Impacts of Climate Variability and Change on Agricultural Systems in Adama District, Ethiopia

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Abstract

In this study all the 20 GCMs data from the Coupled Model Inter-comparison Project 5 (CMIP5) were downscaling using delta statics method in which two Representative Concentration Pathways (RCPs) of 4.5 and 8.5 for mid (2040-2069) and end (2070-2099) century were downscaled. All CMIP5 GCMs project a general increase in maximum and minimum temperature at all locations. Most GCMs project an increase in rainfall at all locations. Particularly, IPSL-CM5A-LR, IPSL-CM5A-MR, BNU-ESM and CanESM2 show an increment greater than 50%.

Once we have found the projected climate change scenarios at each locations, the assessment of climate change impacts on maize production The crop simulation models result shows that maize yield increase in all AEZs except in sub-moist AEZs zones. The models also simulated fairly similar responses in grain yield to changes in temperature and rainfall. We also found out that short maturing variety would not perform well under projected climate change as the long varieties will do. Adverse impacts of climate change were also observed in case of farmers planting late and using low plant population.

The economic impact per capita income due to climate change was calculated using the Trade-off Analysis Multi-Dimensional (TOA-MD) impact assessment tool. The climate change will lead to an increase in per capita income of 26-53 and 20- 43USD/annum/ha as per APSIM and DSSAT model respectively at all AEZs.

Introduction

While the evidence for climate change grows stronger, uncertainty prevails over the precise nature of these changes and their impacts at local and farm level. Past work on impact assessment was mostly carried out at national and global level using highly aggregated data, partly due to lack of farm level data for model parameterization and partly due to difficulties in developing location specific climate change scenarios. Since most adaptation decisions are made at the farm level, information on climate sensitivity of management practices adopted by smallholder farmers is of crucial importance.

This study was initiated to assess the impacts of climate change on smallholder farms in four East African countries - Ethiopia, Kenya, Tanzania and Uganda - using AgMIP protocols and tools. This poster presents the process followed and results from Ethiopia case study.

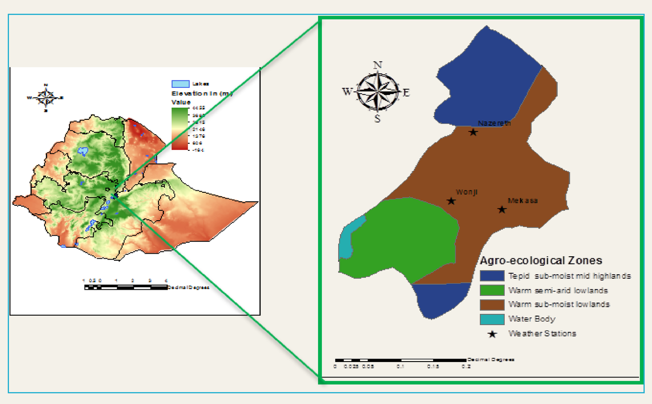


Figure 1: Sentinel sites of the experiment at Adama Woreda, Ethiopia

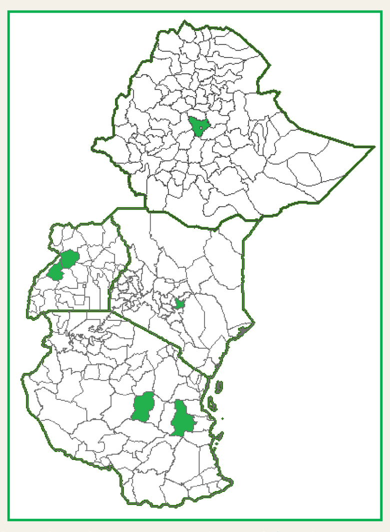
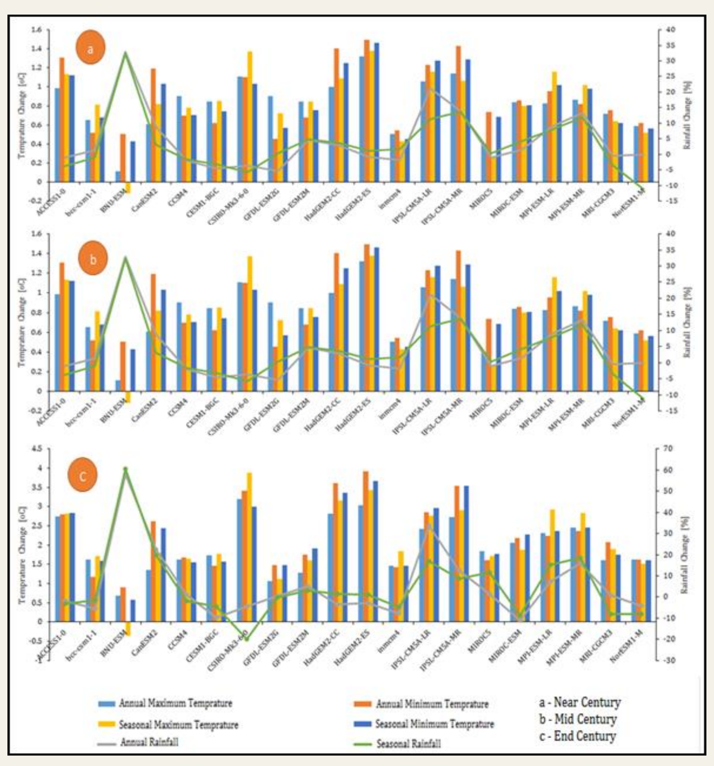


Figure 2: Map showing areas selected for the assessment in Ethiopia, Kenya, Tanzania and Uganda

Climate Scenarios

- Projected future climate change scenarios for mid (2041-70) and end (2071-2100) century periods for 20 CMI5 GCMs were downscaled to three weather stations using delta method.



- GCMs predicting higher increase in rainfall are generally predicting marginal decrease in temperature

Figure 3: Projected future climate changes scenarios a) Near Century, b)Mid Century and c) End-Century

Crop model calibration

- Crop simulation models APSIM and DSSAT were calibrated for three varieties representing early, medium and late maturity groups
- The calibrated model was used to validate the farmer reported yields with farmer adopted management practices. A total of 441 farms with diverse management practices were selected
- Both APSIM and DSSAT predicted higher maize yields compared to farmer reported yields. However, trends in simulated yields in different agro-ecologies matched well with the trends in farmer yields

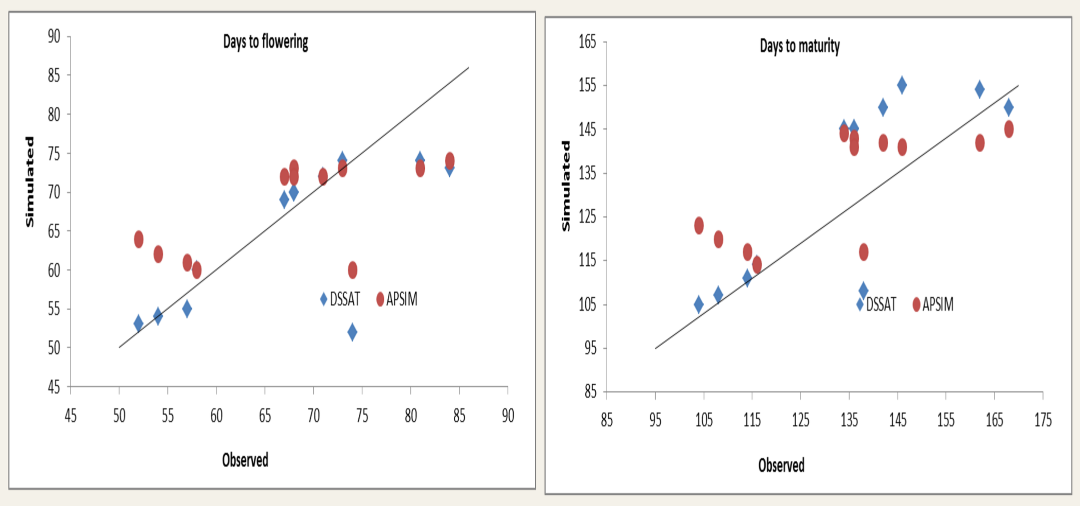


Figure 4:Crop simulation models APSIM and DSSAT were calibrated for three varieties representing early, medium and late maturity groups

Crop simulation

- Increase in rainfall is one of the major contributor for increased yields. Also, temperatures after increase remained within optimal range set for both models APSIM (26-34) and DSSAT (18-33)
- Impacts of climate change were found to be different in different agro-ecologies. In few like CESM1_BG in both DSSAT and APSIM crop simulation model

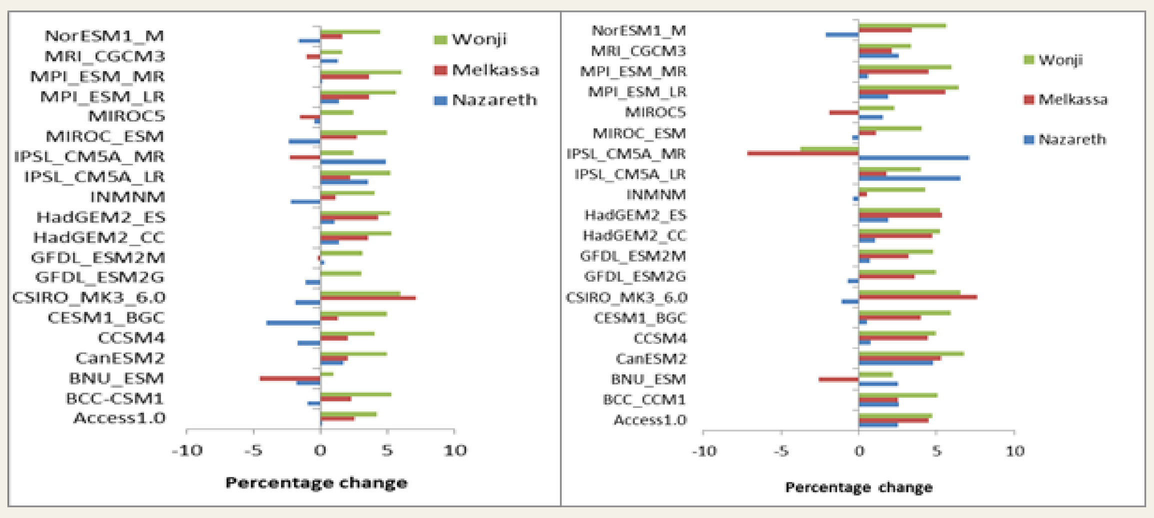


Figure 5:Performance of maize crop across different agro-ecologies in Melkassa, Adama and Wonji mid century under RCP 4.5 (left) and RCP 8.5 (right) in APSIM

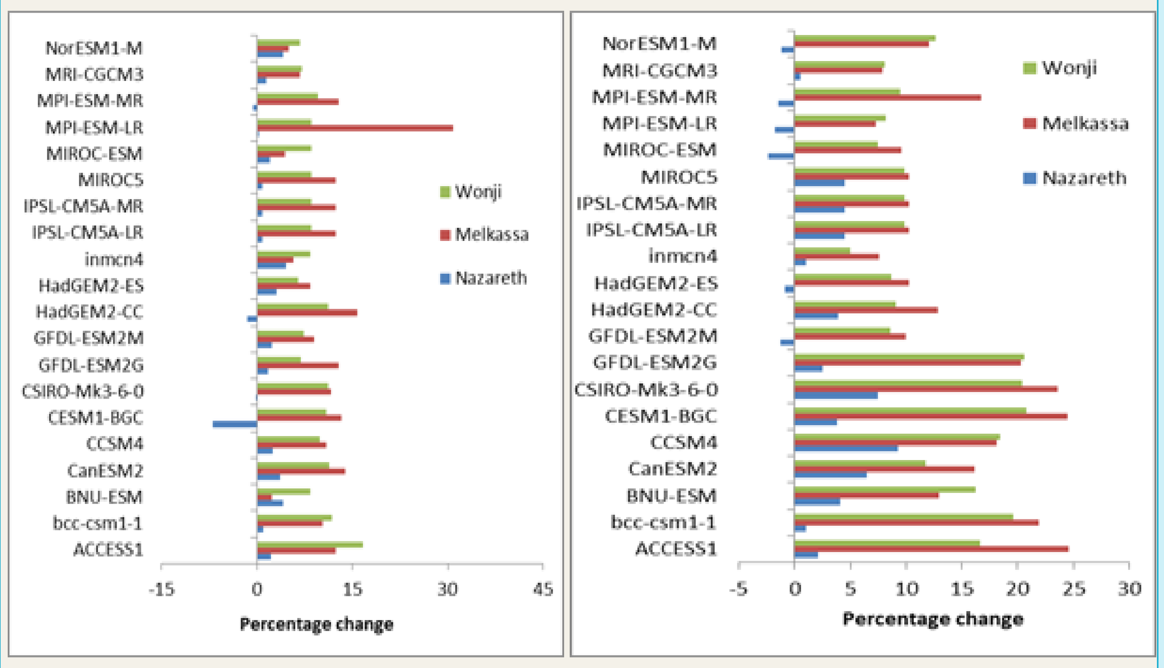


Figure 6: Performance of maize crop across different agro-ecologies in Melkassa, Adama and Wonji under RCP 4.5 (left) and RCP 8.5 (right) in DSSAT

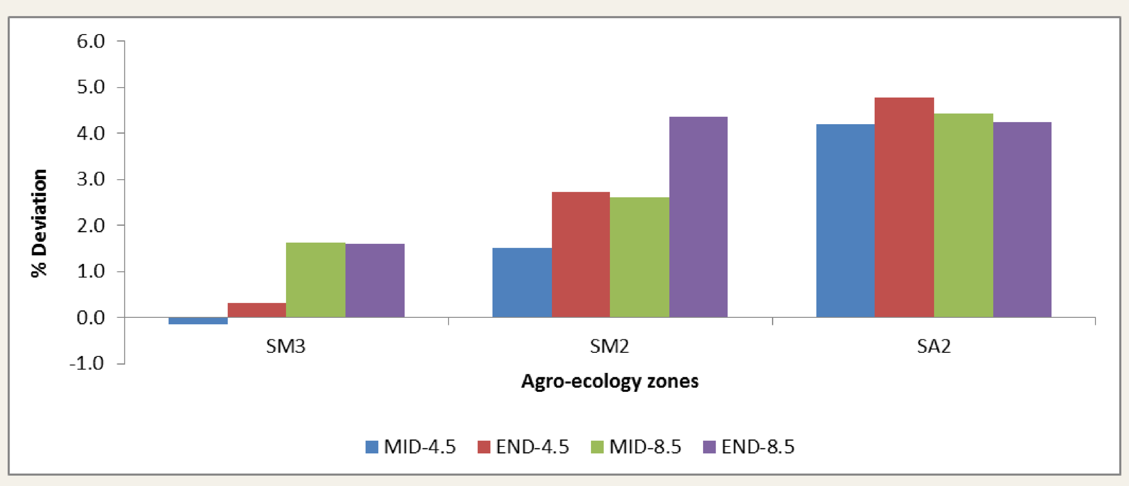


Figure 7:Crop Projected changes in maize crop yields in the climate change scenarios in DSSAT

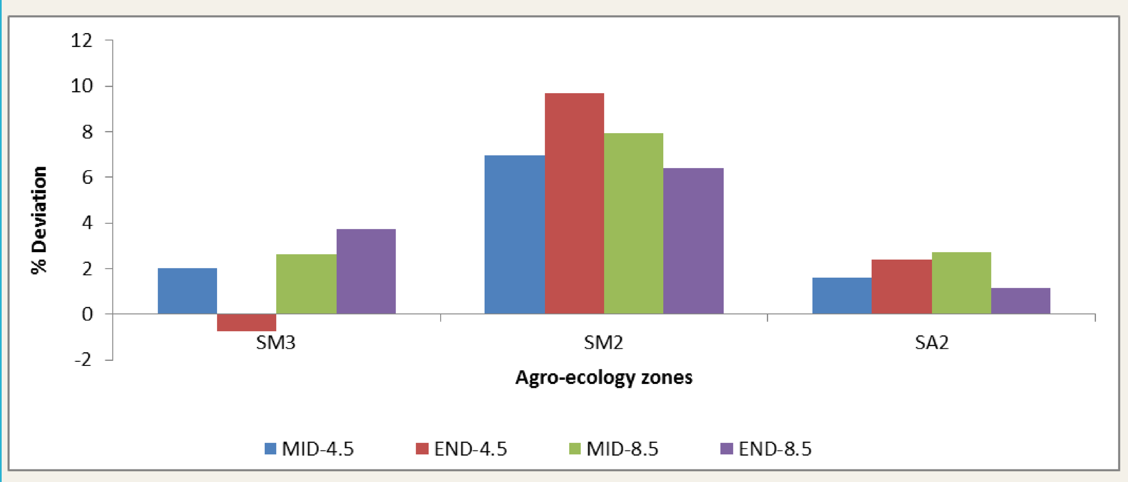


Figure 8: Projected changes in maize crop yields in the climate change scenarios in APSIM

Adaptations

Most agro-ecologies in the Wonji, Melkassa and Wonji are benefitted by projected changes in climate but there are practices which may not help farmers in realizing the full benefits of changes in their climatic conditions

Some adaptation options identified:

- Shift to medium duration variety from short duration Katumani
- Use of higher plant population
- Adjustment to planting dates

Table-1: Selected best management practices under each agro-ecology zones during the baseline and in the projected climate RCPs

Agro-ecology	Planting date	Planting population	Fertilizer application rate(N)	Cultivar
Melkassa	Late	3.3	60 Kg/Ha	Melkassa-2
Wonji	Normal	5.3	60 Kg/Ha	Melkassa-2
Adama	Early	5.3	60 Kg/Ha	Melkassa-2

Benefits of Adaptation

In this scenario, the question we are answering is how the various indicators of income poverty and per capita income change if the future system under climate change is subjected to adaptations

Using TOA-MD, impact of these adaptations to climate change on the indicators of per capita income, net farm returns and poverty were assessed. The assessment also determined the percentage of farmers in each AEZ who gain from climate change adaptations.

Table-1: Selected best management practices under each agro-ecology zones during the baseline and in the projected climate RCPs

AEZ	Projected future mean maize yield (Kg/ha)	The benefits of climate change adaptations									
		APSIM Time-averaged relative yield (r=s2/s1)					DSSAT Time-averaged relative yield (r=s2/s1)				
		CCSM4	GFDL	HadGEM_2ES	MIROC-5	MPI_ESM	CCSM4	GFDL	HadGEM_2ES	MIROC-5	MPI_ESM
WONJI	600.8	2.24	2.19	2.30	2.26	2.32	2.28	2.28	2.28	2.27	2.36
MELKASA	783.6	2.70	2.69	2.70	2.66	2.69	2.75	2.73	2.76	2.62	2.73
NAZRETH	764.0	3.48	23.45	3.39	3.47	3.40	3.69	3.66	3.66	3.69	3.61
AGG	716.2	2.80	2.78	2.80	2.8	2.8	2.90	2.89	2.89	2.86	2.70

Conclusion and Recommendations

There is high level of uncertainty in the downscaled projections, especially with rainfall which most GCMs predict to increase significantly. This along with current less than optimal temperatures to grow maize are contributing an increase in maize yields in most agro-ecologies. The expected increase in maize yield is higher with DSSAT when CO2 fertilization is included

Use of high levels of fertilizers doesn't work to get high grain yield rather the scientific recommended fertilizer application rate of the area was the one that suite for the base line as well as for the mid and end century.

It is possible to offset the reduction in maize yields due to climate change under certain agro-ecologies and management conditions through simple adjustments to the current management practices adopted by farmers

Refernces

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