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Assessing the farmers perception of climate variability and change: A case study of Miesso-Assebot Plain, Eastern Ethiopia

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Assessment of farmers' perception and adaptation mechanisms at local level has enormous advantages in Ethiopia, where the driver of the economy is agriculture. This study was conducted to assess the perceptions of farmers to climate change and increased climate variability, and to identify the potential adaptation options. Most farmers noted an increase in temperature and decrease in precipitation in the last fifty years. The farmers' perception of increasing temperature was in accordance with the statistical climate data record; however, the farmers could not differentiate between consistent changes in climate and yearly rainfall fluctuation. Moreover, majority of the farmers were aware of frequent drought occurrence, shift in onset date and early withdrawal of rainfall. As a result, the farmers indicated decreased diversity of cultivated crops, changes in farming practices, new patterns of diseases, crop infestations with new weed species and frequent total crop failures. Furthermore, the majority of the respondents perceived water shortage, great loss of biodiversity and forest resources, and decline in soil fertility as the most serious impact of climate change. Use of different planting dates, on farm soil and water conservation, use of local and early maturing varieties were the major adaptation strategies practiced by farmers to mitigate climate change impacts at Miesso. However, production of drought tolerant cultivars with optimum maturity periods, introduction of new crops, varieties and crop management practices that go in line with the changing climate are recommended to offset climate change impacts on crop production at Miesso-Assebot plain, Eastern Ethiopia.

Key words: Climate variability and change, perception, adaptation options, Miesso-Assebot Plain.

INTRODUCTION

Climate change is rapidly emerging as one of the most serious threats to the totality of human existence. Different studies revealed that global mean surface temperature will be increased by 1.4 to 5.8°C between

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1990 and 2100 which is expected to be a much more rapid rate of warming than during the 20th century (Gruza and Rankova, 2004; Majule, 2008). Majule (2008) reported that the average global precipitation was projected to increase but, at regional levels there will be both increase and decrease in intensity of rainfall ranging from 5 to 20°C. Globally, these projected higher temperature and variable precipitation levels will unequivocally reduce crop yields through direct effects as well as indirect impact by triggering insect pests, diseases and weeds (Gadgil et al., 1998). The threats to food security and sustainable growth of developing countries will be much higher as the extent to which the impacts will be felt depends on adaptive capacity of communities (Mendelsohn and Dinar, 2009; Mtambanengwe et al., 2012).

About 66% of the total area of Ethiopia falls within arid and semi-arid climatic zones of the country (MoA, 1998). Nevertheless, agriculture, which is highly sensitive to climate variability and change (Hellmuth et al., 2007; Thornton et al., 2006; Teshome et al., 2008), is the driver of the country's economy as it accounts for half of GDP and 80% of employment (MoARD, 2007). Climate variability, particularly rainfall variability and associated drought, and increased frequency of extreme events could make rainfed agriculture more risky and aggravate food insecurity in Ethiopia (Seleshi and Zanke, 2004; Stern, 2007; Conway and Schipper, 2011). Preliminary projections suggested that climate change can have a sizeable impact that ranges in the order of 7-8% of GDP loss per year in Ethiopia (UNDP, 2011). These will form a serious concern for both researchers and development planners in Ethiopia and elsewhere.

Moreover, in Ethiopia, the risks associated with change in climate patterns that smallholderface is believed to be due to low adaptive capacity of society and limited adaptation options of agricultural sector (Yesuf et al., 2008; Mengistu, 2011). Hence, the livelihood approach of a locality could provide a baseline to probe adaptation options to climate related risks through assessing farmers' perception and local adaptation mechanisms in order to formulate mitigation strategies (Thomas et al., 2007; Stage, 2010; Belaineh et al., 2012). On the other hand, the farmer perception must be integrated with research information and proposed technologies in order to reduce the vulnerability and strengthen the adaptive capacity of communities.

The Miesso-Assebotplain in Eastern Ethiopia is one of the areas where staple food crops are extensively grown under high rainfall variability and unpredictability, strong winds, higher temperature and high evapotranspiration (Mamo, 2005). Therefore, apart from understanding meteorological variability and change on crop production and productivity *per se*, it is important to know the perception, and adaptation mechanisms of communities so as to develop viable climate change and variability adaptation options in a given area. Therefore, this study was conducted to assess the perceptions of farmers to climate change and increased climate variability, and the likely adaptation options used in crop production. The farmers' sources of climate change information and barriers to adaptation were also investigated in this study as these perceptions determine what farmers consider as alternative best adaptation options.

MATERIALS AND METHODS

Study area

The study was conducted in Miesso-Assebot Plain, located in Eastern escarpment of the Central Rift Valley of Ethiopia that forms the heart and corridor of the Ethiopian Rift Valley (Figure 1). The geographical location of the area ranges between 8° 48" 12'- 9° 19" 52'N latitude, 40° 9" 30' and 40° 56'' 44' E longitudes and altitude varying from 1107 to 3106 m above sea level. According to Lemma (2008) and Worku (2006), Miesso is dominated by silty clay loam soil texture with slightly alkaline pH ranging from 7.8 to 8.3. The farming system of Miesso is dominated by crop production. The major crops grown in the area include sorghum (66% of cultivable land), maize (24%), common bean and sesame as staple and cash crops (Kidane et al., 2006).

Miesso-Assebot plain is predominantly categorized under hot and warm sub-moist agro-ecological zone (MoA, 1998), receiving annual average rainfall of 727 mm distributed in a bimodal pattern. The first rainy season extends from March to May while the second (main rainy season) extends from June to September (NMSA, 1996). The annual mean minimum and maximum temperature of the district is 15 and 30.6°C, respectively.

Data collection

Primary data were collected through structured questionnaire using farmers' participatory methodologies which include formal interviews, direct observations and oral discussions. Data were collected on farmer perceptions of magnitude of change in climate patterns along with their underlying causes and consequences as well as the adaptation strategies used in crop production to tackle the risks associated with climate variability and change. Others were perception of farmers on the climate change impacts using indicators such as diversity of livelihood strategies, changes in crop diversity, change in crop management practices, and access to and knowledge of climate related helpful information for their farm level decision that has been in use in the past fifty years. The major constraints to using existing adaptation options were assessed through the questionnaire survey. The questionnaire was pre-tested and improvement made on the results obtained from the pre-test. Long-term temperature and rainfall data of Miesso station were obtained from National Meteorological Service Agency (NMSA, 1996) which was analyzed using Microsoft Office Excel 2007 to present patterns and trends of rainfall and temperature in the form of graphs. The farmers' perceptions were then compared with the meteorological record data analysis.

Sampling techniqueand data analysis

A multi-stage sampling technique was used to select five Peasant Associations (Gorbo, Husse-Mandera, Hunde-Misoma, Odabala and Torbayo) and draw sample farmers for the study. The questionnaire was administered into a total of 75 farmers of the district (15 from each Association). Household heads above the age

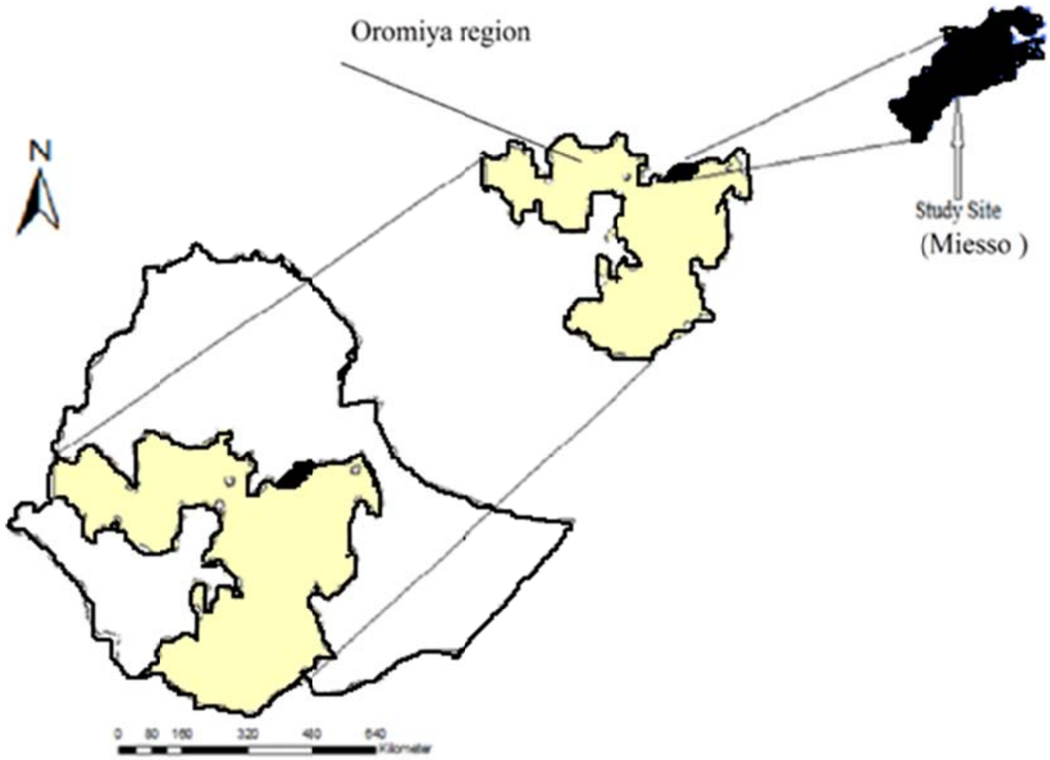

Figure 1. Geographical location of the study area.

of 50 were purposively administered the questionnaires, as more experienced and matured farmers are better at distinguishing climate variability from merely inter-annual variation of weather scenarios (Ishaya and Abeje, 2008). The total sample size was proportionally categorized into primary adopters (50) and non-adopters (25) of new technologies while growing sorghum to make their living. The crucial reason for this category is to compare the perception and adaptation mechanisms between technology adopters and non adopters. Agricultural office workers and development agents of the districts were involved in selecting the farmers.

Qualitative data collected through interview were examined and presented in different forms. Quantitative data were edited, coded and entered in a computer and Statistical Package for Social Science (SPSS) software version 17.0 spread sheet was used for the analysis (Greasley, 2008). Descriptive statistics such as mean, frequency and percentages were used for analysis of the data. Multiple response questions were analyzed so as to give frequencies and percentages. Tables, pie and bar charts were used to present different variables.

RESULTS AND DISCUSSION

Local perception on climate changes

Farmers' perceptions on climate variability and changes over the last fifty years (1960-2009) were assessed (Figure 2) in comparison with measured climate records (Figures 3, 4 and 5). The majority of farmers rated the reduction in rainfall amount as low during the period ranging from 1960-1980, medium during 1981-2000, and high and very high in the 2000s (Figure 1a, b and c). The farmers also opined that the rainfall amount was decreasing progressively every year since 1960s and resulted in drought conditions year after year. The great majority of farmers also indicated that changes which occurred in their ecosystems are related to severe droughts.

In view of that, the farmers ranked the frequency of droughts as low and very low, moderate, high and very high during 1960-1980, 1981-2000 and 2001-2009, respectively. However, the record data on rainfall from 1974-2009 showed that annual and seasonal (March-April-May and June-July-August-September) rainfall trend did not exhibit great reduction in amount except its variability from year to year (Figures 3 and 4). This result is in agreement with previous study on rainfall trend in Ethiopia (Sileshi and Zanke, 2004; Cheung et al., 2008). These indicate that the farmers were not able to differentiate between consistent changes in climate and yearly rainfall fluctuations.

Regarding temperature, most of the farmers interviewed perceived long-term changes in temperature. The farmers are of the view that the rise in temperature is as low (50%) and very low (25%) in the 1960s; moderate (47%) and high (25%) in the 1990s, high (55%) and very high (39%) in the 2000s (Figure 2). By and large, the analysis showed that the farmers' perception of increasing temperature is in accordance with the

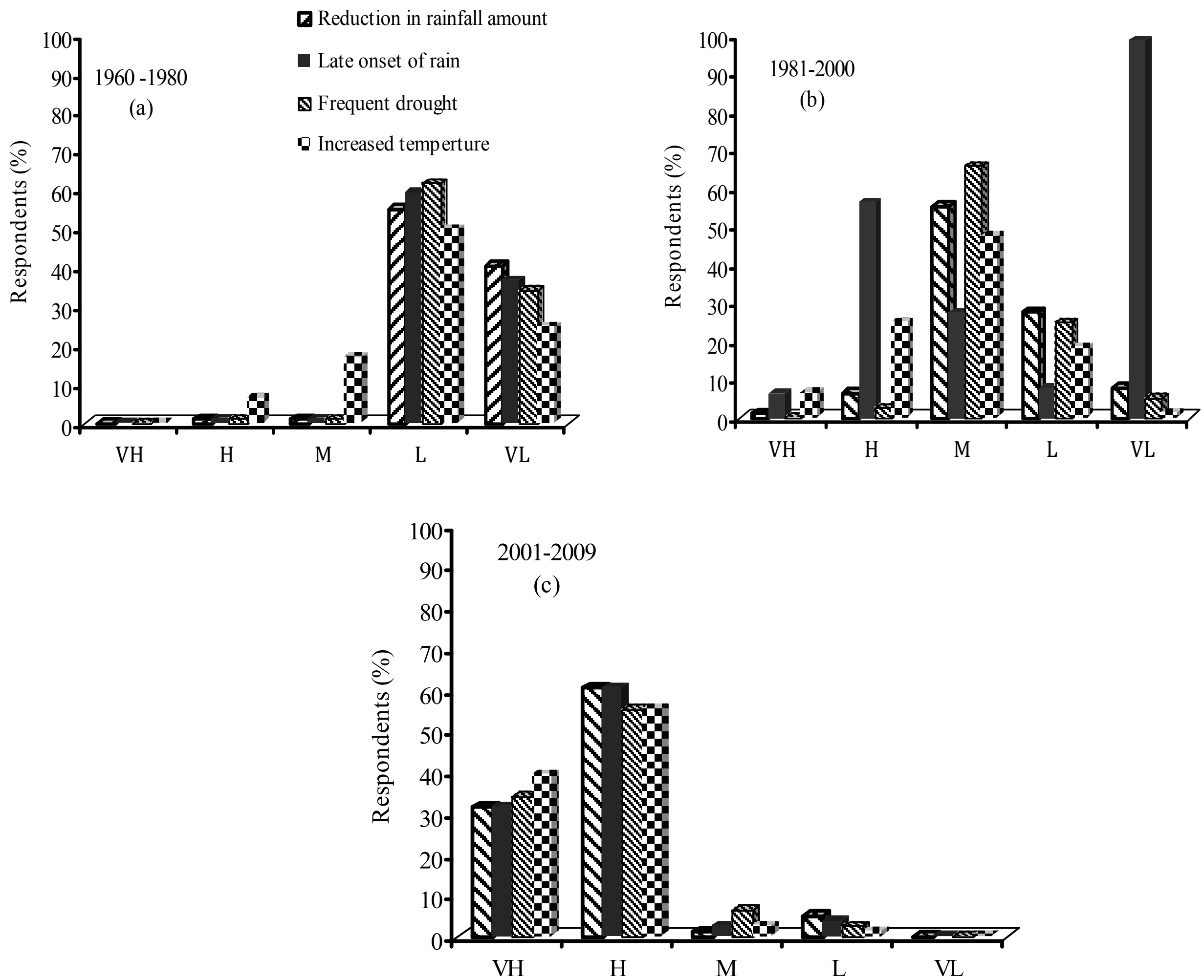

Figure 2. Farmers' perception of extent of change in climate patterns over the last fifty years. VH = very high; H = high; M = moderate; L = low; VL = very low.

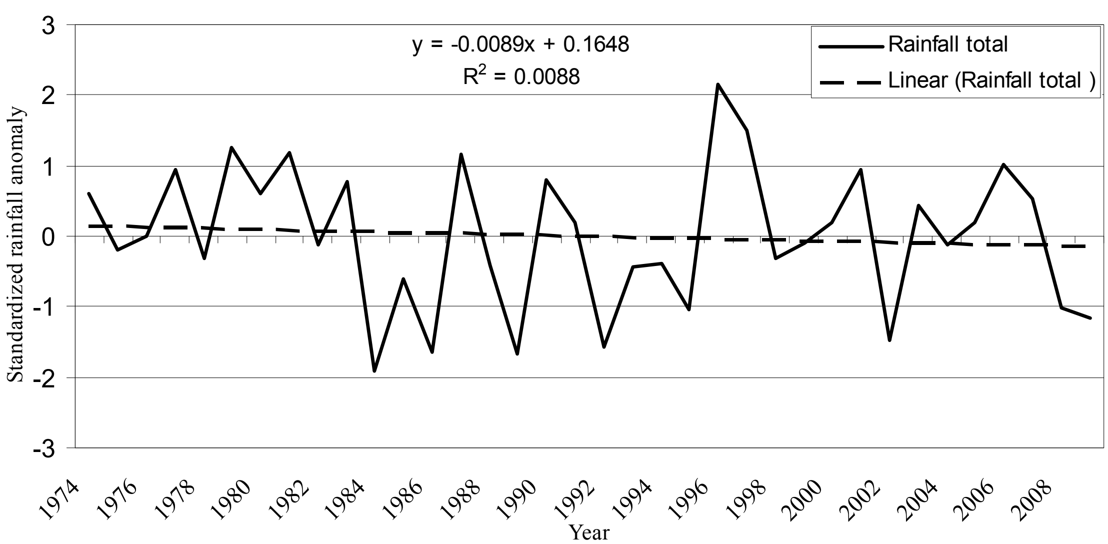

Figure 3. Annual rainfall trend in the study area.

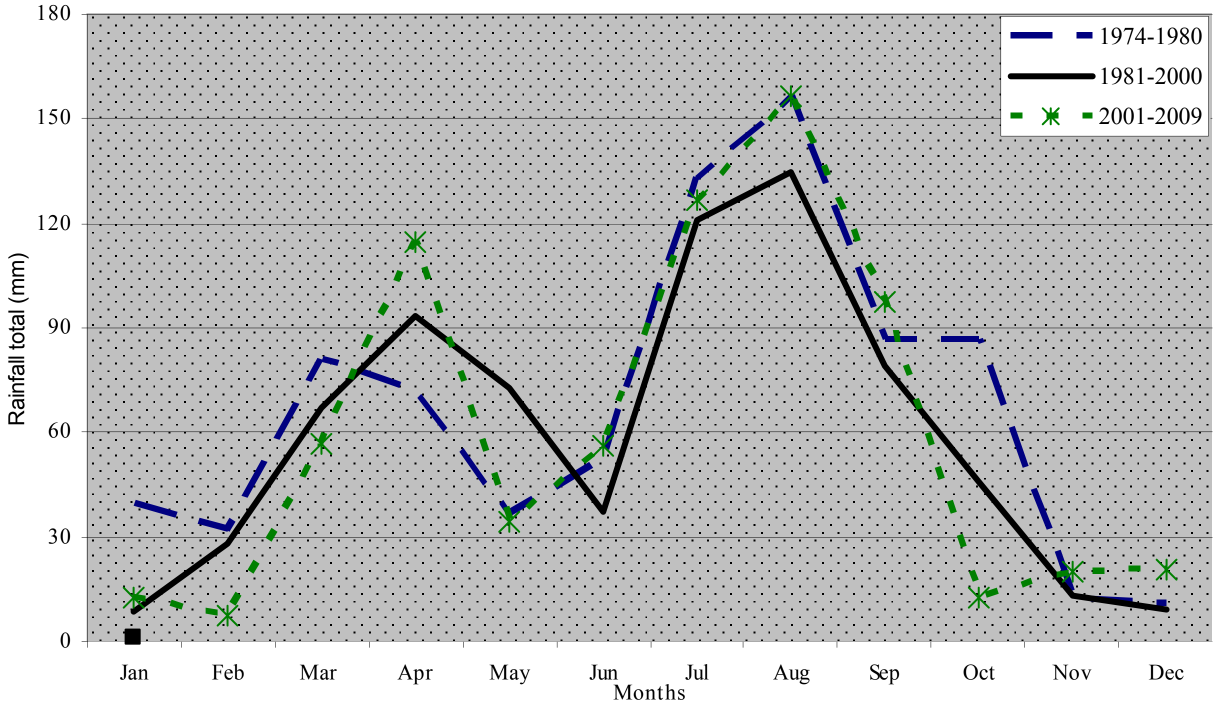

Figure 4. Monthly rainfall trend in the study area.

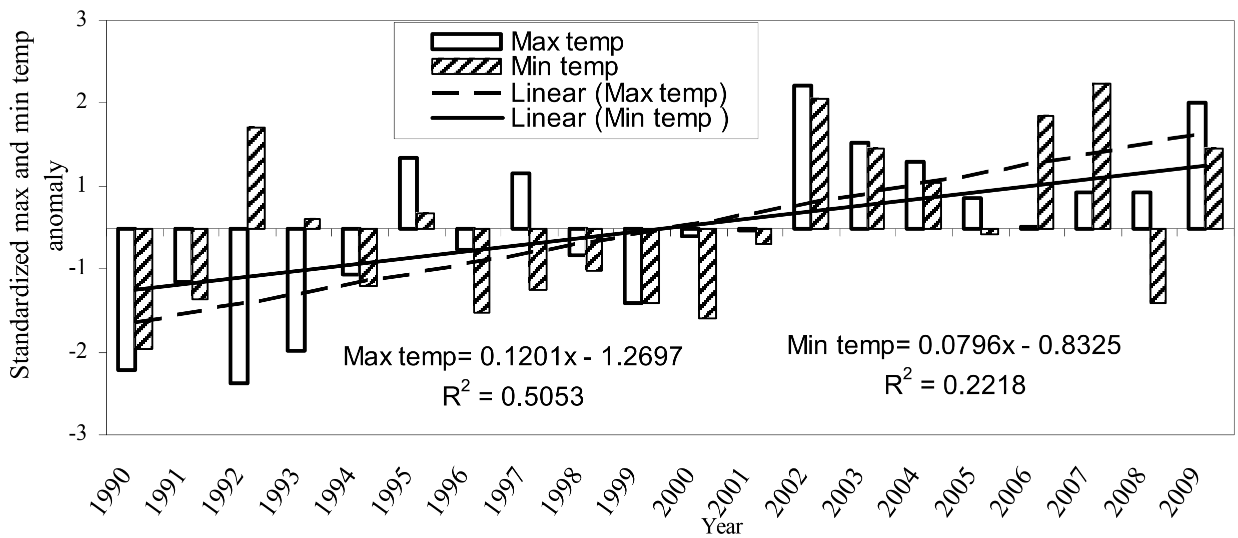

Figure 5. Annual average minimum and maximum temperature trend at Miesso.

statistical record of temperature data (Figure 5). This apart, most of the respondents perceived a shift in onset dates of rainfall, early cessation of rainfall (57%) and erratic rainfall distribution (41%). This corroborated the findings of Mengistu (2011) and Belaineh et al. (2012) which showed awareness of farmers to increased temperature, changes in timing of rains and frequent drought than it was before in central Tigray and Western Hararghe of Ethiopia.

Generally, using their indigenous knowledge and longer years of farming experience, majority of the respondents interviewed had a clear awareness of changing climate. The majority of respondents' awareness on increasing temperature could be attributed to the fact that more experienced sorghum growing farmers were selected as respondents for this study. Similar results were reported

Table 1. Farmers perception of major causes of change in climate patterns.

Variable	Percent of respondents*		Total
	Technology Adopters	Non technology adopters	
Gods anger	61.2	76.9	66.7
Deforestation	69.4	53.8	64.0
Increased population pressure	10.2	23.1	14.7
Burning fossil fuel	4.1	3.8	4.0
Concentration of greenhouse gases in the atmosphere	0	0	0

*Percentages do not add up to 100% because of multiple responses.

Table 2. Farmers' perception of risks (consequences) of climate variability and change.

Variable	Percent of respondents*	
	Serious problem	Very serious
Frequent total crop failures	4.0	96.0
New pattern of diseases and pests of crops	4.0	96.0
Appearance of new weed species	42.7	57.3
Shortage of feed for animals	5.3	94.7
Water scarcity or shortage	25.3	74.7
Loss of biodiversity and forest resources	9.3	90.6
Increased soil degradation (fertility and erosion)	48.0	52.0

*Percentages do not add up to 100% because of multiple responses.

in South Africa and Nigeria in that farmers with more farming experience perceived changes in climate as compared to their less experienced counterpart (Maddison, 2006; Ishaya and Abeje, 2008; Gbetibouo and Ringler, 2009).

Farmers' perception on causes of climate change

About 66.7% of respondents (61% technology adopters and 77% of non adopters) were convinced that the vagaries of climate were a sign of divine anger, that is, punishment from God (Table 1). For example, drought with serious consequences and diseases epidemic to crops and humans, and regular crop infestation by pests were God's punishment. Likewise, most of the respondents (64%) believed that changes in climate patterns were mainly attributed to deforestation (tree cutting and environmental destruction) by the communities, either for short-term economic gains or an attempt to expand arable land. For instance, one of the respondents (Code GR-15) detailed changes in rainfall pattern linked with forest resources as follows: 'Forests attract wind; winds hold (attract) rain; rain comes from mountains and forested areas to other places'. Hence, he concluded that deforestation is the major factor causing climate changes'. Ishaya and Abeje (2008) reported that majority of farmers attributed climate changes to human activities such as deforestation (cutting trees for fuel, roofing and farm land extension).

On the other hand, 14.7% of respondents stated that increased human population that put mounting pressure on natural resources was a major cause of changes in climate patterns. Likewise, 4.1% of technology adopters and 3.8% of non-adopter farmers indicated that fossil fuel burning which comes from other areas or industrialized countries was the cause of climate change at and around the area. This result is in line with the study conducted by Manyatsi et al. (2010) in that a significant number of respondents did not provide any scientifically proven cause of climate change.

Consequences of climate variability and change

Farmers in Miesso areas noted high infestation of crops by new patterns of diseases such as head smut (*Sphacelotheca sorghi*), leaf blights (*Exserohilum turcicum*) and pests such as shoot fly (*Atherigona soccata*) and frequent total crop failures due to reduced rainfall amount, changes in timing of onset of rains and high temperature (Table 2). Increased pest damage may arise from changes in production system and production of crops in warmers climatic regions where plants are

Table 3. Diversity of crops grown by farmers at Miesso over the last 50 years.

Period	Diversity of crops grown (number)		
	Maximum	Minimum	Mean
1960-1980	10	2	5
1981-2000	10^{+++}	1	4
2001-2007	5^{++}	1	3^{+}
2008- recent	4***	1*	2**

*Sorghum (*Sorghum bicolar*); **Sorghum and maize (*Zea mays*); ***Sorghum, maize, sesame (*sesam umindicum*) and soybean (*Glycine max*); + Sorghum, maize and sesame; ++Sorghum, maize, sesame, soybean and tef (*Eragrostis tef*); +++Sorghum, maize, barley (*Hordeum vulgare*), tef, sesame, lentil (*Lens culinaris*), soybean, wheat (*Triticum aestivum*), linseed (*Linum usitatissimum*) and cowpea (*Vigna unguiculata*).

more susceptible to pests (Mary and Majule, 2009). In addition, the local farmers observed various forms of crop infestations with new weed species that reduced the quality and quantity of crops produced. Moreover, many respondents mentioned shortage of feed for animal as a very serious effect of climate variability and change that caused loss and weakness of oxen (Table 2).

Furthermore, the majority of respondents perceived water shortage, great loss of biodiversity and forest resources through excessive de-forestation, and decline in soil fertility as the most important effects of climate variability and climate change. Generally, the outcome shows the sensitivity of social, economic and environment aspects of Meisso farmers (Table 2) to the impacts of climate variability and change. Hence, the interplay between the above climate variability and change consequences and its direct adverse effect on crop yields are the source of vulnerability of production system the farmers at Miesso faced.

Changes in crop diversity (1960-2009)

The majority of farmers revealed that they have switched over to cultivation of only two crops (sorghum and maize) out of diverse types of crops they were earlier cultivating as a result of change in climate patterns (Table 3). Due to losses in climate events that were repeated over time, capacity of crops to maintain productivity has reduced resulting in the withdrawal of crops from production systems. For the different peasant associations assessed, the farmers also recognized that different crops and some species of sorghum (land race or local varieties) are no longer being farmed due to the negative effects of climate variability and change on the productivity of the crops (Table 3).

Changes in farming practices due to climate change

As a result of negative impacts of change in climate patterns, 93% of the respondents changed farming practices. Most of the farmers revealed that decreased tillage frequency, increased frequency of weeding and increased seed rate are practiced in recent periods than before (Table 4). The majority of farmers associate the decrease in tillage frequency with drought and delay in onset of rain as land becomes dry and difficult to plough and feed shortage leads to oxen weakness. Greater use of seed rate is attributed to recover damaged crops due to lack of precipitation which hinders germination of cultivated seeds. Moreover, the highest proportion of households with crop production in their farming portfolio chose not to use farm inputs (fertilizer, herbicides and pesticides). According to the respondents, this situation has resulted in a good opportunity for weeds to stay on cropping land, out compete crops and increased frequency of weeding.

The other farm practice changed include, intercropping, crop rotations and fallowing (Table 4). The increase in fallowing practice is attributed to frequent drought and power shortage. As a result of the impacts of climate change, most of the farmers showed the tendency to allocate more lands to improved sorghum varieties (drought tolerant or early maturing) than local varieties in the 2000s. These findings are in line with a study by Lema and Majule (2009) in semi-arid zone of Tanzania, who reported that farmers adopted tillage methods and other agronomic practices in the face of climate variability and changes risks in order to maximize yield.

Source of climate information

More than 97% of the respondents rated climate information availability from high to very high to their day to day activities. However, the majority of farmers did not have adequate information on climate variability and change for farm level decision making. The limited climate information accessible to farmers was through radio in the form of daily weather forecast (Figure 6). But, the farmers indicated that they did not trust the weather information dispatched through radio. The feeling of the farmers was that the weather information broadcast by radio was not specific to their location or region.The farmers also indicated that at times the season was forecast as good and they invested high in terms of inputs but later it turns out a dry season. The other sources of climate information used include expecting from God (32%), religious leaders and neighbors (4%), and market and radio (9%) (Figure 6).

Adaptations to climate variability and change

Adaptation measures and practices followed by Meisso farmers to combat the adverse effects of climate variability and change over the last fifty years are mostly followed as one or in combination with another measure.

Table 4. Changes to farming practices at Miesso over the last 50 years*

Cropping practice	1960-1980	1981-2000	2001-2007	2008/09
Frequency of tillage	H	H	L	L
Frequency of weeding	L	L	H	H
Fertilizer application	N	N	N	N
Mulches	H	H	H	L
Intercropping	H	H	L	L
Seed rate (kg/hectare)	L	L	H	H
Crop rotation	N	N	L	L
Fallowing	N	N	N	H
Pesticides and herbicides	N	N	N	N
Use of improved seed	N	N	H	H

H = High; L = low; N = Not practiced (used); * = the data are based on the highest percentage of respondents.

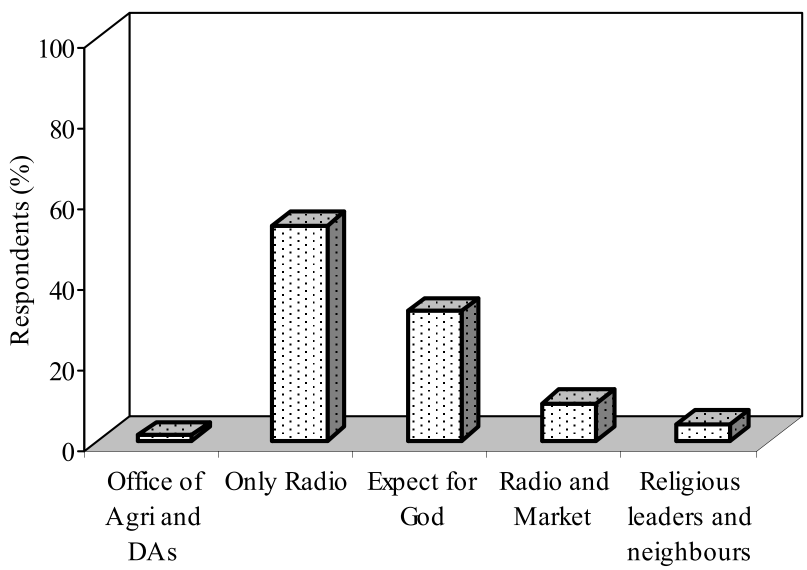

Figure 6. Source of climate information to farmers in Miesso area.

Despite the fact that, livelihood adaptation strategies chosen are not free from constraints a combination of several strategies are used by farmers to cope with the impacts of climate change (Belaineh et al., 2012). They are grouped as agronomic or crop management, technology adoption and promotion activities, and livelihood adaptation strategies (Table 5).

The dominant adaptation systems are using different planting dates (86.7%) and on farm soil and water conservation practices (80%). The greater shifting of planting dates was for the purpose of reducing the risks of crop damage during germination due to dry spells soon after sowing. Likewise, Komba and Muchapondwa (2012) reported that large size owned farmers preferred crop and variety diversification than planting dates to easily spread climate change risks. The use of on farm soil and water conservation practices as an adaptation method is associated with the efficient use of scarce rainfall received over the area. Other adaptation strategies practiced by farmers include application of fertilizers and chemicals (4%) and water harvesting techniques for supplemental irrigation (34.7%). The low use of fertilizers, chemicals and water harvesting techniques as on farm adaptation mechanism could be due to the fact that these practices require high capital investment. The results of farmers agronomic adaptation strategies practiced by Miesso farmers are similar to autonomous adaptation strategies reported by FAO (2007) and Hassan and Nhemachena (2008), which were carried out in response to or in anticipation to changing climate patterns.

Since crop cultivation is the dominant livelihood strategy of farmers, growing of local/land race cultivars

Table 5. Types of climate variability and change adaptation strategies used by farmers in Meisso.

	Adopter (%)*	Non-adopter (%)	Total (%)
A. Agronomic or crop management			
Use of different planting dates	89.8	80.8	86.7
Use of fertilizers and chemical	6.1	-	4.0
Use of on farm soil and water conservation practices	81.6	76.9	80
Use of water harvesting techniques for supplemental irrigation	38.8	26.9	34.7
B. Technology adoption			
Use of local/land race varieties	81.6	92.3	85.3
Use of drought resistant varieties	59.2	19.2	45.3
Use of early maturing varieties	73.5	26.9	57.3
C. Livelihood adaptation options			
Changing from farming to non-farming	10.2	38.5	20.0
Move to different site	10.2	7.7	9.3
Use of credit	18.4	7.7	14.7

*Percentages do not add up to 100% due to multiple responses.

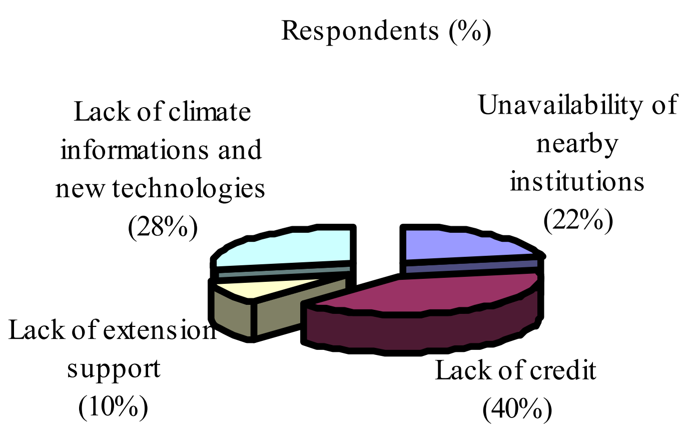

Figure 7. Constraints that hinder climate variability and change adaptation of farmers in Miesso area.

(85.3%) is one of the adaptation option for climate variability and change. Greater use of local varieties is associated with their use as animal feed resources during severe droughts because of their good fodder quality and productivity. The use of drought resistant varieties (45.3%) and early maturing crop varieties (57.3%) are other adaptation strategies practiced by farmers. Planting short season and drought resistant crop varieties increases the chances of successful harvests despite adverse climatic conditions (Mano and Nhemachena, 2006). These adaptation mechanisms are in line with the adaptation practices reported by Cox et al. (2008). Livelihood diversification (shift from farming to non-farming such as charcoal making, firewood sale) was one of the most commonly used adaptation methods by the farmers (Table 5), whereas temporary migration (9.3%) to other places was the rarely practiced adaptation method during severe conditions. Likewise, 14.7% of respondents used credit (from government or local lenders) as an adaptation strategy against the shocks of changing climate patterns to recover and develop resilience for the next event (s). Similar adaptation strategies were reported from various studies conducted in Ethiopa, Zimbabwe, South Africa and Nigeria (Mano and Nhemachena, 2006; Hassan and Nhemachena, 2008; Deressa et al., 2009; Mengistu, 2011; Belaineh et al., 2012). The proportion of technology adopter farmers that use the adaptation mechanisms is almost equal to the proportion of non-adopter farmers except the high proportion of technology adopters in using early and drought resistant crop varieties.

Major constraints to adaptation

The survey results indicate that, there are four major constraints to climate variability and change adaptation by sorghum farmers in Miesso area. These are unavailability of nearby supporting organizations (that provide technologies, farm inputs, information related to farm activities and climate), lack of credit, lack of support from extension workers and lack of climate information and new technologies (Figure 7).

Lack of credit for input purchase (improved seed, fertilizer, chemicals) is the prominent constraint to adapting climate variability and change effects. This result is in line with the survey carried out across Africa by Maddison (2006), where 33% of respondents in Ethiopia reported lack of credit as the main constraint to adapting to climate change. Lack of information on climate and new technologies is the second main barrier to adaptation in Miesso. This is also related to week support from extension and research in the provision of up-to-date information and technologies.

Summary and recommendation

The analysis of perception of farmers on climate variability and change indicated that the majority of farmers were aware of a decline in rainfall amount, increasing temperature, shift in onset dates of rainfall, early withdrawal of rains and frequent drought occurrence. As a result, majority of farmers indicated decreasing diversity of cultivated crops, changes in farming practices and reduction in crop yields due to changes in climate patterns in their area. Production of drought or heat tolerant crop cultivars with optimum maturity periods are recommended to offset the adverse effects of increasing temperature. Moreover, introduction of new crops, varieties and crop management practices that goes in line with the changing climate patterns should be the prior agenda for research and development planners in order to arrest declining diversity of crop grown in the area due to climate change. Additional advantage can be achieved by the distribution of pamphlets containing weather and climate information prepared by Ethiopian weather service. The farmers should be encouraged to stabilize their family size.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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