Climate Change and Variability: Implications for Household Food Security in Agro-pastoral Areas of Jigjiga District, Eastern Ethiopia

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Abstract

Ethiopia is one of the most vulnerable countries of the world to the impacts of climate change and variability. The impact is even stronger in pastoral areas of the country. However, studies on the actual climate change dynamics and its effect on food security at local and household levels are limited. The present study took Jigjiga district as a case and analyzed changes in local climate; status of household food security; the relative significance of climate related causes of food insecurity; and household level determinants of food security. The study used rainfall and temperature data from the period 1952 to 2010 and primary data gathered from 140 sample households and focus group discussions. Using Mann-Kendall trend test, the study revealed the existence of statistically significant declining trend in rainfall in the rainy season and increasing trend in temperature at annual and seasonal time scale. Moreover, respondents confirmed the presence of climate change, with increasing temperature, decreasing rainfall amount and increasing seasonality of rainfall in the past two decades. The Rash model estimation result based on the Food Security Core Module showed high prevalence of food insecurity in the district with 81 per cent of food insecure households consisting of 27 per cent food insecure without hunger, 29 per cent food insecure with moderate hunger, and 25 per cent food insecure with severe hunger. Respondents ranked climate factors as their top most important causes of food insecurity. These are drought, low annual rainfall, high temperature, and water shortage. The econometric model estimation result revealed the important factors determining household food security. These are household perception of climate change, use of soil and water

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conservation practices, use of livestock feed management techniques, loss of livestock due to drought and/or disease, literacy level of household head, and dependency ratio. Among other things, the study suggested improving climate change awareness and strengthening the existing adaptation measures that have positive impacts on food security.

Keywords: climate change, climate variability, adaptation measures, food security, agro-pastoralism.

1. Introduction

There is clear scientific evidence that the earth's climate is changing (IPCC, 2007; Spore, 2008). Some facts about this global change include: increasing temperature (temperature has increased by 0.74°C over the20th century), melting polar icecaps, uncontrolled forest fires and annual average increase in sea level of 3.1 mm (Spore, 2008). The changes occur mainly because of increasing concentration of greenhouse gases emitted from various activities of human beings. Such changes have already had some impacts on the natural equilibrium at the risk of the survival of human beings. The problem is recognized as one of the most serious global challenges of the 21st century with multiple effects on basic human support systems such as agriculture, forest, water resources, and the ecosystem (Aklilu and Alebachew, 2008).

Climate variability and change are a major threat to food security in Africa and many regions of the developing world, which are largely dependent on rain-fed and labor-intensive agricultural production (Parry et al., 2004; IPCC, 2007). Within the African region, the Horn countries are among the most vulnerable but least prepared for adverse global environmental change in the word. Among the horn countries, Ethiopia is one of the most poverty stricken, ecologically fragile countries whose growing population and feeble economy are heavily impacted by climatic events (Aklilu and Alebachew, 2008).

In Ethiopia, there is a general trend of increasing temperature, decreasing precipitation and increasing frequency of droughts and floods (World Bank, 2003; NMA, 2007). According to the National Adaptation Program of Action (NAPA) report of National Meteorological Agency (NMA, 2007), the average annual minimum and maximum temperature have increased by about 0.250C and 0.10C respectively every ten years. The report further showed that there was a very high variability of rainfall over the past 50 years. This has already led to a decline in agricultural production, and cereal production is expected to decline still further under moderate global warming (Ringer, 2008). Moreover, it has led to shortage of food, a decline in biodiversity, and increases in human and livestock health problems, rural-urban migration and dependency on external support.

Pastoral and agro-pastoral livelihood systems in the lowlands of the country are among the most vulnerable to the impacts of climate change and variability (NMA, 2007). Over the past several decades, pastoral livelihood systems were affected by repeated droughts, famine and epidemics that relate to the changing climatic condition. As a result, the losses of productive assets and increasing household food insecurity have become defining features of lowland poverty in Ethiopia (Sandford and Yohannes, 2000; Beruk, 2003; Pantuliano and Wekesa, 2008).

There exists a dearth of empirical evidences regarding the relationship between global climate change and food security at local and household levels in Ethiopia. Moreover, the existing studies focused on household adaptation strategies and climate change impact on agriculture while they are not comprehensive particularly in terms of household level assessment (Temesgen et al., 2008; Zenebe, et al., 2011; Virtanen, et al., 2011). For example, Temesgen et al. (2008) have conducted an integrated quantitative vulnerability assessment for seven Regional States of Ethiopia using biophysical and social vulnerability indices of Ricardian approach. The study has found that decline in precipitation and increase in temperature are both damaging to Ethiopian agriculture. The result of the study has further pointed out that Somali National Regional State (SNRS), where this study is conducted, is one the two highly vulnerable regions to climate change impacts in the country. As their study is aggregated, the authors have acknowledged the need for further study at local and district levels.

Therefore understanding the implication of climate change for household food security at local level is critical to looking for options to adaptation as well as mitigation of climate change impacts. This study therefore assesses the role of climate change on food security of agro-pastoral households in Jigjiga district, in Eastern Ethiopia. Specifically, the following objectives would be pursued in investigating this research problem:

- To analyse the presence of significant changes in local climatic variables such as temperature and rainfall,
- To assess the perception of households on climate change;
- To assess the perception of households on the significance of climate related causes of food insecurity;
- To quantify the status of household food security; and to
- To identify determinants of food security at household level.

2. Climate change and food security linkages

Climate change has an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock (FAO, 2008). Some of the direct and indirect impacts of climate change on livestock and livestock systems are:

Water: Increasing water scarcity is an accelerating condition affecting 1-2 billion people worldwide, resulting in problems with food production (MA, 2005). Climate change impacts will have a substantial effect on global water availability in the future. This will not only influence livestock drinking water sources, but it also affect livestock feed production systems and pasture yield (Thornton, et al., 2008).

Feed quality and quantity: climate change can be expected to have several impacts on feed and grazing including; changes in herbage growth, changes in the composition of pastures and changes in herbage quality (Hopkins and Del Prado, 2007). As climate becomes more variable, species niches change (i.e. plant and crop substitution) which brings about changes in land use system, species composition and quality of plant material. This may modify animal diets and compromise the ability of smallholders to manage feed deficits (Thornton et al., 2008).

Biodiversity: climate change may accelerate the loss of genetic diversity in crops as well as domestic animals. A 2.50C increase in global temperature will see major losses: 20-30 percent of all plant and animal species assessed could be at high risk of extinction (IPCC, 2007). Local and rare breeds are at risk of being lost through the impact of climate change and disease epidemics. The recent FAO report on animal genetic resources indicates that 20 percent of reported breeds are now classified as at risk, and that almost one breed per month is becoming extinct (CGRFA, 2007).

Livestock diseases and disease vectors: climate change may bring about substantial shifts in disease distribution. Higher temperatures may increase the rate of development of pathogens or parasites that spend some of their life cycle outside their animal host, which may lead to larger populations (Harvell et al., 2002). Changes to winds could affect the spread of certain pathogens and vectors. Expansion of vector populations into cooler areas (in higher altitude areas: malaria and livestock tick-borne diseases) or into more temperate zones (such as bluetongue disease in northern Europe). Changes in rainfall pattern may also influence expansion of vectors during wetter years, leading to large outbreaks of disease (Rift Valley Fever virus in East Africa) (Thornton et al., 2008).

3. Methodology

3.1 The study site

The study site is located in the Somali region (Eastern Ethiopia). Somali is the second largest region of Ethiopia with an area of 327,000km2. According to the 2007 Census of Central Statistics Agency (CSA), Somali Region population was numerated at 4.4 million in 2007, of whom 2.5 million were male and 1.9 million were female(CSA, 2007).The region is overwhelmingly rural and the level of urbanisation is low, at 14.3 per cent (Devereux, 2006). There are approximately 665,397 households in Somali Region with household size averaging 6.6, with a range from 6.3 in urban to 6.7 in rural areas (CSA, 2007).

The study site, Jigjiga district, has a total population of 276,818 of whom 148,862(53.78 percent) were men and 127,954 (46.22 percent) were women; 151,232 (54.63 per cent) are rural and 125,584 (45.47 percent) are urban dwellers (CSA, 2007). The district has two major seasons Gu (long rainy season) and Jilaal (dry season). Unlike other parts of the region, the rainy season (Gu) in the district has three sub seasons: Dira (April - May), Hagaa (June - July), and Karan (August -September) all of which are equally important for cultivation of crops; availability of water and pasture for livestock. Furthermore, the dry season, Jilaal (October - March) is divided in to two sub seasons: Deyr (October - November) and Kalil (December-March) (Devereux, 2006; SC UK, 2007).

The district has two major livelihood systems; sedentary farming and agro-pastoral systems. Sedentary farmers depend on rain-fed crop production (sorghum, wheat, barley and maize) and livestock (mainly shoats and cattle) while agro-pastoralists highly depend on animal rearing (shoats, camel and cattle) besides some opportunistic farming (mainly sorghum). Agro-pastoralists and farmers highly depend on rain-fed agriculture and pasture which makes them particularly vulnerable to drought, livestock disease and crop pests (SC UK, 2007).

3.2 Data collection

The study used both quantitative and qualitative data, to capture information on the changing climate and its multiple effects on household food security. Hence, relevant data were derived from both primary and secondary data sources. Primary data were collected from sample agro-pastoral households and community groups in Jigjiga district. Time series rainfall and temperature data for Jigjiga district were collected from the NMA Jigjiga branch office. The data cover the period from 1952 to 2010 (59 years). The lack of metrological station that provides long-term climatic data in other pastoral areas of the Region and the time available for field research has led to conduct the study in one administrative area.

A two stage sampling technique was applied to select sample households. In the first stage, 5 villages were randomly selected out of the total 20 agro-pastoral villages in the district. In the second stage, a total of 140 households were randomly selected using probability proportional to sample size sampling and simple random sampling technique from the list of households enumerated in each of sampled villages. Household surveys were carried out to obtain information regarding the effect of climate change and other factors on household food security. A range of vulnerability factors were identified and included in the questionnaire for sampled households to indicate the extent of these factors to have effect on their food security.

USDA's Food Security Core Module (FSCM) was included in the household questionnaire for the assessment of household food security status. FSCM is a structured survey questionnaire having a set of 10 questions for households with no children and 18 questions for households with children. The food security status of each household was assessed by responses to the questions about food-related behaviors, experiences, and conditions that are known to characterize households having difficulty meeting their food needs. In order to triangulate household data and gain a better understanding of the link between climate change and food security, ten focus group discussions (2 per sampled PAs) were made using participatory methods such as semi-structured group interview and ranking.

3.3 Data Analysis

This study mainly employed the Mann-Kendall non-parametric trend test, to detect significant trend among climatic variables (rainfall and temperature), Likert-scale, to summarize household perception of the changing environment and its effect on their food security; Rasch model, to analyse the status of household food security; and logistic regression model, to identify factors influencing household food security.

3.3.1 Mann-Kendall Trend Test

The basic principle of Mann-Kendall (Mann, 1945; Kendall, 1975) test for trend involves the examination of the sign of all pair-wise differences of observed values. The Mann-Kendall test is based on the statistic S. Each pair of observed values xj, xk (k> j) of the random variable is inspected to find out whether xk>xj or xk<xj. The test statistic for the Mann-Kendall test is given as:

$$S = \sum_{k-1}^{n-1} \sum_{j=k+1}^{n} \mathrm{sign}(x_i - x_k) \quad \textbf{(1)}$$

Where xj and xk are the sequential data values and j <k, n is the length of the data set and

$$\mathrm{sign}(x_j - x_k) = \begin{cases} 1 & \mathrm{if} x_j - x_k > 0 \\ 0 & \mathrm{if} x_j - x_k = 0 \\ -1 & \mathrm{if} x_j - x_k < 0 \end{cases} \quad \textbf{(2)}$$

The Mann-Kendall test has two parameters that are important for trend detection. These parameters are the significance level that indicates the test strength and the slope magnitude estimates that indicates the direction as well as the magnitude of the trend. Given the null hypothesis that xj are independent and randomly ordered, the statistic S is approximately normally distributed when $n \geq 8$, with zero mean and variance (Capodici et al., 2008).

The Mann-Kendall test allows inquiring on the presence of tendency of long period without having to make an assumption about the distributional properties. Moreover, the non-parametric methods are less influenced by the presence of outliers in the data compared with other methods (Capodici et al., 2008).

3.3.2 Likert Scale

In Likert scale method, a sample household indicates his or her degree of agreement or disagreement for a variety of statements related to the perceived changes of a given variable over time. Total score can then be calculated by summing up the values for all statements to see the significance of each variable. An important assumption of this scaling method is that each of the statement measures some aspect of a single variable so as to legitimately apply summation. In addition, the relative importance of sub categories of statements can be measured, by relating its score with the household's total score (Bunce et al., 2009). For this study a 5 point Likert scale method was used.

3.3.3 Rasch model

It has already been mentioned that this study employed the FSCM to assess household food security status. An essential characteristic of the FSCM is that the items/questions comprising it vary across a wide range of severity of food insecurity. The precise severity level of each item is estimated empirically using Rasch model (named after the Danish Mathematician, Georg Rasch) (Mesfin and Zelalem, 2008).

In determining the household food security status, first; responses of 'yes', 'often true', or 'sometimes true', and 'two or more months' for the frequency of occurrence follow up questions were coded as affirmative responses.

Then, the responses were combined into a food security scale using Rasch measurement model. Finally, households were classified into four food security categories based on USDA's classification standard (Bickel et al., 2000). These include:

- Food secure: households that show no or minimal evidence of food insecurity. The group's value ranges from 0-2.32 on the food security scale
- Food insecure without hunger: with a food security scale values that ranges from 2.33-4.56, households in this group concern about adequacy of food and show adjustments to household food management, including reduced quality of food and increased unusual coping patterns.
- Food insecure with moderate hunger: food intake for adults in the household has been reduced to an extent that implies that adults have repeatedly experienced the physical sensation of hunger. Such reductions are rarely observed among children in households that have food insecurity in this range of severity. The group's value on the food security scale ranges from4.57-6.53.
- Food insecure with severe hunger households: at this level, all households with children have reduced the children's food intake to an extent indicating that the children have experienced hunger. For some other households with children, this already has occurred at an earlier stage of severity. Adults in households with and without children have repeated experience of more extensive reductions in food intake. The group's value ranges from 6.54-10.0.

3.3.4 Logistic regression model

This study used household food security status as a dependent variable for the identification of factors influencing food security at household level. As has been indicated in the preceding section, sample households were classified into four food security categories based on their food security scale. This gives the dependent variable to have an ordinal characteristic i.e. the prevalence of food insecurity varies among different food security categories. In such variables, the difference among adjacent categories cannot be treated as the same and cannot be easily modelled with classical regression models (Gujarati, 2003).In this case, either ordered logit or probit models are used as a framework for analyzing such responses (Green, 2004). For practical applicability, the study used ordered logit model to assess the determinants of household food security. The functional form of logistic regression model is specified as follows (Green, 2004)

$$y^* = \alpha + \sum_{k=1}^{k} \beta_k X_k + \varepsilon \qquad \textbf{(6)}$$

where y* is the exact but unobserved dependent variable; X is the vector of independent variables, β is the vector of regression coefficients and ε is the unobservable factor which is assumed to follow a certain symmetric distribution with zero mean such as normal or logistic distribution.

Instead of y*, what we can only observe is the categories of response:

$$y = \begin{cases} 1 \text{ if } y* \leq \mu_1 \\ 2 \text{ if } y* \leq \mu_2 \\ 3 \text{ if } y* \leq \mu_3 \\ \quad \vdots \\ j \text{ if } y* \leq \mu_{j-1} \end{cases} \qquad (\mathbf{7})$$

Where y is observed in j number of ordered categories, μs are unknown threshold parameters separating the adjacent categories to be estimated with βs.

The general form for the probability that the observed y falls into category j and the μs and the βs are to be estimated with an ordinal logit model is:

$$\text{Prob}(y = j) = 1 - L\left(\mu_{j-1} - \sum_{k=1-1}^{k} \beta_k X_k\right) \qquad (\mathbf{8})$$

Where L (·) represents cumulative logistic distribution.

Marginal effects on the probabilities of each food security category were calculated by:

$$\frac{\partial \text{Prob}\,(Y=j)}{\partial X_k} = \left[f\left(\mu_{j-1} - \sum_{k=1}^{k} \beta_k X_k\right) - f\left(\mu_j - \sum_{k=1}^{k} \beta_k X_k\right)\right] \qquad \textbf{(9)}$$

Where f (·) represents the probability density function.

The table below summarizes the definitions and expected signs of explanatory variables hypothesized to affect household food security status (the dependent variable) in the ordered logit model.

Table 1: Summary of explanatory variables included in the logistic regression model

Variable type and code	Variable definition	Expected sign
Continuous (Mean and SD)		
AGE	Age of household head	+ve
DPR	Dependency ratio	-ve
LND	Land holding (ha)	+ve
LSIN	Total livestock income in ETB	+ve
DSMKT	Distance from market centre in km	-ve
CCP	Climate change perception (mean 5 point Likert – scale)	+ve
DRGT	Total livestock died due to drought and/disease TLU	-ve
Dummy (Number and percent)		
SEX	Sex of HHH; 1, if male; 0, otherwise	+ve
LTRCY	Literacy level of HHH; 1, if literate; 0, otherwise	+ve
RIDG	Moisture conservation practice; 1, if used ridge; 0, otherwise	+ve
CHRD	Change in herd composition; 1, if changed herd composition; 0, otherwise	+ve
FMP	Livestock feed management practice; number of feed management practices used	+ve

4. Results and discussions

4.1 Socioeconomic characteristics of respondents

Demographic features: The mean age of sample household heads was 45.32 years. Dependency ratio, the proportion of dependent household members (household members aged less than 15 years and those older than 64 years) to that of the active age group (15-64), was close to one (0.98). The proportion of male headed households was about 83 per cent, while the remaining 17 per cent were female headed households. Out of the total sample household heads (N=140), 26 people (18.6 percent) were able to read and write at the time of the survey, while 114 (81.4 percent) could not. A livelihood study conducted among selected pastoral and agro-pastoral areas of SNRS found similar result with regard to dependency ratio but less literacy rate of only 13.7 percent (Devereux, 2006).

Land holding: Land is the most important natural capital held by agro-pastoral households in the study area. Regardless of the size, all the respondents have reported that they own land. The average land holding was 2.82ha out of which 1.33ha was pastureland and 1.5ha was cultivated land during the study period. A household food security study in agro-pastoral district of SNRS reported similar result for average cultivated land (Guled, 2006).

Livestock production: In pastoral communities, livestock serve as the main financial asset. The herd composition of sample households shows that cattle comprise significantly large proportion (about 73 percent) followed by sheep (13 percent), goats (7 percent) and camels (3 percent). Finally, average livestock holding calculated using tropical livestock units (TLUs) reveals that mean livestock ownership for the total sample equals 8.67.

Cash income: the average yearly income of sample households was just over 7200. Income from livestock and livestock product appears to constitute nearly all amount of the total household income (90 percent or 6510 ETB). On the other hand, income from sell of crop and non/off farm sources were less significant (452 ETB and 240 ETB respectively).

4.2 Household food security status

Based on the transformed Rash model estimation result using USDA's classification standards described earlier, there is high prevalence of food insecurity in the study area. Out of the total 140 surveyed households, 113 (81 percent) were food insecure. The remaining 27 (19 percent) were food secure. The food insecure households comprised of; 35 (25 percent) food insecure without hunger, 41 (29 percent) food insecure with moderate hunger, and 37 (27 percent) food insecure with severe hunger.

4.3 Identification of trends in local climate

This section investigates the existence of significant changes in temperature and rainfall chronologies of Jigjiga district. Moreover, agro-pastoralists' perception of climate change was contrasted with the historical trend.

4.3.1 Climate observations

4.3.1.1 Rainfall

Analysis of total annual rainfall data for the period 1952-2010 reveals a consistent decline since 1976, when a maximum amount of 1825mm was recorded. Before 1976, the total annual rainfall was for most of the time in excess of the long term average (about 681 mm). However, since 1976 the total rainfall has never exceeded the long term average more than five times. However, the Mann-Kendall trend analysis revealed no statistically significant trend in the amount of annual rainfall in the period. On the other hand, dividing the whole period into two halves (1952-81 and 1982-2010), it is interesting to note that the average rainfall of the later period is significantly lower than the previous period. The mean difference between the two periods is about 170mm (Table 2)

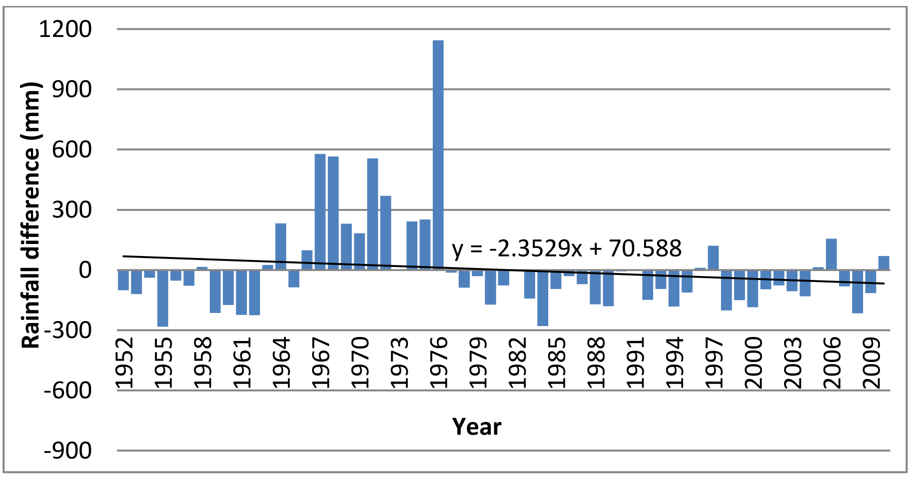
At seasonal scale, the trend analysis shows a significant negative trend at ten per cent probability level for the Gu (long rainy season starting from March to September). On the other hand, rainfall trend in the Jilaal (dry season) is positive with no statistical evidence. A closer look at the rainfall data for the rainy season reveals a stronger declining and statistically significant trend at five per cent probability level for Karan (the third rainy season which coincide with Keremt season in the highland of Ethiopia).

Table 2: Mann-Kendall and t-statistic results of annual and seasonal rainfall

Time scale	1952-1981		1982-2010		t	1952-2010		Change/ decade
	Mean	MK***	Mean	MK		Mean	MK	
Annual	764.7	0.251*	594.4	0.079	-2.84*	681	-0.09	23.53
Gu-wet season	584.2	0.228*	422.6	-0.03	-3.42*	504.8	-0.17*	28.18
Dira (Ap, M)	160	0.143	116.2	0.163	-2.12**	138.5	-0.07	6.11
Haga (J, Jl)	165.1	0.329**	112.4	0.039	-3.60*	139.2	-0.15*	8.24
Karan (Ag, S)	227.9	0.108	147.9	-0.05	-3.83*	188.6	-0.23**	16.93
Jilaal-dry season	180.4	0.168	171.9	0.172	-0.35	176.2	0.072	4.65
Deyer (O, N)	31.88	-0.02	26.06	0.168	-1.13	29.02	0.013	3.22
Kalil (D-Mar)	116.7	0.195	126.5	0.118	0.42	121.5	0.113	7.87

*, and **; Significant at 10% and 5% probability levels, respectively; ***Mann Kendal
Source: Computed based on data obtained from NMSA, Jigjiga Branch Office

Figure 2: Year to year annual rainfall difference compared to 1952-2010 average (mm)



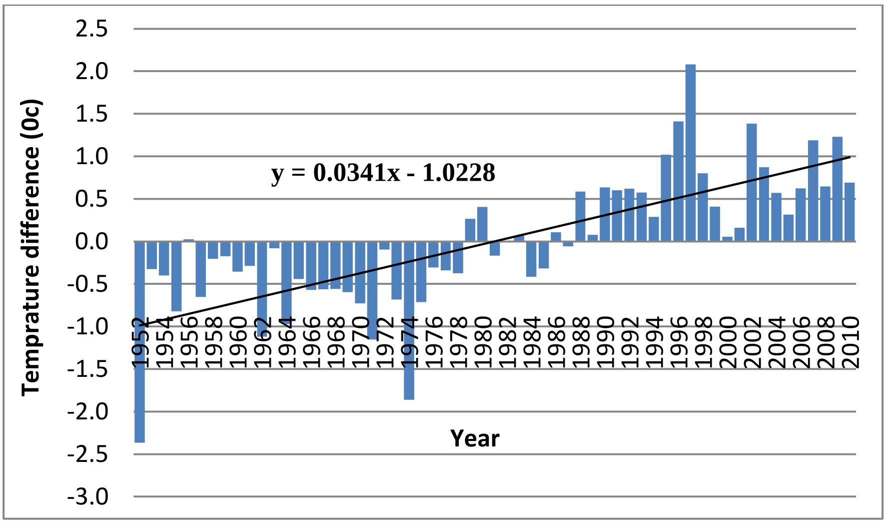
Source: Computed based on data obtained from NMSA, Jigjiga Branch Office

4.3.1.2 Temperature

The year to year variation of mean annual temperature expressed in terms of temperature differences from the long term average (1952-2010) is shown in Figure 3. As it can be seen from the figure, the years until early 1980s were cooler than later years. Specifically, temperature has never exceeded the long term average until 1981 while the reverse was true for nearly all of the subsequent years.

Figure 3 clearly reveals the warming trend in the mean annual temperature over the past 59 years. The regression line shows that it has been increasing by about 0.340c every ten years (Figure 3).

Figure 3: Year to year Temperature difference (^{0}c) compared to 1952-2010 average



Source: Computed based on data obtained from NMSA, Jigjiga Branch Office

Table 3 shows the results of Mann-Kendall trend test and the mean difference test between the periods 1952-81 and 1982-2010 at annual and seasonal time scale. For the whole period, the Mann-Kendall trend test indicates a positive and significant trend at one per cent probability level for all time scale levels (at annual and all seasons). More strikingly, these changes are mainly attributed to the alarming rate of temperature increase in recent years. During the second period (1982-2010), statistical trends have been found at all time scale levels, while it was only Hagaa season that has statistical trend during the first period (1952-1981). The t test further revealed a significant difference in the mean temperature between the two periods at both annual and seasonal time scale (Table 3).

Table 3: Mann-Kendall and t-statistic results of annual and seasonal temperature

Time scale	1952-1981		1982-2010		t	1952-2010		Change/ decade
	Mean	MK	Mean	MK		Mean	MK	
Annual	19.04	0.09	20.14	0.43***	7.57***	19.58	0.59***	0.34
Gu-wet season	20.4	0.12	21.43	0.44***	6.49***	20.91	0.57***	0.34
Dira(Ap, M)	20.66	-0.05	21.41	0.27**	4.55***	21.03	0.36***	0.22
Haga(J, Jl)	20.41	0.25*	21.57	0.40***	5.24***	20.98	0.57***	0.41
Karan (Ag, S)	20.14	0.1	21.32	0.36***	5.94***	20.72	0.51***	0.39
Jilaal-dry seas.	17.37	0.05	18.52	0.29**	5.79***	17.93	0.47***	0.34
Deyer(O, N)	17.75	0.07	19.07	0.28**	4.95***	18.4	0.44***	0.39
Kalil (D-Mar)	17.66	0.08	18.74	0.22*	5.89***	18.19	0.45***	0.32

*, **, ***; Significant at 10%, 5% and 1% probability levels, respectively

Source: Computed based on data obtained from NMSA, Jigjiga Branch Office

The preceding results of increasing trends in temperature and declining rainfall for the rainy season have clearly negative impacts for the livelihoods of agro-pastoral households in the study area as their livelihood depend on the availability pasture and water which in turn depend on the amount of rainfall and temperature.

4.3.2 Perception of climate and other changes

Sample households were asked to indicate their general perceptions of the changes in climate, climate induced hazards and other variables such as population, market prices and land use changes in the last one or two decades. Table 4 shows the direction and magnitude of changes using a five point Likert scale, with; -2 showing the highest decrease, -1 decrease, 0 no change, +1 increase, and +2 the highest increase. The right side column (Mean) shows the perception index of households calculated by averaging the absolute values of Likert scale results.

In line with the climatic data presented earlier, respondents indicated overwhelmingly highest perceptions (-2 or +2) of trends in climatic variables. The survey data show that a large share of households perceive temperature has been increasing overtime (83 per cent), that rainfall has been decreasing (84 per cent) and that irregularity of rainfall has been increasing (86 per cent). The mean value of Likert score indicate that temperature is the most important to have had changed over the past one or two decades followed by annual rainfall and altered rainy seasons (including early secession and late start). A few households reported that temperature has been declining (6 per cent) and that rainfall has been increasing while about 11, 12 and 14 percent of the respondents perceive no changes in temperature, seasonality and annual rainfall respectively (Table 4). Though it is not large, this intra household variation in the perception of climate change could be attributed to a range of factors that determine the level of household perception including the characteristics of households, asset ownership and access to institutions (Dosset al., 2006; Temesgen, 2010).

Table 4: Perceived changes in climate, climate induced hazards and other variables

Variables	Rank	Changes (Number and Percent) -2	-1	0	+1	+2	Mean
Climate variables							**1.20**
Temperature	1	2(1.4)	6(4.3)	16(11.4)	27(19.3)	89(63.6)	1.39
Annual rainfall	2	47(33.6)	72(51.4)	17(12.1)	1(.7)	3(2.1)	-1.14
Altered rainy seasons	3	0(0.0)	0(0.0)	20(14.3)	89(63.6)	31(22.1)	1.08
Climate change induced hazards							**1.22**
Parthinium and other species encroachment	1	0(.0)	2(1.4)	0(.0)	15(10.7)	123(87.9)	1.85
Frequency of drought	2	0(0)	1(.7)	2(1.4)	17(12.1)	120(85.7)	1.83
Water shortage	3	1(.7)	12(8.6)	3(2.1)	54(38.6)	70(50.0)	1.29
Crop pest infestation	4	0(.0)	0(.0)	9(6.4)	85(60.7)	46(32.9)	1.26
Land degradation	5	13(9.3)	1(.7)	15(10.7)	38(27.1)	73(52.1)	1.12
Livestock disease outbreak	6	1(.7)	1(.7)	16(11.4)	93(66.4)	29(20.7)	1.06
Frost hazard	7	6(4.3)	3(2.1)	44(31.4)	21(15.0)	66(47.1)	0.99
Pasture shortage	8	3(2.1)	24(17.1)	5(3.6)	67(47.9)	41(29.3)	0.85
Human health problems	9	2(1.4)	11(7.9)	31(22.1)	75(53.6)	21(15.0)	0.73
Other Changes							**0.98**
Cereal prices	1	0(0.0)	6(4.3)	9(6.4)	59(42.1)	66(47.1)	1.32
Livestock holding	2	36(25.7)	97(69.3)	7(5.0)	0(0.0)	0(0.0)	-1.21
Crop land	3	8(5.7)	5(3.6)	11(7.9)	79(56.4)	37(26.4)	0.94
Livestock prices	4	2(1.4)	21(15.0)	12(8.6)	66(47.1)	39(27.9)	0.85
Human population	5	8(5.7)	0(0.0)	31(22.1)	57(40.7)	44(31.4)	0.92
Settlement on grazing area	6	0(0.0)	3(2.1)	47(33.6)	54(38.6)	36(25.7)	0.88

Note: Numbers in parenthesis represent percent; Values -2, -1, 0, +1, +2 indicate; highly decreased, decreased, no change, increased, and highly increased, respectively
Source: Survey data

Sample households were also reported nine most important hazards to have had increased over the past years. These are; invasion of parthinium and other unwanted plant species (99 per cent), frequency of drought (98 per cent), water shortages (89 per cent), crop pest infestations (81 per cent), land degradation (79 per cent), livestock disease outbreak (87 per cent), frost hazard (62 per cent), pasture shortage (77 per cent), and human health problems (69 per cent). Similarly, the perception of households to other changes such as market prices, land use and human population was indicated (Table 4). In here, the most important changes reported were an increase in cereal price, a decline in livestock holding, and expansion of area under crop. The implication of such changes on the livelihoods and food security of agro-pastoral household is mostly negative. For example, as agro-pastoralists are more reliant on market for food/cereal, the increase in price could exacerbate food insecurity in the area unless it is backed by increase in the livestock prices which leads to a better terms of trade. However, the reality is that though respondents confirmed that there is improvement in livestock price in recent years, the magnitude of price increase is less than that of the increase in cereal prices.

4.4 Climate change and the underlying causes of food insecurity

In Ethiopia, food security of pastoral livelihood systems has been highly threatened by climate change and its variability (NMA, 2007). This section describes the relative importance of climate related variables amongst myriad of other variables threatening household food security in the study area. Using 5 point Likert scale, households were requested to indicate the extent (5, a very great extent; 4, great extent; 3, medium extent; 2, slight extent; and 1, no extent at all) that they considered each variable has effect on their food security. Then, the relative significance of each variable was calculated by dividing the total score values given by all households in the sample for each variables to the total sample size (N=140).

The rated vulnerability factors by food security status of households are shown in (Table 5). The variables include climate and climate change induced hazards, market and service problems and human factors[4]. The relative importance of major factors is indicated in the right side of (Table 5). The result reveals that climate and climate change induced hazards were rated first. This was followed by market and service problems, and by human factors, in that order.

[4] Adapted from Nnamchi and Ozor (2009) and Bunce *et al.,* (2009)

4.4.1 Climate and climate change induced hazards

Climate and climate related factors are of great concern to the agro-pastoralists in the study area. These include aspects of rainfall and rainfall variability such as low rainfall in a year and early cessation and late start of rainy season; high temperature; and the effect of these factors like drought, invasion of unwanted plant species, water shortage, crop pest infestation, pasture shortage and livestock disease outbreaks. Surprisingly, only climate and climate change related factors were rated in the top ten most important causes of food insecurity except the high cereal price which was rated seventh. According to their order of importance; drought, invasion of unwanted plant species (parthinium), low annual rainfall, high temperature, and water shortage are the five most important causes of food insecurity (Table 5).

Respondents in focus groups expressed similar views with that of survey respondents and discussed a broad range of climate change impacts and relationships. They reported that, most of the natural, financial, human and social capitals up on which they depend for food and livelihood security are already significantly affected by climate-related hazards. Communities described that drought and high temperature have significant effects on natural resources such as pasture, water sources and crop land. These in turn increase pasture and water shortages which impact the livestock and crop resources that serve as main sources of food and cash income. Other factors like Parthinium largely reduce pasture availability and quality which translates into a reduction in milk availability and quality. In addition, the problem has effect on human health (skin irritation, exposure to respiratory disease-asthma when they try to uproot the stem and serve as breeding ground for mosquito and other biting flies during wet season). Moreover, according to the groups, livestock holdings are at critical stage due to expansion of drought induced livestock diseases (like anthrax, black leg and pasteurellosis) and pasture shortage. Shortage of water source is a very series problem due prolonged drought and none functionality of most birkas that used to serve as a main source of water for communities.

Table 5: Mean Likert-scale results of sample households response to the underlying causes of food insecurity

Food insecurity causes	Rank	Mean
Climate and Climate change induced hazards		4.19
Drought	1	4.91
Parthinium and other species encroachment	2	4.81
Too low rainfall in a year	3	4.42
High temperature	4	4.4
Water shortage	5	4.3
Crop pest infestation	6	4.26
Pasture shortage	8	3.95
Livestock disease outbreak	9	3.94
Early cessation of rainy season	10	3.91
Late start of rainy season	12	3.86
Human health problems	16	3.76
Frost	18	3.73
Market and service problems		3.69
Cereal price increase	7	4.16
Lack of farm inputs	11	3.87
Poor market price for livestock	13	3.79
Lack of veterinary services	14	3.78
Poor extension services	19	3.69
Lack of credit-services	20	3.68
Lack of improved crop varieties	22	3.45
Lack of improved animal varieties	23	3.44
Poor transport facilities	24	3.33
Human factors		3.23
Land degradation	15	3.77
Human population pressure	17	3.74
Settlements on grazing areas	21	3.57
Pasture land enclosure	25	3.04
Mobility restriction	26	2.64
Lack of farmland	27	2.64

Source: Survey data

Focus groups also shared their experience of how climatic factors inter-related to each other. For instance, drought is linked to occurrence of livestock disease (through reduced disease resistance, transmission of diseases when livestock concentrated at few water points, death of livestock when rain finally comes), and crop pests (occur mostly when rain comes after prolonged droughts). In addition, drought exacerbates human health problem such as child malnutrition (because of lack of milk).

4.4.2 Market and service problems

These include market problems like high cereal price and poor price for livestock; service problems such as lack of veterinary, credit and extension services; and other problems like lack of farm inputs, improved varieties and poor transport facilities. Out of all factors under this category, cereal price increase was ranked first. Households mainly depend on market for cereal/food consumption and their main source of income is from livestock sale which was at the same time reported to be unfavorable.

Focus group discussions reveal that the availability of farm inputs (especially fertilizer), credit and extension services are almost none-existent in the area and these largely hinder improvement in farm productivity and food security. Groups also cited sky rocketing rental price of tractors and lack of farming skills like the use of oxen for traction purpose as important constraints of crop production and food security in the area. Moreover, villages visited were in a poor state, with non-functional water points and little infrastructure such as schools, human and animal health clinics.

4.4.3 Human factors

This category contains population growth and land use change related factors. These include; land degradation, expansion of settlement on grazing areas, pastureland enclosure, and mobility restriction. In general, sample respondents downplayed the impact of these factors on their food security.

As shown in Table 5, most of the factors under this category were ranked last and did not appear among the top ten causes of food insecurity.

4.5 Adaptation measures

In response to the changing climatic situation of the area, agro-pastoral households have developed various adaptation and coping strategies to minimize the risks posed by climate change and extreme events. As an agro-pastoralist, households in the study area implemented a combination of techniques that minimize crop failure and shortage of pasture due to drought and/or any other climate related hazards (Table 6).

Table 6: Number and percentage of sample households using adaptation and cooping measures

Adaptation measures	Number	Percent
Adaptation	**96**	**68.6**
Herd mobility	66	47.1
Use of moisture conservation (ridge)	31	22.1
Changing herd composition	31	22.1
Preparing hay and using cut and carry	29	20.7
Use of short season verities	4	2.9
Coping	**113**	**80.7**
Livestock sell	47	33.6
Use of crop residue	37	26.4
Purchase feed and hay	28	20.0
Renting pastureland	19	13.6
Convert failed crop to feed	27	19.3
Grass uprooting	24	17.1
Sought off farm opportunities	15	10.7

Source: Survey data

Herd mobility and livestock sale are the major adaptation and coping strategies, respectively whereas use of short season varieties was the least adaptation practice used by sample households in response to crop failure.

More use of livestock sale practice could be associated with the liquidity nature of the asset and easy access by agro-pastoralists; and limited use of short season verities could be attributed to lack of access to improved technologies and extension service in the area. These adaptation and coping measures are similar to the findings of the adaptation study in pastoral and agro-pastoral areas of Ethiopia (Richéet al., 2009).

4.6 Determinants of household food security

Logistic regression model was fitted to analyze the factors influencing household food security status. Before the estimation of the ordered logit model parameters, the problem of multicollinearity and heteroscedasticity were checked using the variance inflation factor (VIF) and Contingency coefficient (CC) test for continuous and discrete variables, respectively. Accordingly, there was no serious problem of multicollinearity among the explanatory variables. Moreover, the problem of heteroscedasticity was checked using Breusch-Pagan/Cook-Weisberg test for heteroskedasticity. The result reveals that p value of 0.97 which is acceptable level of significance for accepting homoscedasticity.

The estimated result of ordered logit model and its marginal effects are shown in Table 6. Positive coefficients imply improvements in the household food security status as the value of explanatory variables increase, whereas the reverse is true for variables having negative coefficients. In addition, the calculated marginal effects show the expected changes in the probability of household food security status with respect to a unit change in the independent variable, ceteris paribus. These are shown in right side of Table 6 for each categories/outcomes of the dependent variable (Y=4, …,Y=1; representing improvements in the food security status from the worst level of food insecurity to food secure category).The explanatory variables included in the model are jointly significant at P< 0.000 and the Pseudo R2 is 0.143. Hence, the hypothesis that all coefficients except the intercept are equal to zero was rejected. Therefore, it is possible to interpret the results meaningfully.

Out of the total twelve independent variables, six significantly influenced household food security at one and five percent probability levels. These are; Dependency ratio, Income from livestock and livestock products, use of water conservation technique (ridge), climate change perception, TLU of livestock lost due to drought/disease, and use of livestock feed management practices.

Table 6: Results of ordered logit model

Variables	Coefficients	P>|z|	Marginal effects			
			Y=4	Y=3	Y=2	Y=1
AGE	-0.00754	0.581	-0.00082	-0.00101	0.00062	0.00121
DPR	-1.28130***	0.000	-0.13865***	-0.17148***	0.10460**	0.20553***
SEX	0.24116	0.602	0.02459	0.03281	-0.01689	-0.04052
LTRCY	0.86421*	0.054	0.11448	0.09787**	-0.09518	-0.11717*
LND	0.00739	0.914	0.00080	0.00099	-0.00060	-0.00119
LSIN	0.00008***	0.000	0.00001***	0.00001***	-0.00001**	-0.00001***
DSMKT	-0.00247	0.842	-0.00027	-0.00033	0.00020	0.00040
CCP	1.48936***	0.003	0.16117***	0.19932**	-0.12159**	-0.23890***
DRGT	-0.08209**	0.018	-0.00888**	-0.01099**	0.00670	0.01317**
RIDG	0.94982**	0.022	0.12539*	0.10719**	-0.10306*	-0.12952***
CHRD	-0.39244	0.329	-0.03916	-0.05347	0.02557	0.06706
FMP	1.18234***	0.001	0.11580***	0.15427***	-0.06295*	-0.20711***
Number of obs. = 140		Prob.>chi2=0.0000			Pseudo R2 =0.1643	
LR chi2(12) = 63.28		Log likelihood = -160.90352				

***, **, * significant at 1%, 5% and 10% probability level, respectively;
Source: Survey data

Dependency ratio was negatively related to household food security status, implying that households with large dependency ratio were more likely to be food insecure than those with less dependency ratio. This result is in agreement with the findings of Hillina (2005) for pastoral areas of Somali

Region. According to Sandford and Ashle (2008), high dependency ratio is one of the characteristics of poor pastoral households (Sandford and Ashle, 2008). Moreover, a livelihood study documented the existence of high dependency ratio in the study area and raised questions about the nature and sustainability of future livelihood opportunities and the adverse synergies between more frequent and severe droughts, and environmental degradation in the area (Devereux, 2006).

As expected, income from sale of livestock and livestock products (LSIN) was found to be positively correlated to household food security status (at one per cent significant level). The fact that increasing livestock income increases the likelihood of households being classified as food secure is associated with the use of livestock as a main source of income by agro-pastoralists to buy grains from the market and become food secure (Sandford and Ashle, 2008; Amwata, 2009).

Climate change perception (CCP) was positively related to household food security, implying that households with highest perception of climate change were more likely to be food secure and less likely to be food insecure. The probable explanation is that households that perceive change in climatic conditions have higher chances of being food secure through taking adaptive measures in response to observable changes. Different studies of determinants of climate change adaptation have shown that perception significantly affects adaptation strategies (Maddison, 2006; Hassan and Nhemachena, 2008; Temesgen, 2010). It is, therefore, important to raise awareness of the climate changes among households in the study area.

Loss of livestock due to drought or disease (DRGT), the number of livestock (measured in TLU) that died due to drought and/or livestock diseases, was found to be negatively associated with household food security status. The result shows that prevalence of drought and/or disease has a significant impact in determining agro-pastoral households' food security status. The negative correlation indicates that higher mortality of livestock increase household vulnerability to food insecurity. The probable reason is that an increase in livestock morbidity and mortality would result in a lower number of animals. This implies reduced income and a declining in home food production, eminently contributing to increased vulnerability to food insecurity (Lai, 2007).On the other hand, households who took preventive measures to minimize loss of livestock could have greater probability of being foods secure than those households who could not through reduction in the number of died animals. Studies points out that those pastoralists who undertake measures like herd mobilization during climatic disasters have considerably fewer livestock losses than those who do not (Little et al., 2001; Kaimba et al., 2011).

The model result confirmed that undertaking moisture conservation technique (RIDG) like ridging positively and significantly affects household food security status. The marginal effects shows that the use of ridge at farm on farming fields increases the probability of being food secure and food insecure without hunger by about 13 and 10 per cent, respectively. While the same reduces the probability of either being food insecure with moderate hunger or food insecure with severe hunger by 11 and 10 per cent, respectively. The fact that taking soil and water conservation measures reduces household vulnerability to food insecurity is in line with the argument that the measures help mitigate soil erosion and conserve the little rain which both increases crop production that directly contribute to a better food security status (Li et al., 2001; Mmbaga and Lyamachai, 2001; McHugh et al., 2007; Tesfaye, et al., 2010).

Livestock feed management practices (FMP) is another category of adaptive measure which households took in response to pasture shortage problem. The variable was found positively related to household food security status. The result shows that as a household start implementing a new type of feed management techniques such as hay preparation, using crop residue, and cut and carry system, his/her probability of being food secure increases. The probable explanation is that declining pasture availability in the study area has caused agro-pastoralists to adopt new feed management techniques that reduce the risk of food insecurity because of loss of livestock. Households who did not start alternative measures face food insecurity that arises from loss of livestock due to pasture shortage.

5. Conclusion and recommendations

Ethiopia is one of the most vulnerable countries of the world to the impacts of climate change and variability. The impact is even stronger in the pastoral areas of the country, where small changes in rainfall and temperature could cause serious impact on the livelihood and food security of these communities (NMA, 2007; Aklilu and Alebachew, 2008). However, studies on the effects of local climate change and variability on food security is limited. The main objective of this study was to assess the role of climate change on food security of agro-pastoral households in Jigjiga district, in Eastern Ethiopia. In relation to this, the study attempted to analyze trends in local climate; quantify the status of household food security; assess the perception of households on the significance of climate related causes of food insecurity; and identify determinants of food security at household level.

Rainfall and temperature data for the period from early 1950s were used to test the presence of significant changes using Mann-Kendal test for trend. The result showed statistically significant changes for both rainfall (for the rainy season) and mean temperature (annual and seasonal).Furthermore, the time series climate data were contrasted with agro-pastoralists perception of the changes in climate, climate variability and other factors undergoing in the area. The result reveals that a very large proportion of respondents perceive changes in climate; with increasing temperature, decreasing amount of rainfall, and increasing seasonality of rainfall. Moreover, a significant majority perceive the consequences of these changes like invasion of parthinium and other unwanted plant species, increased frequency of drought, water shortages, crop pest infestations, livestock disease outbreak, frost hazard, and pasture shortage.

The food security status result from Rasch model estimation indicated a very high prevalence of food insecurity in the district. Out of the total 140 surveyed households, 81 per cent were food insecure; consisting of 25 per cent food insecure without hunger, 29 per cent food insecure with moderate hunger and 27 per cent food insecure with sever hunger.

Likert-scale was used to assess the relative importance of climatic factors in affecting household food security. The result showed the high importance attached by sample agro-pastoral households and communities in Jigjiga district to climate change and variability causes of food insecurity. These factors constitute the five most important causes of food insecurity in the area. These are drought, invasion of unwanted plant species (parthinium), low annual rainfall, high temperature, and water shortage.

In response to the above problems, respondents have adopted various strategies including sale of animals, soil and water conservation practices, use of crop residue, changing herd composition, hay making and the use of cut and carry system.

Finally, ordered logit model was used to closely analyze factors influencing the status of household food security. The result confirmed that variables hypothesized in relation to climate change were important in determining household food security. Among these, household perception of climate change, use of conservation technique (ridge), and use of livestock feed management techniques influenced household food security status positively and significantly; whereas loss of livestock due to drought and/or disease was found negatively and significantly related to household food security. Moreover, income from livestock and livestock products were found to be positively related to food security status, while the reverse was found to be true for large dependency ratio.

Given the negative trends in local climate and high prevalence of food insecurity, there is a need for urgent action aimed at addressing the causes of food insecurity mentioned in this study. These may include:

Promoting climate change awareness among the local people. This may require strengthening early warning and disaster risk reduction institutions starting from community level, so that both government and local communities could be informed of the changing climate and accordingly take appropriate actions.

Strengthening the existing adaptation strategies having positive role on the food security of agro-pastoral households. In addition, government policies should support adoption of new technologies that have the potential to reduce risk of crop failure and livestock losses; such as the use of drought tolerant crop and livestock varieties, water harvesting, and pasture conservation and management practices. In line with this, the realization of access to services such as extension, micro-finance and credit facilities could increase local resilience to climate change and food insecurity (Hassan and Nhemachena, 2008).

The Livestock resource of agro-pastoral households could play an important role in reducing the prevalence of food insecurity and vulnerability to climate change. Improving livestock income through promoting livestock marketing and diversification activities such as providing easy access to market information, increasing milk collection centres, adding value to livestock products such as milk and ghee could contribute to increased incomes and food security.

Increasing investments on key infrastructure and services that reduce the vulnerability of agro-pastoralists. For example, construction of animal health clinics, their appropriate staffing and supply of veterinary medicine could reduce livestock mortality from preventable diseases, and reduce vulnerability during drought events. Increasing family planning service reduce dependency ratio.

References

Aklilu, A., & Alebachew, A. (2008). Assessment of climate change-induced hazards, impacts and responses in the southern lowlands of Ethiopia. Addis Ababa: Forum for Social Studies (FSS).

Amwata, D. A. (2009). Climate Variability, Land-use and Livelihoods in Kiboko-Kibwezi observatory, Kenya. Tunis: Observatoire du Sahara et du Sahel (OSS).

Ayalneh, B., & Abebaw, S. (2009). Household level determinants of food insecurity in rural areas of Dire Dawa, Eastern Ethiopia. AJFAND , 1915-1926.

Beruk, Y. (2003). Food Security Situation in the Pastoral Areas of Ethiopia. Oxfam GB, Addis Ababa.

Bickel, G., Mark, N., Cristofer, P., William, H., & John, C. (2000). Measuring Food Security in the United States, United States Department of Agriculture (USDA).

Bunce, M., Rosendo, S., & Brown, K. (2009). Perceptions of climate change, multiple stressors and livelihoods on marginal African coasts. Environ Dev Sustain (2010) 12 , 407–440.

Capodici, F., Ciraolo, G., La Loggia, G., Liazzo, L., Noto, L. V., & Noto, M. T. (2008). Time Series Analysis of Climate and vegitation variables in the Oreto watershed (Scili, Italy). Eurpian Water 23/24 , 133-145.

CGRFA (Commission on Genetic Resources for Food and Agriculture). 2007. The state of the world's animal genetic resources for food and agriculture. FAO, Rome, 523 pp.

CSA. (2007). Population and Housing Census of Ethiopia: 2007. Draft report, Addis Ababa.

Devereux, S. (2006). Vulnerab livelihoods in Somali Region, Ethiopia. IDS Research Report 57. Brighton: Institute of Development Studies.

Doss, C., McPeak, J., & Barrett, C. (2006). Interpersonal, Intertemporal and Spatial Variation in risk perception: evidence from East Africa. Economic Growth Center Discussion paper No. 948, Yale University.

FAO (Food and Agriculture Organization of the United Nations). (2008). Climate change and food security: a framework document. Rome: Food and Agriculture Organization.

Green, W. H. (2004). Econometric analysis (5th Edition ed.). Upper saddle river, New Jersey: Prentce Hall.

Gujarati, D. (2003). Econometrics (3rd ed.). New York: McGraw-Hill.

Guled Abdulahi. 2006. Food insecurity and coping strategies of agro-pastoral households inAwbare woreda, Somali Region, Ethiopia.MSc Thesis, Alemaya University.

Harvell, C. D., Mitchell, C. E., Ward, J. R., Altizer, S., Dobson, A. P., Ostfeld, R. S., et al. (2002). Ecology - Climate warming and disease risks for terrestrial and marine biota. Science 296, 2158-2162.

Hassan, R., and Nhemachena, C. (2008). Determinants of African farmers' strategies for adapting to climate change: multinomial choice analysis. AfJARE Vol 2 No 1, 83-104.

Hillina, M. (2005). Dimentions and determinants of povertiy in pastoral areas of Eastern Ethiopia: the case of Shinile Zone in Somai National Regional State. MSc Thesis, Alemaya University.

Hopkins, A., and Del Prado, A. (2007). Implications of climate change for grassland in Europe: impacts, adaptations and mitigation options: a review. Grass and Forage Science 62, 118–126.

IPCC (Intergovernmental Panel on Climate Change). (2007). Working Group I (AR4) [6], Summary for Policymakers.

Kaimba, K. G., Njehia, K. B., & Guliye, Y. A. (2011). Effects of cattle rustling and household characteristics on migration decisions and herd size amongst pastoralists in Baringo District, Kenya. Pastoralism: Research, Policy and Practice , 1:18.

Kendall, M. G. (1975). Rank correlation Methods (3 ed.). New York: Hafner Publishing Company.

Lai, C. (2007). How Livestock is Used as a Coping Mechanism with Respect to Food Insecurity among Livestock Keepers of Africa: a Literature Review from a Current Perspective. Land O'Lakes Inc.

Li, X. Y., Gong, J. D., Gao, Q. Z., and Feng-Ru. 2001. Incorporation of ridge and furrow method of rainfall harvesting with mulching for crop production under semiarid conditions. Agricultural Water Management, 50 (3), Pages 173-183.

Little, P. D., Smith, K., Cellatious, B. A., Coppock, D. L., & Barret, C. B. (2001). Avoiding disaster: Diversification and risk management among East African herders. Development and Change, 32, 401-433.

MA (The Millenium Ecosystem Assassment). 2005. Ecosystems and Human Well-being: Scenarios, Volume 2, Island Press, 2005.

Maddison, D. (2006). The perception of and adaptation to climate change in Africa. CEEP Discussion paper no. 10, Center for Environmental Economics and Policy in Africa, Univesity of Pretoria.

Mann, H. B. (1945). Non Parametric tests again trend. Econometrica (13), 245-259.

McHugh, O. V., Steenhuis a, T. S., Berihun, A., & Fernandes, E. C. (2007). Performance of in situ rainwater conservation tillage techniques on dry spell mitigation and erosion control in the drought-prone North Wello zone of the Ethiopian highlands. Soil and Tillage Research , 19-36.

Mesfin, B., & Zelalem, Y. (2008). Measuring Food Security in the Dominican Republic: Adaptation to the U.S. Food Security Survey Module. USDA.

Mmbaga, T. E., & Lyamachai, C. Y. (2001). Drought managment options in maize production in Northern Tanzania. Seventh Eastern and Southern Africa Regional Conference 11th - 15th February, 2001 (pp. 281-287). CIMMYT (International Maize and Wheat Improvment Center).

NMA (National Meteorological Agency). (2007). Climate Change National Adaptation Program of Action (NAPA) of Ethiopia. Addis Ababa: NMA.

Nnamchi, H. C., & Ozor, N. O. (2009). Climate Change and the Uncertainties Facing Farming Communities in the Middle Belt Region of West Africa. Human Dimensions of Global Environmental Change (IHDP Open Meeting 2009) held at the United Nations University, Bonn, Germany between 26 April and 1 May, 2009.

Pantuliano, S., & Wekesa, M. (2008). Improving drought response in pastoral areas of Ethiopia Somali and Afar Regions and Borena Zone of Oromiya Region. Prepared for the CORE group (CARE, FAO, Save the Children UK and Save the Children US). London:Overseas Development Institute.

Parry, M. L., Rosenzweig, C., Iglesias, A., & Liverm, M. (2004). Effects of climate change on global food production under SRES emissions and socioe-conomic scenarios'. Global Environ. Change 14:53–6.

PFE (Pastoralist Forum Ethiopia). (2010). Paturalism and land: land tenure, adminstration and use in pastoral areas of Ethiopia.

Riché, B., Hachileka, E., Awuor, B. C., & Hammill, A. (2009). Climate-related vulnerability and adaptive-capacity in Ethiopia's Borena and Somali communities, Final assessment report. Save the Children UK and Care.

Ringer, C. (2008). Food and water under global change: developing adaptive capacity with a focus on rural Africa. Paper presented in the workshop "How can African agriculture adapt to climate change? 11–13 December 2008, Nazareth, Ethiopia.

Sandford, J., & Ashle, S. (2008). Livestock Livelihoods and Institutions in the IGAD Region. IGAD LPI Working Paper No. 10 - 08.

Sandford, S., and Yohannes Habtu. 2000. Emergency Response Interventions in Pastoral Areas of Ethiopia: Report of the Pastoral Appraisal Team. Department for International Development (DFID).

SC (Save the Children) UK. (2007). Livelihood Profile Somali Region.

Spore. (2008, August). The megazine for African agricultural and rural development. Retrieved from Spore: http://spore.cta.int/index.php

Temesgen, T., Hassan, R. M., & Ringler, C. (2008). Measuring Ethiopian Farmers' Vulnerability to Climate Change Across Regional States. International Food Policy Institute.

Temesgen, T. (2010). Assesment of the vulnerability of Ethiopian agriculture to Climate chnange and farmers' adaptation strategies. PhD Thesis, Environmental Economics, University of Pretoria.

Tesfaye, A., Cornelis, W. M., Nyssen, J., Govaerts, B., Tewodros, G., Tigist, O., et al. (2010). Impact of conservation agriculture on runoff, soil loss and crop yield on a Vertisol in the northern Ethiopian highlands. World Congress of Soil Science, Soil Solutions for a Changing World (pp. 93-96). Brisbane, Australia: Published on DVD.

Thornton, P. K., Jones, P. G., Alagarswamy, A., and Andresen, K. 2008. The temporal dynamics of crop yield responses to climate change in East Africa. Global Environmental Change.

Thornton, P., Herrero, M., Freeman, A., Mwai, O., Rege, E., Jones, P., et al. 2008. Vulnerability, Climate change and Livestock – Research Opportunities and Challenges for Poverty Alleviation. ILRI, Kenya.

Virtanen, P., E. Palmujoki, and Dereje T.G. (2011). Global Climate Policies, Local Institutions and Food Security in a Pastoral Society in Ethiopia. Consilience: The Journal of Sustainable Development Vol. 5, Iss. 1, Pp. 96-118.

World Bank. (2003). Ethiopia: Risk and Vulnereability Assesment. Draft Report.

Zenebe G., Je sper Stage, Alemu Mekonnen, and At l aw Al emu (2011). Climate Change and the Ethiopian Economy: A Computable General Equilibrium Analysis. Environment for Development, Discussion Paper Series No. EfD DP 11-09.