean temperature record of 29.5 ^{o}c. The annual average rainfall is 701.5mm whereas the minimum and maximum rainfall is 628 and 775mm respectively. Dello Mena District is Endowed with several rivers, Nine perennial river flow across the district namely Welmel, Yadot, Erba-1, Erba-2, Deyu, Denda, Doya Gomogoma and Shawe. The rivers and other Deep walls, Ephemerals ponds, seasonal streams are source of water for livestock and people (DBAO, 2015)

Sinana district is located in the northern western part of Bale zone. It is bounded with Goro and Ginir in East, Dinsho in West, Agarfa and Gasera in North and Goba and Barbare district in the south. The total area of the districts is about 163554 hectares which ranked as the third smallest district in the zone and their area account about 1.67 % out of the total area of the zone (6966km^2). The administrative center of the district is Robe town and has 22kebelesfrom which two of them are urban and 20 are rural kebeles. Out the total area of the district, highland accounts about 10% and semi- high lands are about 90 % (Source: Sinana district Agriculture and Rural Development office, 2014). The lowest and highest altitude of the district is extended from 1500 to 2300m above sea level respectively. The minimum and maximum temperature is 18^{o}c and 25^{o}c whereas annual average temperature of the areas is 21.5^{o}crespectively. The annual average rainfall is 1105mm whereas the minimum and maximum rainfall is 1060 and 1150mm respectively (Source: Sinana district Agriculture and Rural Development office, 2014).

Ginir district has diverse landscape that causes varied microclimate of an area. This accounts for the possibility of producing variety of crops. Climate plays decisive roles on the activities of Agriculture. Agriculture, on the other hand, is an important economic sector, on which the life of the majority depends on. In addition, climate, particularly, temperature and rainfall are the two determinant elements for the success of Agricultural production. The annual average temperature is 25.45 the minimum and maximum temperature is 23.2^{o}c and 27.7^{o}c respectively while the area has 24.45^{o}c annual mean temperature record. The annual average rainfall is 700mm whereas the minimum and maximum rainfall is 200 and 1200mm, respectively.

Ginnir District have two major cropping season which is known as Meher and Belg. Cereals, pulses, Oilseed, fruit, vegetables and spice are the known crop grown in the zone. Maher season is the main cropping season for zonal farmers and the production produced during this season take a lion share over others season of production because of rain suitability. Cereals, pulses, oil seed, vegetables, fruit, and spices are the main crops that are produced during this season.

Study Design of Social Survey

For this study Cross-Sectional Research Design was employed. Therefore, data related with farmer's response farming was collected at one time shot from the respondents to achieve the study objectives.

Sampling Techniques

Bale Zone was purposefully selected to achieve the objective of the study based on its accessibility. In order to achieve the objectives of the study a multi stage sampling procedures was followed. In the first stage, Bale Zone was stratified in to highland, Lowland and semi highland districts to avoid biasness in study area selection. Unless the districts are categorized under different strata, there might be a higher probability of single agro ecology to be included in the study. In the second stage of sampling procedure, Sinana, Ginir and Dello Mena were purposefully selected from each strata of Bale zone based on the presence of meteorological station. In the third stage, two kebeles from each district were randomly selected. Thus, Ilu sanbitu and selka from sinana; Irba and Gongoma from Dallo Mana; Ebisa and Akasha kebele from Ginir district were selected. Finally, a total of 370 households were randomly selected for interview.

Sample size determination techniques

For this study household sample size was determined following the principles (Gupta 2002).

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

n = indicates sampling units, N = indicates total population (4895), e = indicates the error which wecan tolerate (0.05).

Therefore, sample size becomes **370** households for this study.

Data Collection Methods

In order to achieve the objectives of the study, different research approaches were used to collect data from primary and secondary sources. The primary data was collected using household survey, focus group discussions, and key informant interview with different social groups. Moreover, observations were made to check the reality on the ground. Secondary data was collected from office, literature review and newspapers were used as supplementary input for survey data.

Survey questionnaire:

The selected households were interviewed using semi structured questionnaire. This household survey will be conducted on **370** sample households. Socioeconomic features of the households, knowledge of the farming community towards crop water requirement, response farming practices of the Households were major issues addressed in the questionnaire.

Focused Group discussion:

This was arranged to support the data was obtained from household survey and from interview of various stakeholders. In all the six kebeles were surveyed discussions were made with a group of farmers composed of different social groups. Specifically, gender, age and expertise were used as inclusion criteria. Thus one group which consists of 12 members was formed in each kebele. For this study group discussion checklists were designed to lead the discussions. The major focuses of the discussions were generated information at community level that can complement the survey data in response farming practices. As far as possible, the discussions were also supplemented with personal observation of the facts on the ground.

Key informant interview:

It was employed with 18 officials three from each kebeles that were selected through purposive sampling method in relation to their responsibilities on environmental protection. This was helped to know the opinion, importance, interest, shortcoming, the interaction, willingness/ awareness and commitment to cooperate with others in the management of climate elements.

Data analysis

The data which was collected through semi-structured interview schedule was processed and coded by using SPSS 20 version software. Combinations of analytical tools were employed in this study. The data which was obtained from questionnaire was analyzed in descriptive as well as inferential statistics such as chi-square test for categorical variables and T- test for continuous variables will be used to examine the socioeconomic characteristics of the respondents.

Multinomial Logit Model (MLM) Description

To describe the MNL model, let y denote a random variable taking on the values {1, 2, . . ., J} for j, a positive integer, and let x denote a set of conditioning variables. In this case, y denotes adaptation options or categories and x contain different household characteristics, economic variables, institutional and social factors. The question is how ceteris paribus changes in the elements of x affect the response probabilities (P(y = j/x), j = 1, 2 . . . J. Since the probabilities must sum to unity, P(y = j/x) is determined once we know the probabilities for j = 2 . . . J. Let **x** be a 1 × K vector with first element unity. The MNL model has response probabilities:

$$P\ (y = j/x) = \frac{\exp(X\beta j)}{\left[1+\sum_{h=1}^{J}\exp\ (x\beta h)_{,}\right]} \text{ --------------------------------------- (1)}$$

Where, is βjK× 1, j = 1, ……….J

The equation of multinomial logit model in Eq. (1) requires the independent of irrelevant alternative assumption (IIA) (Temesgen *et al.*, 2009). More specifically it indicates that the probability of using a certain adaptation options by a given household needs to be independent from the probability of choosing another adaptation option (that is, Pj/Pk is independent of the remaining probabilities) (Hassan and Nhemachena, 2008).

The directional effect of the independent variables on the dependent variable is determined by the parameter estimates of the MNL model, nonetheless estimates made by the model do not represent either the actual magnitude of change nor probabilities. Separating Eq. (1) with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\frac{\partial Pj}{\partial Xk} = P_j\,(\beta_{jk} - \sum_{j=1}^{j-1} Pj\beta jk) \text{ --(2)}$$

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from its mean (Green, 2000).

3. RESULT AND DISCUSSION

Participants on Response farming to climate change

This household survey study was consisted a total of 370 households, 301 of men and 69 of women were independently sampled for this studies (Table 1). There was no refusal to respond the interview. In addition, this study was presented response farming to climate change during Focus Group Discussions (FGDs). The analysis was indicated that total participants of the study farmers have observed increasing of climate change. Thus, it was observed that information gathered through FGDs was in line with secondary data gathered and information from Ethiopia National Meteorological Service which was presented in previous chapters of this study.

Determinants of Household Response farming to Climate Change

The result of this finding was revealed that farmers' had better perception on responsive farming strategies to climate change undertaken across highland, midland and lowland of Bale zone, South-eastern of Ethiopia. It could be observed that the farmers were recognized responsive farming to climate change through various climate information sources (radio, TV, Newspaper) and extension service. Thus, this was highly influenced by age, sex, farm experience, education status, family size, farm size, livestock owned, market accessibility and participation on credit of the household were played a great role as determinant factors (Table 1 and 2). Similarly, Temesgen, (2012) was reported that usage of climate change adaptation strategies directly influenced by sources and level of information, budget and labour availability, household farm size and potential for irrigation. Likewise, higher probability of male households better adapting to climate change also agrees with the fact that male-headed households often have a higher probability of adopting agricultural technologies, mostly, in parts of Africa (Buyinza and Wambede, 2008). Similarly, previous studies have reported that farmers' adaptation to climate change is determined by factors such as education, age, farming experience, gender, access to extension, credit, markets, farm income and farm size (Deressa *et al.,* 2011; Gbetibouo, 2009; Nhemachena and Hassan, 2007).

Approaches of Household Response to Climate Change

The result in Table 11 and 12 were showed that there were statistically significant variations on soil and water conservation techniques, cultural practice, early/late planting, variety selection, use of irrigation and crop diversification across agro-ecological zones due to age, education status, farm experience, family and farm size, livestock owned, market and credit saving accessibility, participation on credit saving, availability of extension service and climate sources at 5% probability level. Additionally, in three agro-ecologies climate change statistically significant difference due to utilization of response farming to climate change (Table 11 and 12). As it was detected from the result education status, family size, livestock owned and age of the respondents were directly proportional to practices of response farming to climate change.

Despite this respondent old age greater than 60, family size greater than eight and education status greater than grade eight inversely proportional to practices of response farming to climate change (Table 11). This result was in disagreement with (Birhan and Assefa, 2017) report in household size was positively and significantly affects the adoption of responses farming to climate change. At farm level adaptation is made by crop diversification, mixed crop livestock farming systems, using different crop varieties, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties and high-yield water sensitive crops were influenced by household age, family size and educational status (Bradshaw *et al.*, 2004). This result was in agreement with Nhemachena and Hassan (2007) findings which indicate use of new crop varieties and livestock species that are more suited to the environment, irrigation, crop diversification, mixed crop livestock farming systems and changing planting dates were common climate change adaptation methods in agriculture determined by household characteristics.

Table 1. Household characteristics * most preferred response farming used

Household characteristics		Most preferred response farming used											
		SWC		cultural practice		early/late planting		variety selection		use of irrigation		crop diversification	
		N	%	N	%	N	%	N	%	N	%	N	%
Sex	Male	128	84.2	44	77.2	43	84.3	52	8	21	80.8	13	68.4
	Female	24	15.8	13	22.8	8	15.7	13	2	5	19.2	6	31.6
Age	<25	15	9.9	6	10.5	5	9. 8	8	12	1	3.8	1	5.3
	25-40	56	36.8	20	35.1	23	45.1	28	43	3	11.5	3	15.8
	41-60	54	35.5	23	40.4	19	37.3	20	31	19	73.1	12	63.2
	>60	27	17.8	8	14.0	4	7.8	9	14	3	11.5	3	15. 8
Education level	Illiterate	13	8.6	2	3.5	5	9.8	2	3.1	ns	ns	2	10.5
	1-4	49	32.2	20	35.1	21	41.2	26	4	10	38.5	7	36.8
	5-8	29	19.1	6	10.5	8	15.7	14	22	7	26.9	3	15.8
	9-10	10	6.6	5	8.8	7	13.7	3	4.6	1	3.8	1	5.3
	10-12	11	7.2	6	10.5	2	3.9	3	4.6	ns	ns	ns	ns
	>12	ns	ns	1	1.8	ns	ns	5	7.7	8	30.8	6	31.6
	Informal	40	26.3	17	29.8	8	15.7	12	18.5	ns	ns	ns	ns
Family size	1-3	6	3.9	10	17.5	ns	ns	ns	ns	ns	ns	ns	ns
	4-5	42	27.6	11	19.3	16	31.4	16	25	11	42.3	5	26.3
	>8	35	23	7	12.3	13	25.5	14	26	11	42.3	3	15.8
	6-8	69	45.4	29	50.9	22	43.1	35	54	4	15.4	11	57. 9

ns: note selected by the household

Table 2. Household characteristics * most preferred response farming used

Household characteristics		Most preferred response farming used											
		SWC		cultural practice		early/late planting		variety selection		use of irrigation		crop diversification	
		N	%	N	%	N	%	N	%	N	%	N	%
Study district	Sinana	61	40.1	19	33.3	13	25.5	34	52.3	11	42.3	7	36.8
	D/Mena	57	37.5	34	59.6	15	29.4	19	29.2	8	30.8	7	36.8
	Gindir	34	22.4	4	7.0	23	45.1	12	18.5	7	26.9	5	26.3
Farm Experience	<10 years[x]	21	13.8	16	28.1	8	15.7	10	15.4	4	15.4	5	26.3
	10-20 years	34	22.4	13	22.8	14	27.5	17	26.2	6	23.1	3	15.8
	20-30 Years	38	25.0	14	24.6	10	19.6	13	20.0	ns	ns	2	10.5
	30-40 Years	15	9.9	8	14.0	12	23.5	9	13.8	11	42.3	3	15.8
	40-50 years	22	14.5	1	1.8	5	9.8	7	10.8	3	11.5	63	1.6
	>50 years	22	14.5	5	8.8	2	3.9	9	13.8	2	7.7	ns	ns
Household land size	0-2ha	59	38.8	23	40.4	14	27.5	13	20.0	1	3.8	10	52.6
	2-4ha	44	28.9	5	8.8	6	11.8	26	40.0	2	7.7	5	26.3
	4-6ha	23	15.1	18	31.6	11	21.6	7	10.8	3	11.5	4	21.1
	6-8ha	19	12.5	8	14.0	7	13.7	7	10.8	7	26.9	ns	ns
	>8ha	7	4.6	3	5.3	13	25.5	12	18.5	13	50.0	ns	ns
Do you have livestock?	No	31	20.4	2	3.5	20	39.2	9	13.8	5	19.2	3	15.8
	yes	121	79.6	55	96.5	31	60.8	56	86.2	21	80.8	16	84.2
Is their Credit and Saving Institution in your area?	No	44	28.9	27	47.4	11	21.6	21	32.3	2	7.7	2	10.5
	Yes	108	71.1	30	52.6	40	78.4	44	67.7	24	92.3	17	89.5
Did you get credit in the last one year?	No	26	17.1	21	36.8	15	29.4	13	20.0	12	46.2	7	36.8
	Yes	126	82.9	36	63.2	36	70.6	52	80.0	14	53.8	12	63.2
Did you have an	No	48	31.6	12	21.1	24	47.1	17	26.2	5	19.2	3	15.8

access to climate information?	yes	104	68.4	45	78.9	27	52.9	48	73.8	21	80.8	16	84.2
Is there any extension organization in your area?	No	42	27.6	20	35.1	20	39.2	15	23.1	8	30.8	8	42.1
	Yes	110	72. 4	37	64.9	31	60.8	50	76.9	18	69.2	11	57.9
Is there any market access in your vicinity?	No	53	34.9	20	35.1	15	29.4	19	29.2	6	23.1	7	36.8
	yes	99	65.1	37	64.9	36	70.6	46	70.8	20	76.9	12	63.2

This analysis was revealed that households were chosen soil and water conservation (41.08%) as the most response farming option. It was followed by variety selection (17.57%), cultural practices (15.4%), early or late planting (13.78%), use of irrigation (7.03%) and crop diversification (5.13%) due to variability in climate (T11).Similarly, according to Temesgen (2007) most of the farmers in Ethiopia consider soil and water conservation techniques as key strategy to adapt to global warming. This output was in line with Apata (2011) which was reported most of the respondents noticed and responded to climate change through different climate change mitigation strategies. The results again in line with Uddin *et al.* (2014) which showed that irrigation practices, improved crop varieties, crop diversification, farm diversification, change of planting dates and income generating activities are among the adaptation practices most frequently deployed by farmers. However, this result was in disagreement with Francis and Tsunemi (2015) which reported majority of respondents (51 %) use crop diversification strategies in response to climatic variability.

The size of land owned by a household lies between 0.5 and 1.5 ha with an average farm size of 1ha which was higher than the average national arable land holding size per household of 0.97ha (MOA, 1989 cited in Gizachew, 1994). Despite this respondent land holding size was inversely proportional to practices of response farming to climate change. There was statistically significant variation in size of land holding per household across the agro-ecology (Table 2).Similarly, accessibility and participation to credit and saving, access to climate information, extension service and market were directly influenced household response to climate change.

Likewise farm experience and agro-ecology were influenced response farming to climate change significantly. This was supported by Birhan and Assefa (2017).

Interpretation of Multinomial Logit Model for Response Farming to Climate Change

The results of the multinomial logistic regression model for the different response farming practices to climate change were presented in Table 4. The results from model were indicated that most of the explanatory variables affected the probability of response farming to climate change as expected.

Variables that positively and significantly influenced response farming to climate change were sex, education status, family size, livestock own, agro-ecology, access to market, farm size, get extension and credit and saving service, access to climate information and farm experience of the head of the household. Thus, study was estimated that the model to determine factors influencing farmers' choice of response farming to climate change in Dalo Mana, Sinana and Gindir district. The MNL model has a chi-square (χ^2) value of 471.098 and pseudo r^2 equal to 0.720. In addition, the likelihood function of the model was found to be 690.314 and statistically significant at ($p<0.01$). This indicated that the data has a good fit to the model. For this particular study, "crop diversification" category was taken as the basis for comparison. In addition, the results were showed that household farm size, get extension, credit and saving service, access to climate information and farm experience significantly ($p < 0.01$) influence the choice of soil and water conservation techniques, cultural practices, early/late planting, variety selection and use of irrigation (Table 1 and 2).

This was implied that when farm size of the household was increased by a single unit the odd ratio of using soil and water conservation techniques, cultural practices, early/late planting, variety selection and use of irrigation practices were increased by 2.479, 5.902, 7.502, 67.807 and 11.139 respectively. This was might be because of as land holding size increase, the households might be used full time on improving their land productivity. This result was in disagreement with Apata (2011) which reported negative relationship between adaptation and farm size.

Furthermore, the age of the household significantly different at ($p <0.05$) due to response farming to climate change practices of soil and water conservation, cultural practices, early/late planting, variety selection and use of irrigation. The results were clearly indicated that the age of the household was reduced the probability of farmers practicing soil and water conservation as response farming to climate change by 82.5% compared to crop diversification. On the other hand, when the age of the household was increased by a single unit the odd ratio of using cultural practices, early/late planting, variety selection and irrigation practices as response farming to climate change were increased by 10.64.7, 3.305, 39.006% and 7.974 compared to crop diversification respectively. According, the result was supported by Elijah *et al.,*(2016) in the adoption of different cultural practices, the result showed that for every unit increase in the age of the farmer, the probability of adopting cultural practices by farmers increase by 0.8. This result was in agreement with a finding from Cassidy and Barnes (2012) where age of head of household was positively correlated with higher livelihood diversity, adaptive capacity and resilience in households in a rural community.

Education level of the household significantly ($p < 0.05$) influence the choice of soil and water conservation, cultural practices, early/late planting, variety selection and use of irrigation. Thus, while the education level of the household was increased by a single unit the odd ratio of using soil and water conservation, cultural practices, early/late planting, variety selection and use of irrigation as response farming to climate change where increased by 7.495, 14.491, 8.382, 11.094 and 4.863 as compared to crop diversification respectively. This was similar with the reports of Gbetibouo (2009) which indicated household education level affect farmers' response strategies to climate change differently.

Sex of the household significantly ($p < 0.05$) influence the choice of soil and water conservation, cultural practices, early/late planting, variety selection and use of irrigation. Thus, when the chance of the household sex was male the odd ratio of using soil and water conservation, cultural practices, early/late planting, variety selection and use of irrigation as response farming to climate change were increased by 16.001, 15.412, 11.679, 9.875 and 2.719 as compared to crop diversification respectively. Family size of the household significantly ($p < 0.05$) influence the choice of soil and water conservation, cultural practices, early/late planting, variety selection and use of irrigation. Thus, at the time family size of the household was increased by a single unit the odd ratio of using soil and water conservation, cultural practices, early/late planting, variety selection and use of irrigation as a response farming to climate change were increased by 10.220, 179.089, 39.740 7.978 and 6.156 as compared to crop diversification respectively. A large family size which enabled a household to execute various agricultural activities specific to peak season is in contrary with the fact that increasing household size increases the likelihood of response farming to climate change (Croppenstedt *et al.,* 2003).

Livestock own of the household significantly ($p < 0.05$) influence the choice of soil and water conservation, cultural practices, early/late planting, variety selection and use of irrigation. This was implied that for every additional of the livestock own of the household was increased by a single unit the odd ratio of using soil and water conservation, cultural practices, early/late planting, variety selection and use of irrigation as response farming to climate change were increased by 8.185, 2.742, 19.021, 21.219 and 4.523 as compared to crop diversification respectively.

Table 3: Result of the multinomial logit model on climate change adaptation

Explanatory variables	SWC		Cultural Practices		Early/Late Planting		Variety Selection		Use of Irrigation	
	Coefficient (Std. Err.)	Wald (Exp(B))	**Coefficient (Std. Err.)**	Wald (Exp(B))	**Coefficient (Std. Err.)**	Wald (Exp(B))	**Coefficient (Std. Err.)**	Wald (Exp(B))	**Coefficient (Std. Err.)**	Wald (Exp(B))
Age	-1.785* (0.944)	3.403 (0.175)	2.365* (1.277)	3.431 (10.647)	1.195** (0.607)	3.882 (3.305)	3.664* (2.166)	2.860 (39.006)	2.076** (1.014)	4.189 (7.974)
Education	2.014* (1.198)	2.825 (7.495)	2.674** (1.365)	3.836 (14.491)	2.126* (1.148)	3.429 (8.382)	2.406* (1.292)	3.470 (11.094)	1.582** (0.709)	4.975 (4.863)
Sex	2.773** (1.152)	5.793 (16.001)	2.735** (1.259)	4.718 (15.412)	2.458** (1.241)	3.923 (11.679)	2.290* (1.180)	3.764 (9.875)	1.001** (0.546)	3.359 (2.719)
Family size	2.324** (1.187)	3.837 (10.220)	5.188** (1.713)	9.173 (179.089)	8.288** (2.077)	15.917 (39.740)	2.077* (1.243)	2.792 (7.978)	1.817** (0.796)	5.208 (6.156)
Farm size	5.513** (2.486)	4.917 (2.479)	1.775** (0.723)	6.034 (5.902)	2.015** (0.725)	7.716 (7.502)	6.519** (2.747)	5.631 (67.807)	2.410** (0.896)	7.242 (11.139)
Livestock owned	2.102** (1.029)	4.174 (8.185)	1.009** (0.399)	6.380 (2.742)	2.946* (1.750)	2.833 (19.021)	3.055** (1.550)	3.887 (21.219)	1.509** (0.711)	4.500 (4.523)

Pseudo R-Square: Cox and Snell 72%; Reference categories: Crop Diversification

While participation on credit and saving service of the household head was increased by a single unit the odd ratio of using cultural and irrigation practices were increased by 94.318 and 0.671 whereas soil and water conservation techniques, early/late planting and variety selection were reduced by 0.023, 0.149 and 0.035 respectively. Similarly, when access to market of the household head was increased by a single unit the odd ratio of using soil and water conservation techniques, early/late planting, variety selection and irrigation practices were increased by 3.030, 9.515, 3.655 and 5.735 whereas cultural practices were reduced by

0.086 respectively. According to Bruin (2011) adaptation strategies include switching crops, shifting crop calendar, engaging new management practices for a specific climate regime, changing irrigation system and selecting different cropping technologies were influenced by credit saving and access to market. Inline this smallholder farmer whose participate on credit and saving service were used soil and water conservation measures and planting trees as response farming to climate change (Yesuf *et al,* 2008).

In addition, as participation on extension service of the household head was increased by a single unit the odd ratio of using soil and water conservation techniques, cultural and use of irrigation practices were increased by 12.197, 9.981 and 3.829 whereas early/late planting and variety selection reduced by0.018 and 0.01 respectively. Maddison (2006) reported that access to extension services creates awareness and promising condition for implementation of farming practices that are applicable under climate change. Likewise, when access to climate information of the household was increased by a single unit the odd ratio of using soil and water conservation techniques, cultural practices, early/late planting, variety selection and use of irrigation practices were increased by 94.318, 9.358, 7.460, 1.898 and 5.017 respectively compared to using crop diversification. This result was in agreement with Hansen *et al.* (2004) who have suggested that information derived from personal experience and information from external sources yield different choice of response farming to climate change. A study by Akter and Bennett (2009) revealed that exposure to mass-media increases the awareness and concerns of the damages associated with climate change.

The results of this study was revealed that expected the farm experience of the household was increased by a single unit the odd ratio of using soil and water conservation techniques, cultural practices, early/late planting, variety selection and use of irrigation practices were increased by 5.735, 9.580, 7.228, 9.806 and 6.589 respectively compared to using crop diversification. Furthermore, Ishaya and Abaje (2008) stated that perception of climate change can be generated from farm experience via age.

Table 4: Result of the multinomial logit model on climate change adaptation

Explanatory variables	SWC		cultural practice		early/late planting		variety selection		use of irrigation	
	Coefficient (Std. Err.)	Wald (Exp(B))	**Coefficient (Std. Err.)**	Wald (Exp(B))	**Coefficient (Std. Err.)**	Wald (Exp(B))	**Coefficient (Std. Err.)**	Wald (Exp(B))	**Coefficient (Std. Err.)**	Wald (Exp(B))
Agro-ecology	3.613* (1.951)	3.429 (37.064)	4.033** (1.069)	14.228 (56.438)	1.335* (0.485)	7.590 (3.800)	3.727** (0.922)	16.344 (41.572)	1.930** (0.824)	5.479 (6.886)
Avail. of credit & saving instit.	2.996** (1.098)	7.444 (20.014)	-2.104** (0.908)	5.368 (0.122)	2.506** (1.176)	4.542 (12.257)	3.235** (1.135)	8.215 (25.863)	2.048** (0.806)	6.456 (7.749)
Farm Experience	1.747** (0.808)	4.673 (5.735)	2.260** (0.886)	6.511 (9.580)	1.978* (1.049)	3.557 (7.228)	2.175** (0.983)	4.900 (8.806)	1.885** (1.065)	3.136 (6.589)
Access to climate info.	4.547** (1.187)	14.662 (94.318)	2.236** (1.097)	4.159 (9.358)	2.010* (1.066)	3.551 (7.460)	0.641* * (0.325)	3.877 (1.898)	1.613** (0.697)	5.356 (5.017)
Extension service	2.501** (0.766)	10.659 (12.197)	2.301** (0.701)	10.784 (9.981)	-4.014** (1.410)	8.099 (0.018)	-4.593** (1.369)	11.262 (0.010)	1.343** (0.715)	3.522 (3.829)
Participation on credit & saving	-3.796** (1.321)	8.142 (0.023)	4.547** (1.187)	14.662 (94.318)	-1.901** (0.955)	3.962 2(0.149)	-3.353** (1.786)	3.525 (0.035)	0.624** (0.761)	1.866 (0.671)
Access to market	1.109** (0.371)	8.906 (3.030)	-2.458* (1.489)	2.724 (0.086)	2.253** (1.051)	4.599 (9.515)	1.296* (0.766)	2.860 (3.655)	1.747** (0.808)	4.673 (5.735)

Pseudo R-Square: Cox and Snell 72%; Reference categories: Crop Diversification

4. CONCLUSION AND RECOMMENDATION

The trend analysis of climate variables (Temperature, Sunshine hour and Relative humidity except for Ginnir stations) for the study period **(2020-2049)** demonstrates that their will be a **slight decrease** over time, while Wind Spead showed a slight increase over the entire district. The result further revealed that wind speed will be **increased** by **0.07 m/s, 0.18 m/s and 0.12 m/s decadall**y in Dello-Mena, Ginnir and sinana districts, respectively. Two growing period were observed in the study districts through focus group discussion and weather conditions analysis. As a results for crop water requirement determinationmajor types of crops grown, length of growing period, effective rainfall and irrigation requirement for different cereals over Delo-mena, Ginnir and sinana district of Bale Zone were calculated using satellite data and actual data from stations.

In Dalo Mana District cropping period and crop water requirement of Mung-Beans crop was observed as it is short and less respectively whereas Teff less and short in crop water requirement and cropping period respectively. Similarly, Ginir district maize the highest water consumer with 180 days to maturity would require a crop water requirement of 576.7 mm while 124.9 mm would be required as supplementary irrigation whereas lentil observed as that has the shortest and lowest cropping period and crop water requirement respectively. Likewise, there was variation between the crop in water requirement but climate projection and crop water requirement scenarios shows less change in comparison to the left districts.

Crop water requirement projection was showed that there will be significant change in the next thirty years. But according to social survey result there was ineffective copping strategies have followed by local communities and governments. However, result of this finding was revealed that farmers' had better perception on responsive farming strategies to climate change undertaken across highland, midland and lowland of Bale zone, Southeastern of Ethiopia. Therefore, the following points were forwarded for all stakeholders:

- Local community and Districts should emphasis on maintenance of soil and water conservation techniques, water harvesting structures, participatory forest management, and implementation of integrated water resource management
- Extension service and access to climate information need more emphasis to bring better adaptation and mitigation capacity to climate change
- Policy makers, water resource manager, agricultural office should incorporate improvement of water supply plan in their strategies
- Create awareness creation of different stakeholders on trends of crop water requirement scenarios and response farming to climate change
- Investors should implement according to their agreement and local government should follow their environmental and social framework implementation.

Conflict of Interest
The authors declare that there is no conflict of interest.

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