academicresearchJournals

Vol. 5(2), pp. 140-150, March 2017
DOI: 10.14662/ARJASR2017.012

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

Exploring the Impacts of Climate Change on Chickpea (*Cicer arietinum* L.) Production in Central Highlands of Ethiopia

Eba Muluneh Sorecha[1], Kibebew Kibret[1], Gebre Hadgu[1a] and Agere Lupi[2]

[1]College of Agriculture and Environmental Sciences, Haramaya University, Ethiopia
[1a]Tigray Agricultural Research Institute, Ethiopia
[2]Melkassa Agricultural Research Center, Melkassa (Adama) Ethiopia
Corresponding author:ebamule1@gmail.com

Accepted 23 March 2017

In Ethiopia, where vulnerability to climate change and variability is high, studying the impact of climate change at a local scale is critical for designing appropriate strategies for adaptive capacity. The study was conducted in Bishoftu area to examine the extent of climate change effects on the production of two chickpea varieties (Arerti and Habru) in the upcoming periods (2050's and 2080's) under two climate scenarios, RCP4.5 and RCP8.5. Future climate data were downscaled using an ensemble of two climate models (CSIRO-Mk3-6-0 and MIROC-ESM-CHEM0) with RCP4.5 and RCP8.5. Twelve years of crop data were collected from Debre Zeit Agricultural Research Center (DZARC). Soil data were also adopted from published documents of DZARC. Decision Support System for Agrotechnology Transfer (DSSAT) model was used for this study. The model employs all collected data to simulate days to flowering (DF), days to maturity (DM), and yield. Prior to simulations, the model was validated for its performance in simulating the yields of both chickpea varieties. The study revealed that the yield of Arerti will increase by 22% from the baseline yield of 2846 kg/ha by 2050's under RCP 4.5. In contrast, by 2050's under RCP 8.5, the yield of Arerti will reduce by 33%. Moreover, the study depicted that 2% yield increment of Habru from the baseline yield of 2787.5 kg/ha will be expected by 2080's under RCP 8.5.The reason for yield increment and decrement could be due to the combined effects of mainly rainfall and maximum temperature versus the tolerance of respective chickpea variety. In general, RCP 8.5 has resulted in more reduction of yield of Arerti variety than RCP 4.5 scenario. However, Habru variety will benefit more from RCP 8.5 scenario. Therefore, chickpea production under a changing climate is possible with appropriate variety choice. The study appreciates similar studies to be conducted on other leguminous crops.

Key words: impacts, climate change, chickpea production, Ethiopia

Cite this article as: Sorecha EM, Kibret K, Hadgu G, Lupi A (2017). Exploring the Impacts of Climate Change on Chickpea (*Cicer arietinum* L.) Production in Central Highlands of Ethiopia. Acad. Res. J. Agri. Sci. Res. 5(2): 140-150

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world next to dry beans and dry peas (Parthasarathy Rao et al., 2010). Chickpeagrows widely intemperate region; however, it's currently spreading to sub-tropical and tropical area of Asia, Africa and Oceania. Ethiopia is the largest chickpea producing region in Africa, covering about 37%. In the last decades, Ethiopia produced about 195,800 tons of chickpea from parcel land of 176,554 ha (FAOSTAT, 2004). Chickpea production in India is very intensive, covering90% of the global chickpea area. However, the crop will be highly influenced by climate change in the upcoming periods.

Ethiopia will face a various climatic features at different time slice as per the climate projection studies. Though climate change highly relies on the extent of emission scenarios and climate models considered, there will be high levels of confidence in increasing temperature in Ethiopia, confirmed by many scholars (Conway and Schipper, 2011; Setegn et al., 2011; Ayalew et al., 2012; Hadgu et al., 2014). They come up with same results that Ethiopia would experience warming by 2020 and 2050 periods than the actual warming. Similarly, the mean annual rainfall will increase with much uncertainty on the pattern of its distribution, timing, and intensity (Conway and Schipper, 2011; NMA, 2007). This has big implications on the productivity crops, a major livelihood system of the country (Kassie et al., 2013; Hadgu et al., 2014). Keane et al. (2009) reported that by 2080's, agricultural yields will be declined by 21%. By 2050's climate change would lead to a 30% reduction of average income (Gebreegziabher et al., 2011), and 10% in Gross Domestic Product (GDP) of Ethiopia (Mideksa, 2009).

Now days, General Circulation Models (GCMs) are widely used tools in capturing the global climate condition (Ghosh and Mujumdar, 2008), but the outputs from GCMs are too coarse, not easily be used for local climate studies. This leads regional climate changes more difficult to predict due to extrapolation from global to local scales are not precise. So, further downscaling to the local level using software like MarkSim weather generator is becoming a mandatory (Jones and Thornton, 2013; Washington et al., 2000). Generated data could be employed in crop models; Decision Support System for Agro-technology Transfer (DSSAT) for climate impacts studies (Hoogenboom, 2000; Bannayan et al. 2003). The aim of this paper was to explore the challenges of climate change on chickpea production in Bishoftu area, central highlands of Ethiopia, to design appropriate adaptation methods.

MATERIALS AND METHODS

Description of the study area

The study was carried out at Debre Zeit Agricultural Research Center (Bishoftu area), central part of Ethiopia. According to Ministry of Agriculture (MOA, 2002), the area is characterized under sub-moist, mountain and plateau, tepid to cool climate based on the growing season, temperature and altitude of the area.The research site is located at 8.730 latitude and 38.980 longitudes with an elevation ranging from 1931- 2097 m above mean sea level.

Climate of the study area

The study area receives an annual average rainfall of about 777mm and annual average maximum and minimum temperatures of 26.81 and 10.95^{0}C, respectively based on the climate data analysis of 1980-2012 periods. Again, the study area received bimodal pattern of rainfall "Belg" or the shorter season's rain, which is quite small to support crop production, usually occurs during the periods from the second week of March to the second or third weeks of May. The long ''kiremt'' rainy season extends from the second week of June to the last week of September. The break period between the two rainy seasons is brief over the central parts of Ethiopia, while it increases from southwest to the northward and eastward directions (Gissila, 2001).

As shown in Figure 1, the area receives the highest amount of rainfall(up to 200mm) in the month of July.Whereas, the least amount of rainfall was recorded in November and February. Moreover, the mean maximum and minimum temperature reach the peak level May and July, respectively.The mean temperature experienced over the last three decades was 17.8^{0}C, and mean rainfall of 72 mm were notified during chickpea growing months (August, September, October, November and December). During the same season (August, September, October, November and December), the average minimum and maximum temperatures reach about 10 and 25.5^{0}C, respectively (Figure 1).

Description of Experimental Materials

Two Kabuli type chickpea varieties known as *Arerti* and *Habru* were used as experimental materials. This is due the fact that in the study area, these varieties are locally well known and widely grown by the local farmers and DZARC as a local check used with other chickpea genotypes of National Variety Trial/ evaluating new breeding lines/genotypes of chickpea. *Arerti* was released in 1991, while *Habru* was released in 1996. Both varieties are suited to an altitude ranging from 1800-2600m and with an annual average rainfall ranges from 700-1200 mm. *Arerti* requires 105-155 days to mature with theyield potential of 1600-5200 kg/ha under experimental fields and 1800-4700 kg/ha at farm level, whereas *Habru* requires 91-150 days to mature and yields about 1400-5000 kg/ha under experimental fields and 2000-4000 kg/ha at farm level.Randomized Complete Block Design (RCBD) with 4 replications was used as an experimental design; spacing used was 30

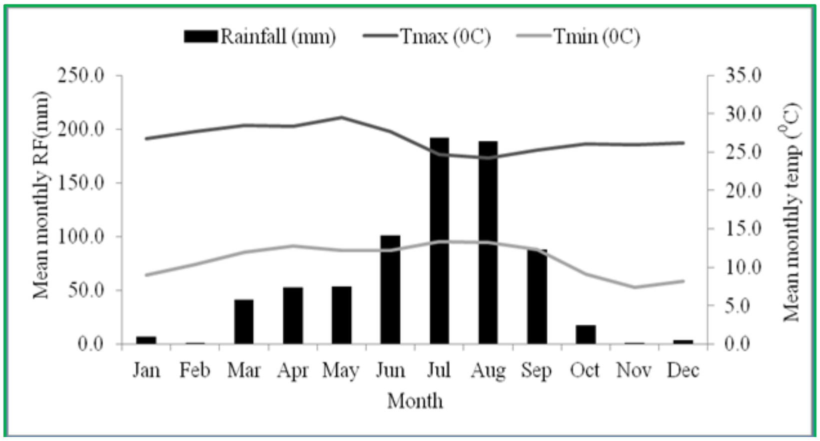

Figure 1. General description of the climate of Bishoftu area for the period of (1980-2012)

cm between rows and 10 cm between plants. The planting density/population used was 33 plants per m^{-2}. Moreover, fertilizer was applied at the time of sowing containing 18-25 kg N and 40-46 kg P ha^{-1}.

Data sources

Future climate data: future climate data were downscaled from ensemble of two GCMs (CSIRO-Mk3-6-0 and MIROC-ESM-CHEM) models with RCP4.5 having CO_2 concentration of 650 ppm equivalent with A1FI SRES of third and fourth assessment report and RCP8.5 having CO_2 concentration of 1370 ppm equivalent with B1 SRES (SimCLIM-2013-AR5-data-manual) using MarkSim (Jones and Thoronton,2000). Therefore, with the selected two models and emission scenarios (RCPs) present in the Markism model, future climate change (temperature, rainfall and solar radiation) were analyzed for two time slots centered at 2050's (2040-2069) and 2080's (2070-2095) andcompared with the base line (1980-2009) period.

Crop Yield and Yield Components and crop Management data: twelve years of yield and yield components data and crop management data (planting and emergence date, planting method, plant distribution, plant population, row spacing, planting depth…)forboth chickpea varieties (*Arerti* and *Habru*) were collected from Debre Zeit Agricultural Research Center (DZARC). About 50% of the data were used for DSSAT model calibration, and the rest 50% were used for model evaluation, thereby, for evaluating possible impacts of climate change on chickpea production via DSSAT crop model.

Description of the Climate Model (GCM) and Climate Scenarios (RCPs)

In this particular study, two climate models: CSIRO-Mk3-6-0 with the resolution of (192*96 Km2) and MIROC-ESM-CHEM with the resolution of (128*64 Km2) were selected based on their spatial resolution for atmospheric variable (longitude*latitude) they had and their further applicability to African climate impact studies with Representative Concentration Pathways (RCPs)(Yang et al.,2014). In climate research, emissions scenarios are used to explore how much humans could contribute to future climate change given uncertainties in factors such as population growth, economic development, and development of new technologies. The RCPs are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its Fifth Assessment Report (AR5). The four RCPs: RCP2.6 - low emissions (CO_2 490 ppm), RCP4.5 - intermediate emissions (CO_2 650 ppm), RCP6.0 - intermediate emissions (CO_2 850 ppm), and RCP8.5 - high emissions (1370 ppm) named after a possible range of radiative forcing values in the year 2100 (of 2.6, 4.5, 6.0, and 8.5 W/m2, respectively) (Vuuren et al., 2011 and Rogeli et al., 2012). With the preferred models above, two different RCPs: RCP4.5 having CO_2 concentration of 650 ppm equivalent with A1FI SRES of third and fourth assessment report and RCP8.5 having CO_2 concentration of 1370 ppm equivalent with B1 SRES were used to downscale the rainfall, temperature (minimum and maximum) and solar radiation data from GCMs to a specific site. The basis for selecting the aforementioned two RCPs for this study was to seriously consider the impacts of CO_2 emitted to the atmosphere at all levels of concentrations: low, medium and high emission concentration.

Research Approach

Crop Model: DSSAT

For this particular study, the CROPGRO model, which is embedded within the DSSAT version 4.5 (Hoogenboom *et al*., 2010) was used to simulate daily phonological development and growth and yieldsof chickpea in response to environmental and management factors.

The model employs soil data, crop management data and daily meteorological data as an input to simulate daily leaf area index (LAI) and vegetation status parameters, biomass production and final yield. The daily meteorological data include solar radiation, rainfall, maximum and minimum air temperatures. The major soil data include soil type, slope and drainage characteristics, and chemical-physical parameters for each soil layer, such as saturated soil water content, lower drained limit, upper drained limit, initial soil water content, relative root distribution, soil pH, bulk density and soil organic matter. The crop management data include variety, planting date, plant density, irrigation and fertilizer (application dates and rates). The model calculates the phasic and morphological development of the crop using temperature, day length and genetic characteristics. The water and nitrogen balance sub models like wise, provide feedback that influences developmental and growth processes in the model (Ritchie *et al*., 1998).Genotypic differences in growth, development and yield of crop cultivars are affected through genetic coefficients (cultivar-specific parameters) that are inputs to the model. The physiological processes that were simulated to describe the crop response to major weather factors include temperature, precipitation and solar radiation and also the effect of soil characteristics on water availability for crop growth. Therefore, using the downscaled climate data as an input for DSSAT, yield simulation for both chickpea varieties*(Arerti and Habru)* for two time slots centered at 2050’s (2040-2069) and 2080’s (2070-2095) were undertaken.The change of yield in percentage from the baseline yield was calculated using a formula:

$$\Delta Y = \frac{Ys - Yb}{Yb} \times 100$$

Where ΔY=change of yield, Ys= simulated yield, Yb= baseline yield for Impact

DSSAT Crop Model Calibration

Model calibration has beendone by comparing the simulated values of development and growth characteristics of each crop with their corresponding observed values, and by calculating statistical parameters of an agreement between simulated and observed values. There are a number of coefficients that can be adjusted in the CROPGRO-Chickpea model. The "genetic coefficients" describe the phenology and grain yield of a particular variety and are located in the file genetics of DSSAT model. To calibrate a given cultivar, the typical genetic coefficients of the cultivar specific chickpea variety present in the model were used and any required changes were made to match the model simulation with the observed field data. Generally, the criterion is to minimize the error between observed and simulated values of a given variable (WMO, 2010). Therefore, to calibrate a cultivars, typical genetic coefficients of the cultivar IB0012 KAK-2 Kabuli type found in the model by default were used for *Arerti* variety and IB0009 ICCC 32 cultivar were used for *Habru* variety and changes were made in Slope of the relative response of development to photoperiod with time (negative for long day plants) (1/hour)(PPSEN) and Time between plant emergence and flower appearance (R1) (photothermal days) (EM-FL) coefficients to match the simulated days to 50% flowering with the observed data of a cultivar recorded over the study area. Similarly, to calibrate the days to maturity, changes were made in Time between first flower and first seed (R5) (photothermal days) (FL-SH), time between first flower and first seed (R5) (photothermal days) (FL-SD) and time between first seed (R5) and physiological maturity (R7) (photothermal days) (SD-PM) coefficients were undertaken. After calibrating the growth cycle phases, the maximum fraction of daily growth that is partitioned to seed + shell (XFRT) coefficients were iterated for calibration. Simulated seed size was matched with the observed data by adjusting the coefficients of maximum weight per seed (g) (WTPSD), Seed filling duration for pod cohort at standard growth conditions(photothermal days) (SFDUR), threshing percentage (THRSH) and time required for cultivar to reach final pod load under optimal conditions (photothermal days) (PODUR). Again, the time between first flower (R1) and end of leaf expansion (photothermal days) (FL-LF), maximum leaf photosynthesis rate at 3 ^{0}C, 350 vpm CO_2, and high light(mg CO_2/m^{2-s}) (LFMAX), specific leaf area of cultivar under standard growth conditions(cm^2/g) (SLAVR), maximum size of full leaf (three leaflets) (cm^2) (SIZLF), average seed per pod under standard growing conditions (#/pod) (SDPDV), fraction protein in seeds (g(protein)/g(seed) (SDPRO), and fraction oil in seeds (g(oil)/g(seed) (SDLIP) were calibrated accordingly.

DSSAT Crop Model Validation

This wasdone by regression to determine the strength of observed value explained by the simulated variables/yields. For both varieties, the regression equation, coefficient of determination (R^2), residual mean standard error (RMSE), normalized root mean standard error (RMSEn) and index of agreement or d-statistic was calculated. The indexes of agreement (d) (Willmott, 1982) for each variety were also computed to measure the coincidence between measured and simulated values. The comparison has been done with simulated mean values of days to flowering, days to maturity and grain yield (kg/ ha) with measured ones.

The value of RMSE approaching to zero indicates the goodness of fit between the simulated and observed values. The RMSE was computed using the following equation:

$$RMSE = \sqrt{1/n \sum_{i}^{n} = (Pi - Oi)}^{2}$$

Where n= number of observations, Pi= predicted value for the ith measurement and O^{i}= observed value for the i^{th} measurement.

Whereas, the RMSEn was also computed as follows:

$$RMSEn = RMSE \times 100 \frac{RMSE \times 100}{\bar{O}}$$

Where RMSE= root mean square error,RMSEn = Normalized root mean square error, and $\bar{O}$ = the overall mean of observed values.

RMSEn (%) gives a measure of the relative difference of simulated versus observed data. The simulation is considered excellent if the RMSEn is less than 10%, good if it is greater than 10% and less than 20%, fair if RMSEn is greater than 20% and less than 30%, and poor if the RMSEn is greater than 30%. On the other hand, d-statistic provides a single index of model performance that encompasses bias and variability and is a better indicator of 1:1 prediction than R^2. The closer the index value is to unity, the better the agreement between the two variables that are being compared and vice versa (Willmott *et al.,* 1985 cited by Musongaleli *et al.,* 2014). The d-statistic was computed as:

$$d = 1 - \left[\frac{\sum_{i-1}^{n}(Pi - Oi)2}{\sum_{i-1}^{n}(/P'i/+/O'i)2}\right], O < d < 1$$

Where n is number of observations, Pi= predicted value for the i^{th} measurement, O_i= observed value for the i^{th} measurement, *O* = the overall mean of observed values, $P'_i = P_i - O$; $O'_i = O_i - O$

However, linear regression was applied between simulations and observations to evaluate model performance and correlation coefficient (R^2) for each simulation (Loague and Green, 1991).

$$R^2 = \frac{SS(regression)}{SS(residual)}$$

Where, SS (regression) is sum square regression and SS (residual) is sum square of residual.

RESULTS AND DISCUSSION

DSSAT Model Calibration

During the calibration of CROPGROchickpea model, several model iterations were run to determine the coefficients for both chickpea varieties (*Arerti* and *Habru*). The results of the model out have been summarized in table 1. The study revealed that the genetic coefficients for both chickpea variety differ, thoughthere are parameters where their coefficients are same. For instance, the genetic coefficients values for PPSEN, LFMAX, SLAVR, SIZLF, and XFRT for both chickpea varieties for showed same. However, it has been found to be different values for EM-FL, FL-SH, FL-SD, SD-PM, FL-LF, WTPSD (Table 1).

Performance evaluation of CROPGRO model in simulating the yield of *Arerti* variety

The specific crop model CROPGRO embedded in the DSSAT model was able to simulate most of the crop parameters with a reasonable accuracy. However, there were over and underestimation of certain parameters for certain years as shown in Figure 2. Accordingly, the model overestimated the grain yield, days to anthesis and days to physiological maturity for Bishoftu area. There was also underestimation for the same crop parameters. However, the variation in observed and simulated days to anthesis, days to maturity and yield were able to explain by 82.76, 84.23 and 82.74%, respectively (Figure 2).

From Figure 2 of simulated versus observed plot, it could be clearly seen that there is almost a little deviation from the trend line for days to maturity, days to flowering and yield. This indicates that the model simulated the actual days to maturity, days to flowering and yield with high precision as also indicated by the high R^2 values, RMSE and d-statistics (Table 2). Therefore, further study on future climate change impact on chickpea-*Arerti* variety using the results of DSSAT as the baseline is capable which in turn leads to develop best adaptation option against the changing climate.

Performance evaluation of DSSAT model in simulating yield of *Habru* variety

Similarly, for *Habru*, the model was able to simulate most of the crop parameters with a reasonable accuracy. However, there were also over and underestimation of certain parameters for certain years as indicated in Figure 3. The model overestimated the grain yield, days to anthesis and days to physiological maturity for Bishoftu area. There is underestimation for the same crop parameters in different years. However, the variation in observed and simulated days to anthesis, days to

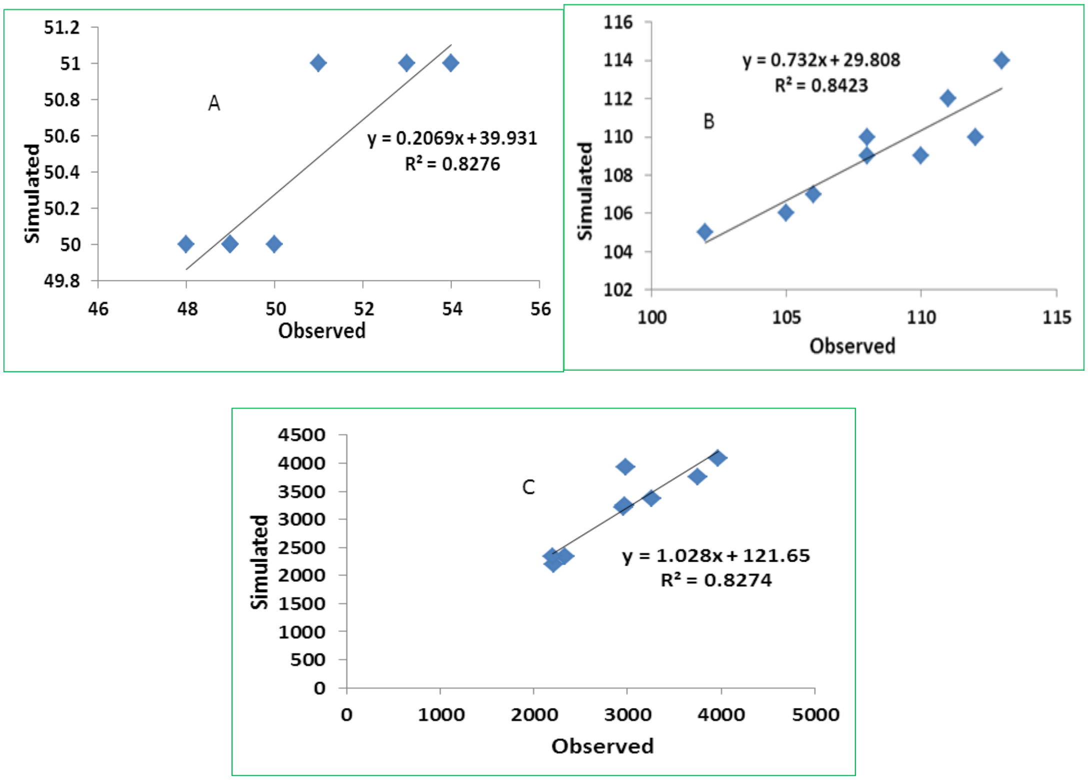

Figure 2. Observed and simulated results for days to anthesis (A), days to physiological maturity (B) and yield harvest (C) for *Arerti* variety

Table 2. Mean comparison of simulated and observed days to anthesis, maturity and grain yield of chickpea varieties during model calibration

	Chickpea varieties									
	Arerti					***Habru***				
	Obse.	**Simu.**	**RMSE**	**R^2**	**d-stat**	**Obse.**	**Simu.**	**RMSE**	**R^2**	**d-stat**
Parameters										
DF(days)	51	52	0.5	0.83	0.81	52	52	0.1	0.864	0.93
DM(days)	108	109	0.3	0.84	0.8	110	112	0.3	0.865	0.76
Yield(kg/ha)	2960	3165	27	0.82	0.65	3054	3153	29.5	0.756	0.77

Where, Obse-observed value, Simu-simulated value

maturity and yield were able to explain by 86.42, 86.55 and 75.89%, respectively. Figure 3 also depicted the simulated versus observed plot showing that a little deviation from the trend line for days to maturity, days to flowering and yield has been notified. This indicates that the model simulated the actual days to maturity, days to flowering and yield with high precision as also indicated by the high R^2 values and other parameters considered to measure the model performance (Table 2). Therefore, further study of future climate change impactson chickpea, *Habru* variety using the results of DSSAT as the baseline is also possible so as to adopt the best adaptation option to the changing climate.

DSSAT model validation

Comparison between simulated and observed days to

Table 1. Cultivar-specific parameters in DSSAT and genetic coefficientvalues of *Arerti* and *Habru* Variety.

Coefficient	**CSDL**	**PPSEN**	**EM-FL**	**FL-SH**	**FL-SD**	**SD-PM**	**FL-LF**	**LFMAX**	**SLAVR**	**SIZLF**	**XFRT**	**WTPSD**	**SFDUR**	**SDPDV**	**PODUR**	**THRSH**	**SDPRO**	**SDLIP**
Arerti	11	-0.14	39	9	14	30	38	1	200	10	0.96	0.283	29	1	18	85	0.216	0.48
Habru	11	-0.14	40	10	15	35	42	1	200	10	0.96	0.181	29	1.2	18	85	0.216	0.48

Source: Cultivar-specific parametersareadopted fromDSSAT module and coefficient values arethe model simulation outputs for each parameter.

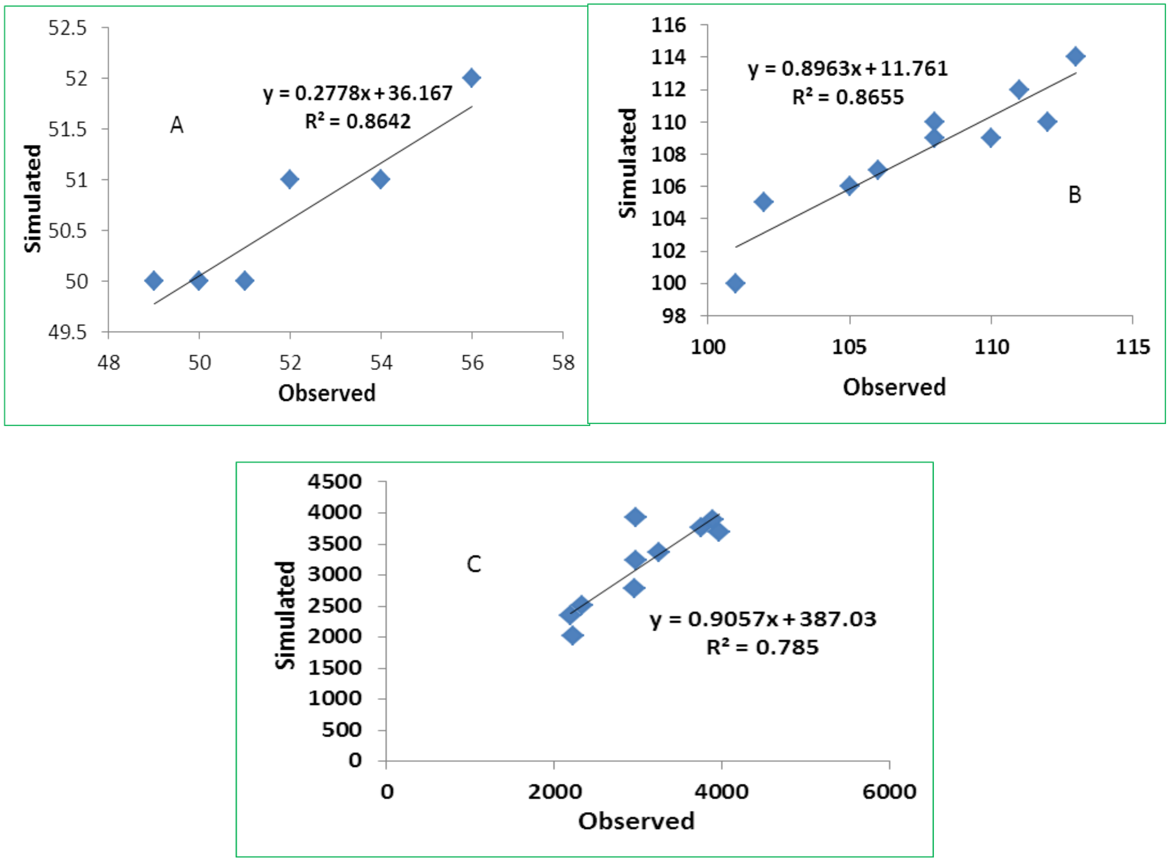

Figure 3. The observed and simulated results for Days to Anthesis (A), Days to physiological Maturity (B) and Yield harvest (C) for *Habru* variety

Table 3. Mean comparison of simulated and observed days to anthesis, maturity and grain yield of chickpea varieties during model validation

	Chickpea varieties									
	Arerti					***Habru***				
	Obse.	**Simu.**	**RMSE**	**R^2**	**d-stat**	**Obse.**	**Simu.**	**RMSE**	**R^2**	**d-stat**
Parameters										
DF(days)	57	58	0.1	0.83	0.91	59	59	0	0.864	0.93
DM(days)	128	133	0	0.84	0.87	126	125	0	0.865	0.76
Yield(kg/ha)	3425	3483	24	0.857	0.85	3564	3553	23	0.785	0.77

Table 4. Annual changes of rainfall in percentage and temperature in degree celsius from the baseline in the upcoming periods under two climate scenarios forensembles of two GCM models: CSIRO-Mk3-6-0 and MIROC-ESM-CHEM0.

	Baseline	**RCP4.5 mid century**	**RCP4.5 end century**	**RCP8.5 mid century**	**RCP8.5 end century**
RF (%)	776.10	+32.10	+35.87	+44.30	+42.20
SD	152.30	75.07	17.56	57.42	54.65
CV	19.62	7.32	1.67	5.20	4.91
Tmin.(^{0}C)	10.94	+0.04	+0.11	+0.12	+0.30
SD	0.53	0.33	0.09	0.61	0.57
CV	1.98	2.89	0.75	5.03	4.02
Tmax.(^{0}C)	26.76	+0.07	+0.05	+0.07	+0.07
SD	0.43	0.34	0.05	0.58	0.49
CV	3.89	1.37	0.19	2.28	1.80

RF is rainfall change in % from the baseline; SD, Standard Deviation; CV, coefficient of Variation in %; Tmin, minimum temperature in ^{0}C; Tmax, maximum temperature in ^{0}C.

anthesis, maturity and grain yield of both chickpea varieties during model validation is depicted in Table 3. During model evaluation, the result showed an excellent performance of the CROGRO model in simulating days to anthesis and maturity. Moreover, there was a good agreement between simulated and observed values of both chickpea grain yields during model validation. The statistical indicators used to evaluate model performance in this study revealed almost better agreement. This might be resulted due to good quality data obtained from DZARC. Thus, all the statistical measures considered showed strong agreement between simulated and observed values of both crops, which revealed the potential of DSSAT in studying the impact of future climate on the productivity of *Arerti* and *Habru* in the study area.

Projected Climate forCentral Highlands of Ethiopia

It has been revealed through this study that there will be an increase in the amount of rainfall to be received compared with historicallyreceived rainfall.This actually depends on the scenarios considered. Rainfall will increase by 32% in midcentury (2050'S) under RCP4.5 scenario with CV value 7.32% and SD value 75 (Table 4). Overall, the study indicated that rainfall will increase consistently from 2050'S to end century (2080'S) under both scenarios. Similarly, minimum temperature will rise up under both scenarios considered under both time slices compared with the baseline, but the values vary with the scenarios (Table 4).The highest minimum temperature increment will be expected by end century under RCP8.5, with CV value about 4% and SD value 0.57. On the other hand, maximum temperature will decrease in both times slices under both scenarios except by end century under RCP8.5 where it will increase by 0.02^{0}C showing CV value 1.8% (Table 4).

Yield Response of Chickpea under Climate Projection

Figure 4 and 5 shows that the two chickpea varieties have responded differently to the future climate change

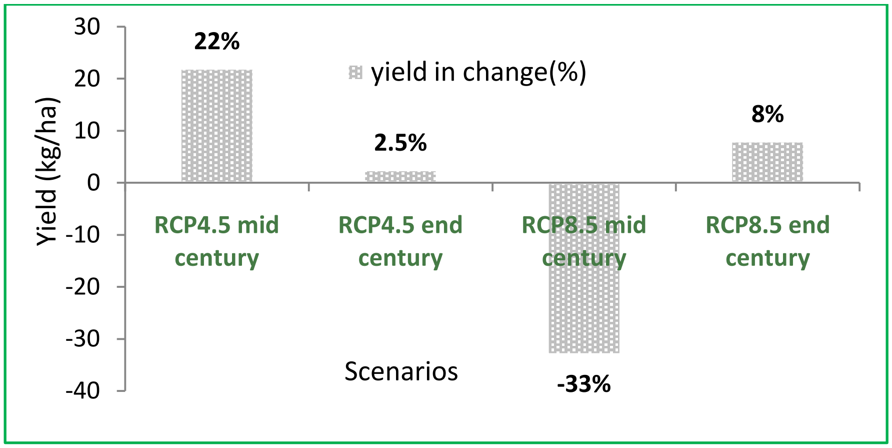

Figure 4. Projected yield change in (%) of *Arerti* variety from the baseline yield under RCP4.5 and RCP8.5 in Bishoftu areafor ensemble of two GCM models: CSIRO-Mk3-6-0 and MIROC-ESM-CHEM0

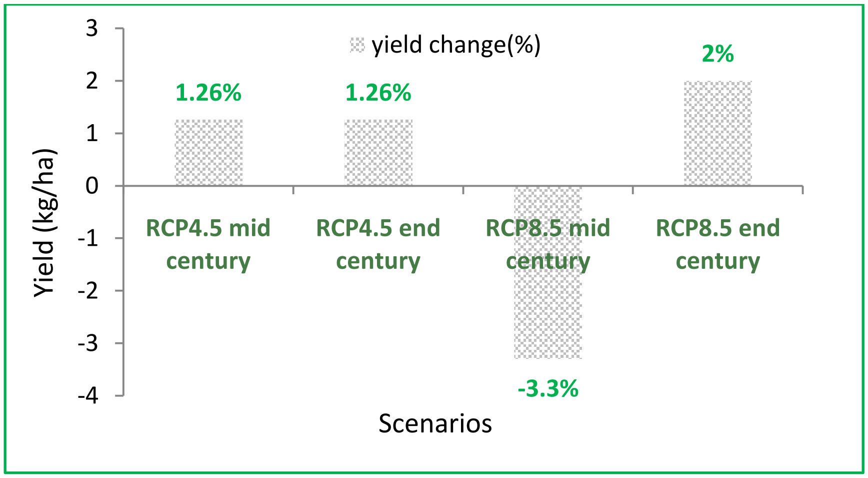

Figure 5. Projected yield change in (%) of *Habru* variety from baseline under RCP4.5 and RCP8.5 in Bishoftu area for ensemble of two GCM models: CSIRO-Mk3-6-0 and MIROC-ESM-CHEM0

under both scenarios. There will be an increase and decrease in the yield of both chickpea varieties in Bishoftu area, central highlands of Ethiopia in the upcoming periods. Projected climate feature has a positive impact on both chickpea varieties (*Arerti and Habru)* yield in Bishoftuarea under both RCPs by2050's and 2080's periods, except by 2050's under RCP8.5 scenario where the yield of both *Arerti* and *Habru*will be expected to decrease by 33 and 3.3%,respectively compared with baseline yield.This could be due to climatic pattern to be seen during this time period. For instance, the rainfall will increase by 43% from the baseline average of 776mm/year. Comparing the two scenarios, the results in Figures 4 and 5revealed that RCP 8.5 has resulted in reducing yield of *Arerti* variety than the RCP 4.5 scenario; meaning that the variety has favorable condition under the RCP 4.5 scenarios than RCP 8.5 scenarios. The reverse is true for *Habru* variety, where RCP 8.5 scenario benefited this crop.

Furthermore, Figure 4 shows an increasing yields for *Arerti*, change from the baseline yield (2846 kg/ha) by 22% in 2050's. This is associated with a rainfall increment by about 32% and minimum temperature by 0.04^0C compared with baseline. This is due to the fact that chickpea can grow in a wide range of climatic feature, but not in extreme climatic condition. Many areas of Ethiopia will maintain moist climate conditions, and agricultural development in these areas could help offset rainfall declines and reduced production in other areas asper the Ethiopia climate trend analysis fact sheet of 2012.Again,the yield of *Habru* will increase by 8% by 2080's under RCP 8.5. In general, there will be a yield variation due to climate change leading to many factors. Climate change is expected to significantly alter African biodiversity as species struggle to adapt to changing conditions (Lovett *et al*., 2005).

On the other hand, for *Habru* variety,same amount of yield change 1.26% from baseline yield of 2787.5 kg/ha will be experienced under RCP4.5 by 2050's and 2080's, although the climatic condition during the two periods vary (Figure 5). Additionally, about 2% yield of Habru will be expected to increase by 2080's under RCP8.5 Scenario.

CONCLUSION AND RECOMMENDATION

Overall, with different time periods, both chickpea varieties respond differently to the impacts of future climate change. Therefore, there need to adopt an appropriate chickpea variety fitting the environment with respective time periods to boost the production of chickpea in the study area. There will be a decline in yields of both crops in different time periods under different scenarios. This might be due to the impact of rainfall: water logging, erosion and other associated hazards with climate change over Bishoftu area, central highlands of Ethiopia. Theremight be also the impact of particularly, maximum temperature extremes resulting in reduction of chickpea yields. Thus, the use of an appropriate chickpea variety fitting the environment with respective of time period could be considered to enhance the productivity of chickpea in central highlands of Ethiopia.

ACKNOWLEDGEMENT

We would like to thanks the Ministry of Education of Ethiopia for budget allocation via Haramaya University for this research work. Our special thanks also geos to Debre Zeit Agricultural Research Center, Pulse Crop Research Team for crop data used for this particular study. Finally, we would extend our sincere appreciation to publisher for considering and publishing this piece of work.

REFERENCES

Ayalew, D., K. Tesfaye, G. Mamo, B. Yitaferu, W. Bayu. 2012. Variability of rainfall and its current trend in Amhara region, Ethiopia. *Africa Journal of Agricultural Research,* 7 (10): 1475-1486.

Bannayan, M., Crout, N. M. J., & Hoogenboom, G (2003). Application of the CERES-wheat model for within season prediction of winter wheat yield in the United Kingdom.*Agronomy Journal*, 95:114-125.

Conway, D. and E.L.F. Schipper (2011). Adaptation to climate change in Africa: challenges and opportunities identified from Ethiopia. Global Environmental Change, 21(1), 227-237.

Food and Agriculture Organization of the United Nations(FAOSTAT) (2004). http://faostat.fao.org/faostat/.

Gebre Hadgu, Kindie Tesfaye & Girma Mamo (2014). Analysis of Climate Change in Northern Ethiopia: Implications for Agricultural Production. *Theoretical and Applied Climatology*, 117: 7-9.

Gebreegziabher, Z., J. Stage, A. Mekonnen, A. Alemu (2011). Climate change and the Ethiopian economy: A computable general equilibrium analysis. *Environment for Development Discussion Paper Series,* 24 p

Ghosh S, Mujumdar PP (2008). Statistical downscaling of GCM simulations to stream flow using relevance vector machine. Adv Water Resour 31:132–146.

Gissila, T (2001). Rainfall Variability and Teleconnections over Ethiopia. MSc thesis (Meteorology), University of Reading, U.K. pp109.

Hoogenboom, G (2000). Contribution of agrometeorology to the simulation of crop production and its applications. Agriculture and Forest Meteorology, 103: 137–157.

Hoogenboom, G., Jones, J.W., Wilkens, P., Porter, C.H., Boote, K.J., Hunt, L.A., Singh, U., Lizaso, J.L., White, J.W., Uryasev, O., Royce, F.S., Ogoshi, R., Gijsman, A.J., Tsuji, G.Y(2010). Decision Support System for Agrotechnology Transfer (DSSAT) Version 4.5 [CD-ROM].University of Hawaii, Honolulu, Hawaii.

Jones, P.G., P.K. Thornton (2000). Mark Sim: software to generate daily weather data for Latin America and Africa. Agronomy Journal, 9: 445–453.

Jones PG, Thornton PK (2013).Generating downscaled weather data from a suite of climate models for agricultural modelling applications. Agric Syst, 114:1–5.

Keane, J., S. Page, A. Kergna, J. Kennan (2009). Climate Change and Developing Country Agriculture: An Overview of Expected Impacts, Adaptation and Mitigation Challenges, and Funding Requirements, ICTSD–IPC Platform on Climate Change, Agriculture and Trade, Issue Brief No.2, International Centre for Trade and Sustainable Development, Geneva, Switzerland and International Food & Agricultural Trade Policy Council, Washington DC, USA.

Kassie, B.T., R.P. Rotter, H. Hengsdijk, S. Asseng, M.K. Van Ittersum, H. Kahiluoto, H. Van Keulen(2014). Climate variability and change in the Central Rift Valley of Ethiopia: challenges for rainfed crop production. *Journal of Agricultural Science*, 152 (01): 58-74.

DOI:10.1017/S0021859612000986.

Loague, K., Green, R.E(1991). Statistical and graphical methods for evaluating solute transport models: overview and application. Journal of Contaminant Hydrology, 11 (3): 44-46.

Lovett, J.C., G.F. Midgely, P.B. Barnard(2005). Climate change and ecology in Africa. African Journal of Ecology, 43: 279-281.

Mideksa, T.K(2010). Economic and distributional impacts of climate change: The case of Ethiopia.*Global Environmental Change*. 20 (2): 278-286. doi:10.1016/j.gloenvcha.2009.11.007.

Ministry of Agriculture(MOA) (2002).rural development strategies MOA , Addis Abeba, Ethiopia.

Musongaleli, B., Filbert, R., Siza, D. and Tumbo, N. K(2014). Sorghum yield response to changing climatic conditions in semi-arid central Tanzania: Evaluating crop simulation model applicability. Agricultural Sciences, 2014, 5, 822-833. http://www.scirp.org/journal/as http://dx.doi.org/10.4236/as.2014.510087. Accessed on 11 March 2017.

National Meteorological Agency (NMA) (2007).Climate Change National Adaptation Program of Action (NAPA) of Ethiopia. Technical Report, United Nations Development Program (UNDP). Addis Abebe, Ethiopia: NMA.

Parthasarathy Rao, P., Birthal, P.S., Bhagvatula, S., Bantilan, M.C.S(2010). Chickpeaand Pigeonpea Economies in Asia: Facts, Trends and Outlook. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India, pp. 76.

Ritchie, J.T., U. Singh, D. Godwin, W.T. Bowen(1998). Cereal growth, development and yield. In: Tsuji, G.Y., Hoogenboom, G., Thornton, P.K. (Eds.), Understanding Options for Agricultural Production. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 79–98.

Rogeli, J., Meinshausen, M., and Knutti, R(2012). Global warming under old and new scenarios using IPCC climate sensitivity range estimates, 2012, Nature Climate Change, DOI: 10.1038/NCLIMATE1385.

Setegn, S.G., D. Rayner, A.M. Melesse, B. Dargahi, R. Srinivasan, A. Wörman (2011). Climate change impact on agricultural water resources variability in the Northern Highlands of Ethiopia. In: A.M. Melesse (ed.), Nile River Basin 241-265. DOI 10.1007/978-94-007-0689-7_12.

Vuuren, D., M. den Elzen, P. Lucas, B. Eickhout, B. Strengers, B. van Ruijven, S. Wonink, R. van Houdt (20011). Stabilizing greenhouse gas concentrations at low levels: an assessment of reduction strategies and costs. Climatic Change, doi:10.1007/s/10584-006-9172-9.

Washington, W.M., Weatherly, J.W., Meehl, G.A., Semtner Jr., A.J., Bettge, T.W., Craig, A.P., Strand Jr., W.G., Arblaster, J.M., Wayland, V.B., James, R. and Zhang, Y(2000). ‘Parallel climate model (PCM) control and transient simulations’, Climate Dynamics 16.pp.755-774.

Willmott, C.J (1982). Some comments on the evaluation of model performance. Bull. Am. Meteorol. Soc. 63, 1309–1313.Zaman-Allah, M., Jenkinson, D., Vadez, V., 2011. A conservative pattern of water use, rather than deep or profuse rooting, is critical for the terminal drought tolerance of chickpea.

Yang, W; Seager, R; and A. Cane, M (2014).The East African Long Rains in Observations and Models. *Journal of Climate,* 27:345-436.