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Assessing the Effect of Climate Change on Crop Production and Adaptation Strategies in Dendi District, Ethiopia

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Abstract

As climate change affects Ethiopia's agriculture and highly disrupting people's livelihood, it is high time to study "the effect of climate change on crop production and adaptation strategies in Dendi District". The study was made on two Cooperatives (Bodda and Welenkomi) from which 200 respondents were selected using simple random sampling technique. Field survey and PRA methods were adopted to collect primary data. Secondary data were collected from the documents of cooperatives and offices concerned. The effect of climate change on crop production was analyzed using Generalized Linear-univariate model. Climate change adaptation strategies were analyzed qualitatively with the help of descriptive statistics. The study showed that solar intensity, disease, flood, temperature, rainfall and landslide were found to be statistically significant to have an adverse effect on crop production. The results from descriptive statistics revealed that farmers' level of awareness of on climate change is low. 96.5% of farmers did not adapt key strategies. The support from disaster department and agricultural cooperatives are not significant. To design appropriate measures and curb the adverse effect of statistically significant climate variables, concerted effort of all stakeholders is of paramount importance. As agricultural Cooperatives are the major stakeholder, they must take measures for increasing farmers' awareness on climate change adaptation. Strengthening vertical and horizontal linkage among stakeholders is vital. Besides, early warning systems should be in place and intensive training on climate change adaptation strategies is advocated to mitigate the adverse effect of climate change and to bring a positive change on members' livelihood.

Keywords: *Adaptation strategies, crop production, effect, climate change*

Introduction

Climate change has become a catch phrase in the global and regional forums. Climate change refers to significant changes in mean values or significant changes in the degree of variability itself. It is the effect of rapid global warming caused by substantially raised emissions of so called "greenhouse gases" in the industrialized part of the world.

Climate change has an effect on rainfall patterns, increased flooding/ droughts, increased water stress/scarcity, decreased flows in rivers, increased heat stress due to rise in temperature, changes in ecology and habitats of plants and animals, increased storms. Agriculture is inherently sensitive to climate variability and change, whether due to natural causes or human activities. These impacts will vary with the degree of warming and associated changes in rainfall patterns, and from one location to another. Climate change influences crop production directly by reducing crop yields. Climate change has the potential to exacerbate the stresses on crop plants, potentially leading to catastrophic yield reductions. Climate change also indirectly affects crop production through its influence on emergence and distribution of crop pests exacerbating the frequency and distribution of adverse weather conditions, reducing water supplies and irrigation; and enhancing severity of soil erosion (Winter et al.,1998; IPCC, 2007; Sebeta, 2009; Craufurd ., Wheeler, 2009).

Agricultural produce is one of the most important developing countries export commodities, and agricultural producers are small-scale farmers faced with a number of problems. Climate change has affected Ethiopia's agriculture, water resources, biodiversity and ecosystems, which will highly disrupt the livelihood of the people. Several studies were undertaken over the past few years showing that Ethiopia will be severely affected by climate change (BoFED 2008; MoFED 2000).

Statement of the Problem

Agriculture in Ethiopia is the most vulnerable sector to the impacts of climate change (Slingo et al., 2005) due to the fact that the sector is dominated by small-scale mixed crop-livestock production with very low productivity. The major factors responsible for low production include; large arable land located in arid and semi arid regions, rainfed agriculture or low irrigation water use, reliance on traditional farming system or techniques, soil degradation caused by overgrazing and deforestation, low capacity to adapt, and poor complementary services. These factors also reduced the adaptive capacity of farmers to future changes in climate patterns.

It is doubtful whether farmers know immediately what constitutes the best response to adverse effect of climate change. Nor can they be expected to recognize immediately that the climate has changed. This would result in latent losses of benefits from agriculture as a result of not taking immediate action in adapting to climate changes. Therefore, adaptation to climate change involves strategies put in place to deliver adaptations by taking adaptive actions or building adaptive capacity against climate risks (Mendelsohn & Dinar., 1999; Benhin, J.K.A., 2008;). The purpose of adaptive action is either to manage (avoid, prevent, reduce, transfer or absorb) climate risks or to exploit beneficial opportunities created by climate change (Robert Kurukulasuriya., Mendelsohn, 2008). It is very pertinent to assess the importance of adaptive strategies.

"Concern for Community" is one of the cooperative principles. It is, therefore, natural to expect that they should encourage proactive stance on the environment protection, adapt climate change and take interest in its conservation and protection for the larger interest of the community. Agricultural cooperatives, besides strengthening the bargaining power of smallholder farmers, they play prominent role in reducing production risks through providing its members with advises on how to adapt adverse effect of climate change on agricultural production. With this background, it is unique to have an attempt to study the effect of climate change on crop production and adaptation strategies in Dendi District. The effect of climate change on agriculture, on the ecosystems, on water bodies, and on health is very sensitive. While a wide body of literature has flourished addressing the process and anticipated adverse effects of climate change on crop production in several countries of the world, the issue has neither been researched nor tabled for a wider public attention in Ethiopia. Even local academics and professional forums have barely addressed it.

Objectives

The overall objective of the study is to analyse the effect of climate change on crop production in Dendi District. This study also tries to specifically identify climate change adaptation strategies on crop production by members of agricultural cooperatives; and to assess supports provided by cooperatives, government and non-governmental organizations in adaptation to climate change for increased crop production in the proposed study area. As a result, this research has tried to answer the following research questions:

1. How do farmers perceive the effect of climate change on crop production?
2. What kinds of adaptations strategies do farmers practice to climate change?
3. What, if any, do cooperatives and government and non-governmental organizations support farmers in adaptation to climate change?

Research Methodology

Description of Study Area

Dendi is one of the 180 woredas in the Oromia Region of Ethiopia. Part of the Mirab Shewa Zone, Dendi is bordered on the south by the Debub Mirab (Southwest) Shewa Zone, on the west by Ambo, on the north by Jeldu, and on the east by Ejerie. The administrative centre of this woreda is Ginchi; other towns in Dendi include

Ehud Gebeya, and Olonkomi. *(http://en.wikipedia.org/wiki/Dendi_(woreda), accessed on 3.1.2011)*

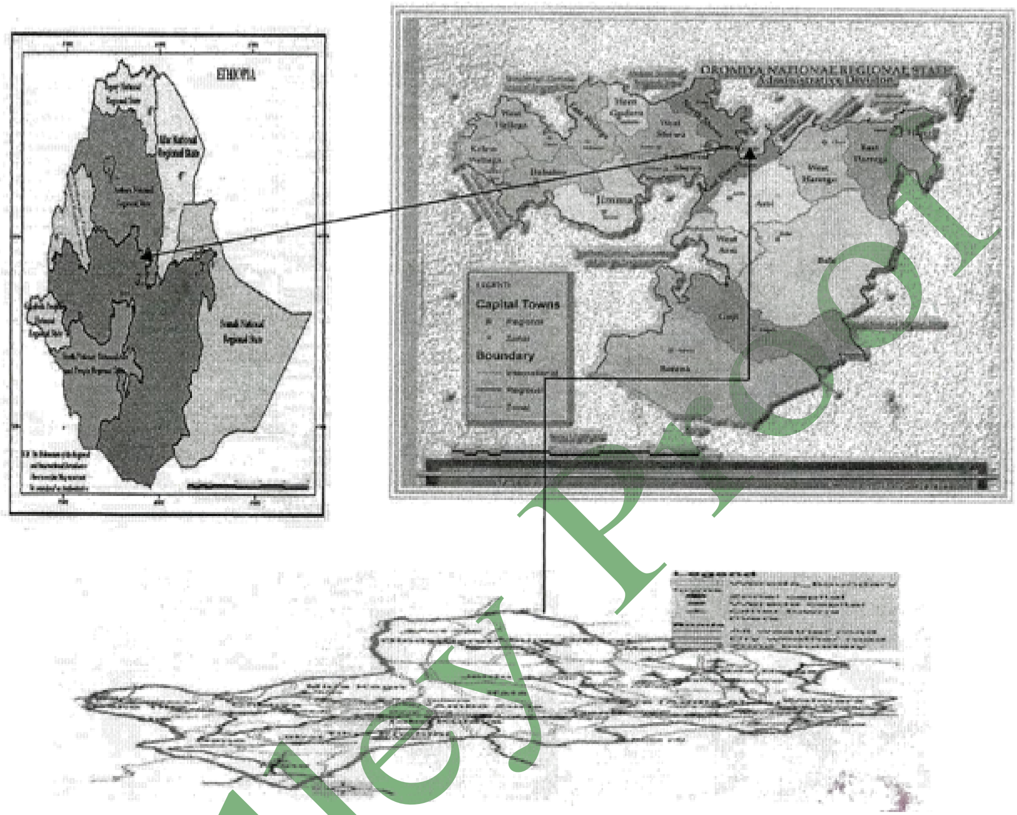

Figure 1. Map of the study Area

The highest point in this woreda is Mount Dendi (3260 meters). Notable landscape features include the Chilimo forest, a wooded area 2400 hectares in size near Ginchi, which is a remnant of the dry afromontane forest on the Ethiopian Central Plateau. It is characterized by high altitude, ranging from 2,400-3,054 masl. Rainfall pattern is bimodal with the main rainy season from June to September and short rainy season from February to March with a mean annual rainfall of c. 1000 mm, with annual variations from 700 mm to 1600 mm. In the classic agro-climatic zones of Ethiopia, the area falls into the upper weyna dega and the dega zone. Monthly mean temperatures are between 15°C and 19°C. The lower area (Rare), below the main road in Welenkomi, is the warmest, while the Dega Egu area is colder and wetter. Normally, 70% of total annual rainfall falls between June and September; March/April is the small rains season. Despite the relatively good climatic conditions, irregularity in the timing and amounts of rainfall can reduce substantially the agricultural production, even if the area has been spared from serious drought and famines. Soils in the area differ in quality, with the richest and less acidic soils being found on the lower plateau (dark grey soils, vertisols, koticha) (Alex Baudouin, 2007). On-farm activities are the main economic activities in the district with very little number of farmers working in off-farm activities. Source of cash income in the area includes sales of crops such as barley, wheat, live animals, animal products and potato. Land under little vegetative cover is subject to high surface runoff and has low water retention. Runoff causes sheet erosion to intensify and rills and gullies to widen and deepen. On the steep slopes of the study area the soils are shallow and exposed to erosion.

Sampling design

Since the research intended to study adaptation strategies to climate change, field survey method was adopted. Crop production in Dendi district is affected by climate change in terms of rainfall, flood, drought, and soil erosion, which is a crucial problem at present (WSZPB, 2012). The crop production shows a decline between 1971 and 2000/2001. Yields have not been increasing to compensate for the reduction in area cultivated per capita and the smaller farm sizes (Mesfin W.M., 1971; Kibret, Samuel Lemma, 2004). One among the reasons for this is the effect of climate change. Based on the criterion that the area under operation is most affected by climate change as justification, two Multipurpose Agricultural Cooperative Societies namely Boda and Olomcomy in Dendi District were selected purposively. 200 respondents were selected both from Bodda and Welenkomi primary agricultural cooperatives to collect primary data using simple random sampling technique.

Method of Data Collection

Primary data were collected from three different sources namely, from the farmer members (200), Key Informants (5) and from Focus group participants (2 full groups comprised of 15 each). Appropriate tools such as, interview schedule for the member respondents, checklist for the Key Informants and Focus Group Discussion were used to gather primary data regarding climate change effect, and adaptation strategies. Secondary data were collected from the records and documents of the cooperatives and offices concerned. Data were collected by the enumerators who undergo training and orientation before data collection with the supervision of the investigators.

Method of Data Analysis

The data were analyzed by using both qualitative and quantitative approach. The effect of climate change on crop production was analyzed using GLM-univariate model. Climate change adaptation strategies by members of agricultural cooperatives were analyzed qualitatively with the help of descriptive statistics.

Model Specification

$$Y = \sum_{i=0}^{n} BiXi + e$$

Where,
Y= the response variable
Xi= the i^{th} explanatory variable
Bi= the parameter of the i^{th} explanatory variable
e= error term or residuals

Results and Discussion

Effect of Climate Change on Crop Production

Levene's Test of Equality of Error Variances

Levene's Tests of equality of error variances was used to test the null hypothesis that the error variance of the dependent variable is equal across groups. Since the significance value of the (F-test at df1=55, df2=141), 0.223, is greater than 0.15, there is no reason to believe that the equal variances assumption is violated. Thus, the equal error variance assumption is accepted.

Univariate-ANOVA

The partial Eta Squared shows that there is no significant variation accounted for by the model. Each term in the model, plus the model as a whole, is tested for its ability to account for variation in the dependent variable. The significance value for explanatory variables SOLI, DSEFCPRO and FDEFCPRO is statistically significant at *P*=5% while the variables such as TPEFCPRO, RFEFCPRO and LSEFCPRO are statistically significant at 10% level of significance. The Eta squared statistic reports the practical significance of each independent variable (fixed factor). Larger value of Partial Eta Squared indicates a greater amount of variation accounted for by the model terms, to a maximum of 1. But, here the individual variables while statistically significant do not have great effect on the value of the dependent variable since the value of Eta is so small.

Lack of fit tests

In order to check whether the relationship between the dependent variable and the explanatory variables are adequately described by the model or not, lack of fit tests was used. Accordingly, the null hypothesis that the model does not describe the relationship between the dependent and the explanatory variables adequately [Fcal >Ftab] was tested. The result indicates that since [Fcal,45=df=1.26]<[Ftab,45=df=1.64]. The null hypothesis which states that the model does not describe the relationship adequately is rejected on the basis that the F-test P-value=0.154 is greater than 0.05 level of significance; and the alternative hypothesis is accepted qualifying that the model fits into the data.

GLM Univariate Analysis

Table 1: GLM-Univariate Analysis of the Effect of cc variables on crop production

Parameter	B	Std. Error	t	Sig.	95% Confidence Interval		Partial Eta Squared
					Lower Bound	Upper Bound	
Intercept	25.658	3.318	7.733	.000	19.112	32.204	.243
[TPEFCPRO=.00]	13.139	6.725	1.954	.052	-.128	26.407	.020
[TPEFCPRO=1.00]	0[b]	.	.	.	.	.	.
[RFEFCPRO=.00]	7.725	4.228	1.827	.069	-.616	16.066	.018
[RFEFCPRO=1.00]	0[b]	.	.	.	.	.	.
[DSEFCPRO=.00]	23.671	10.750	2.202	.029	2.464	44.878	.025
[DSEFCPRO=1.00]	0[b]	.	.	.	.	.	.
[LSEFCPRO=.00]	5.073	2.818	1.800	.073	-.487	10.633	.017
[LSEFCPRO=1.00]	0[b]	.	.	.	.	.	.
[FDEFCPRO=.00]	8.509	4.183	2.034	.043	.258	16.761	.022
[FDEFCPRO=1.00]	0[b]	.	.	.	.	.	.
[SOLI=.00]	-18.698	4.803	-3.893	.000	-28.173	-9.224	.075
[SOLI=1.00]	0[b]	.	.	.	.	.	.

Source: Computed from survey data, 2013

The GLM- univariate analysis was used to analyze the effect of each of the explanatory variables on the dependent variable. Accordingly, with the assumption that the two groups (who experienced the climate change effect and who did not experienced the effect) have similar effect, the value -18.698 for [SOLI=0] indicates that, crop production for the group that had experienced the effect of solar intensity [SOLI=1] has declined by an amount equal to 18.698 quintals as compared to those who did not experience the effect of solar intensity [SOLI=0]. Similarly, the value 23.671 for [DSEFCPRO=0] indicates that the quantity of crops produced has increased by an amount of 23.671 quintals for those reference groups that have not experienced the effect of disease while it declined by the same amount for those who really has experienced crop disease.

On top of these, the value 8.509 for [FDEFCPRO=0] shows that, production of crop has declined by an amount of 8.509 quintals for those groups who experienced the effect of flood [FDEFCPRO=1]; and it has increased by 8.509 quintals for those who did not experience the effect of flood. The value 13.139 for[TPEFCPRO=0] designates that, production of crops has reduced by the amount of 13.139 quintals for those groups that have experienced the effect of temperature while it has increased the production by an amount of the same for those who did not experience the adverse effect of temperature. By and large the value 7.725 for[RFEFCPRO=0] indicates that, the production has declined by 7.725 quintals for those who have experienced the effect of rainfall; while production has increased by 7.725 quintals for those who did not experience the adverse effect of rainfall. The last but not the least is that the value 5.073 for[LSEFCPRO=0] indicates that, production has increased by 5.073 quintals for those groups that have not experience the effect of land slide while production had fall down by 5.073 quintals for those who experienced the effect of land slide.

Adaptation strategies and support from stakeholders

The respondent farmers were asked to respond to the statements related to awareness on climate change, perception on increase in crop production, adaptation strategies such as, crop diversification, crop replacement, and irrigation. The results are presented in the following table.

Table 2: Farmers' perception on climate change and adaptation strategies

Perception category / Items	Perception response					Total
	Strongly Disagree	Disagree	Neither Nor	Agree	Strongly Agree	
Awareness on climate change	124 (62.0)	73 (36.5)	0	3 (1.5)	0	200 (100)
Increase in crop production	118 (59.0)	79 (39.5)	1 (0.5)	2 (1.0)	0	200 (100)
Crop diversification as adaptation strategy	180 (90.0)	13 (6.5)	1 (0.5)	4 (2.0)	2 (1.0)	200 (100)
Crop replacement as adaptation strategy	186 (93.0)	7 (3.5)	0	5 (2.5)	2 (1.0)	200 (100)
Irrigation as adaptation strategy	92 (46.0)	0	0	0	(54.0)	200 100)

Figures in brackets are percentages to row total

The results from descriptive statistics (see table 2) revealed that level of awareness on climate change and crop production has not increased as evidenced by 98.5% of the respondents. It was statistically significant at a Pearson Chi-Square value of 0.075. Majority (96.5%) of farmers did not use crop diversification and crop replacement as adaptation strategy. It was found statistically significant at Pearson Chi-Square value of 0.037. Moreover, 54.0% of respondents did not use irrigation as adaptation strategy, whereas 46.0% of those who have access to irrigation schemes have used it as adaptation strategy to cope up with the effect of climate changes which is statistically significant at Pearson Chi-square value of 0.039. However, the Focus Group Discussion result showed that the farmers have been using conservation; double cropping, and water storage as supplementary adaptation strategies. The support from disaster department and agricultural cooperatives are not significant as evident from 87.5% of the respondents. The responses given by key informants were also in line with the farmers (member respondents). They also agree with climate change effect and adaptation strategies. They reported that the adaptation to climate change was not as expected, so that there has been a decline in crop production in the study area.

Conclusion

The effect of climate change on crop production is very serious for those member farmers who experienced the effect as compared to those who did not experience. So, it can be concluded that solar intensity, crop disease, flood, temperature, rainfall and landslide are found to be the most serious factors negatively influencing crop production. In other words more severe the adverse effect of climate change the more would be a decline in crop production. With regard to adaptation strategies, it can be concluded that the level of awareness of member farmers on climate change is very low and crop production has declined due to the effect of climate change. Though there are different adaptation strategies, majority of member farmers have been using only conservation; double cropping, and water storage as supplementary adaptation strategies. The support from concerned stakeholders like disaster department and agricultural cooperatives are not significant and the majority of farmers never received food aid, which must be appreciable.

Recommendations

Since the adverse effect of climate change cannot be controlled within a short period of time, long term measures have to be designed and implemented.

- It can be recommended that farmers at their level should adapt different strategies to cope up with the adverse effect of climate change on crop production.
- Concerted effort of all concerned stakeholders is paramount importance to design appropriate measures to mitigate the adverse effect of statistically significant variables to enhance the level of awareness of farmers on climate

change and adaptation strategies for increased crop production.

- Specifically, to mitigate the adverse effect of crop diseases farmers should be trained on the use and application of bio fertilizer, proper pesticides and herbicides.
- The adverse effect of flood and landslide can be adapted by construction of check dams, contour farming and other measures.
- Besides, farmers can use plants that can prevent soil erosion and increase soil fertility as a strategy.
- To cope up with the adverse effect of excessive rainfall, farmers must adapt strategies like crop replacement, crop diversification; short term crops which give yield within a short period, proper irrigation systems, water storage systems, and water shed management.
- On top of these, as Agricultural Cooperatives are the major stakeholder, they must take measures for increasing farmers' awareness on climate change adaptation, strengthening vertical and horizontal linkage among stakeholders; intensive training on climate change adaptation strategies are advocated to mitigate the adverse effect of climate change.

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References

Alex Baudouin. 2007. Welenkomi, 35 years later, Department of Geography, NTNU, Trondheim.

Benhin J. K. A. 2008. South African crop farming and climate change: an economic assessment of impacts. Global Environmental Change 18 (4), 666–678.

Bureau of Finance and Economic Development. 2008. Report of Bureau of Finance and Economic Development, Dendi Woreda.

Craufurd P. Q. And Wheeler T. R. 2009. Climate change and the flowering time of annual crops. *Journal of Experimental Botany* 60(9): 2529–2539.

Geographical location of Dendi district. *http://en.wikipedia.org/wiki/Dendi_(woreda), accessed on 3.1.2011*

IPCC (2007). Climate Change 2007. Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland. Pp 104.

Kibret, Samuel Lemma. 2004. Population changes, implications and strategies: A case of rural Welenkomi area, Central Ethiopia, Department of Geography, NTNU, Trondheim.

Mendelsohn R. and Dinar A. 1999. Climate change, agriculture, and developing countries: Does adaptation matter? The World Bank Research Observer 14: 277-293.

Mesfin W.M. 1971. Welenkomi: A Socio-Economic and Nutritional Survey of a Rural Community in the Central Highlands of Ethiopia. Addis Ababa.

Ministry of Finance and economic Development. 2006. Ethiopia: Building on Progress: A Plan for accelerated and sustained development to end poverty (PASDEP). 2005/06 – 2009-10. Ministry of Finance and Economic Development, Addis Ababa, Ethiopia.

Robert Kurukulasuriya, P. and Mendelsohn R. 2008. How will climate change shift agroecological zones and impact African agriculture? Policy Research Working Paper 4717. World Bank Development Research Group.

Senbate Abate. 2009. Climate change impact on Livelihood, Vulnerability and Coping Mechanisms: A Case Study of West Arsi Zone, Ethiopia, Unpublished M.Sc thesis, LUMES, Sweden.

Slingo J. M., Challinor A. J., Hoskins B. J., & Wheeler T.R. 2005. Introduction: Food crops in a changing climate. Philosophical Transactions of Royal Society B. 360; 1983-1989.

Winters P., Murgai R., Sadoulet E., De Janvery A. & Frisvold G. 1998. Economic and welfare impacts of climate change on developing countries. *Environmental and Resource Economics* 12: 1-24

West Shoa Zonal Promotion Bureau. 2012. A Report.