Farmers' Perceptions of Climate Change and Its Agricultural Impacts in the Abay and Baro-Akobo River Basins, Ethiopia

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Abstract

This article presents an assessment of farmers' perceptions of climate change and its agricultural impacts in the Ethiopian portion of the Nile and Baro-Akobo river basins. A total of 500 randomly selected households were interviewed from 15 kebeles in five woredas, three each from dega, woina-dega and kolla agro-ecological zones. In addition, focus group discussions and key informant interviews were conducted in each kebele. Descriptive statistics and χ^2 and F tests were used to summarize quantitative data, while qualitative data were organized and used to augment the quantitative analysis. Results indicate that a majority of farmers perceived climate change as manifested in temperature and rainfall changes, over the past two to three decades. Regarding agricultural impacts, 77% of respondents stated having observed reduction in crop production while 60% observed reduction in the length of crop growing period. Similarly, 79%, 62% and 44% of respondents perceived increased incidence of insects, plant diseases, and weeds, respectively. Also, about 59% of the respondents perceived shift of suitable areas for major crops. The belg season production, in the traditionally belg growing areas, has been almost totally abandoned. A higher proportion of households in dega and kolla areas perceived negative agricultural impacts as compared to those in woina-dega, the difference being statistically significant. Similarly, statistically significant gender-based differences were observed in perception of climate change and its agricultural impacts, where the proportion of females perceiving climate change was lower than that of males. It is concluded that there is a need for identification and promotion of community-based adaptation measures that take into account local perceptions and knowledge of climate change and its multiple impacts.

Keywords: climate change, agriculture, perceptions, Ethiopia

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Introduction

Available scientific evidences now converge that human-induced climate change is happening (IPCC, 2007), and it is apparently the greatest threat the world is presently facing. Climatic records elsewhere have already revealed some characteristics of climate change such as increased temperatures and frequent extreme weather events (IPCC, 2001; 2007). The impacts of climate change will be of multiple dimensions ranging from impacts on environmental goods and services to direct impacts on human health and wellbeing. All environments and societies will be affected in one way or another. The severity of impacts will however depend strongly upon the existing environmental, demographic, social, economic, governance and other factors that collectively determine exposure, sensitivity and capacity to resist, cope with, adapt to and recover from the effects. In general, the poor developing countries of Africa are among the most vulnerable to experience the worst of climate change impacts. This is because the majority of their populations are dependent on economic activities that are highly exposed and extremely sensitive to climatic variability, and national adaptive capacities are very low due to abysmal poverty and unfavourable and deteriorating environmental conditions (IPCC, 2007; Woldeamlak, 2009; Gete *et al.,* 2010). Ethiopia, the second most populous country in Africa, is one of these countries, vulnerable to be hit hardest by climate change. A recent mapping of climate vulnerability and poverty in Africa has put Ethiopia as one of the countries most vulnerable to climate change with the least capacity to respond (Thornthon *et al.,* 2006).

Given the structure of the national economy where small-scale agriculture constitutes its backbone, climate extremes of particular significance to Ethiopia are variations in rainfall and associated droughts. Drought has historically been a trigger of famine in the country. Even though rainfall variability and droughts are not new phenomena in Ethiopia, there is now a widespread public perception (Markos, 1997; Mulat, 2004) and scientific evidence in some parts of the country (Ketema, 1999; Aklilu and Alebachew, 2009; Gete *et al.,* 2010) that it has become more frequent. Floods, which have not been major problems in Ethiopia, are now becoming significant problems in some parts of the country. For instance, in 2006 the eastern and south-western parts experienced one of the most devastating floods in the modern history of the country. Because of those extreme events, more than 250 people lost their lives, about 250 people remained unaccounted for and more than 10,000 people were made homeless in Dire Dawa (eastern part), while more than 364 people were killed and about 8,350 people were displaced in South Omo area (south-western part) (NMA 2007). Climate change is predicted to lead to a more frequent occurrence of hydrological extremes (droughts and floods) and thereby increased incidence of hazards that can lead to loss of lives and livelihoods.

Nevertheless, there is no sufficient research evidence as to whether or not climate change is perceived as a major problem or even a reality by the Ethiopian public, particularly by the poor and most vulnerable farmers in the rural areas. The only available published materials, as far as is known to the authors, that partly cover climate change perceptions are studies by Meze-Hausken (2004), Mahmud *et al.* (2008), Aklilu and Alebachew (2009), and Temesgen *et al.*, (2009). Meze-Hausken (2004) studied in southern Tigray and northern Afar regions and found that farmers perceived 'a loss of the *belg* rains (short rainy season, March to April) and a shorter *kiremt* season (long rainy season, June to September)' since 'their fathers' time' (20–30 years ago). The study by Aklilu and Alebachew (2009), conducted in the southern lowlands of the country, found that 88% and 93% of respondents (n = 359) perceived decrease in rainfall and number of rainy days, respectively. Similarly, 93% of the respondents perceived increase in mean temperatures. The other two studies (Mahmud *et al.*, 2008 and Temesgen *et al.*, 2009), which are based on a survey of 1,000 households in 20 districts (*woredas*) in the Nile Basin of Ethiopia, reported that the predominant perceptions are increased temperatures and declining precipitations since 20 years ago.

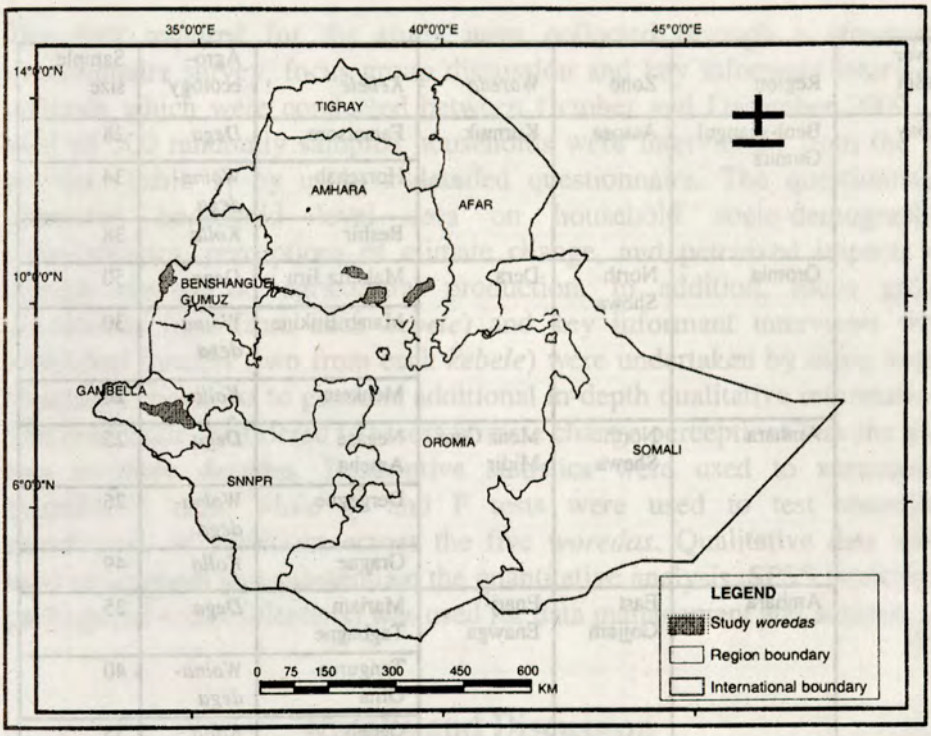
Perceptions of climate change may affect how people respond and adapt to its multiple impacts. In other words, it is the perceived changes that are likely to motivate for adaptive actions. Similarly, understanding local perceptions of climate change and building consensus on the reality of its impacts are important to implement appropriate community-based adaptation strategies. This paper presents an assessment of farmers' awareness and perceptions of climate change and its agricultural impacts in parts of the Ethiopian portion of the Nile river basin. The specific objectives are (i) to assess perceptions on the realities of climate change and its agricultural impacts, and (ii) to identify differences in climate change perceptions by gender and agro-ecological or livelihood zones. Such a study is useful to identify effective community-based adaptation options for improved outcomes and also has benefits for mainstreaming climate change issues in designing and implementing community development projects and programs.

Data and Methods

Study Area and Sampling

The study was conducted in the Abay and Baro-Akobo river basins of Ethiopia, which are two of the three major river basins that constitute the Ethiopian portion of the Nile basin. The specific study sites within the two basins cover five *woredas* (districts) and 15 *kebeles* that were selected by a multi-stage sampling procedure that combined purposive and random sampling methods. Purposive sampling was employed to select the five *woredas* by considering historical occurrence of droughts and/or floods (to include areas frequently affected) and importance of *belg* production (to include areas traditionally producing crops during the *belg* season), as some studies have documented that many *belg* producing areas are significantly affected by climate change (Riché *et al.,* 2009; Oxfam International, 2010). In other words, areas frequently affected by current climate extremes, which may be called 'climate hotspots', were purposively selected. Then, three *kebeles* were selected from each *woreda*, one each from the three major traditional agro-ecological zones of *dega* (cool temperate) *woina-dega* (temperate) and *kolla* (hot lowland). A simple random sampling method was then employed to select 100 households from the three *kebeles* in each *woreda*, the number of sample households from each *kebele* being determined to be proportional to population size. Figure 1 shows the location of the study *woredas*, and Table 1 presents some details about the study sites.

Figure 1. Location of the study *woredas*



Source: Authors' own construction, December 2009

The farming systems in the study areas are generally typical of the traditional mixed farming systems that are found in many parts of the country, where livestock provide the draught power, crop residues are important sources of livestock feed, and household members provide the labour required for production. The major crops cultivated include *teff*, maize, wheat, barley, and millet among cereals and faba bean, field pea and chickpea among pulses. Crop production is almost entirely rain-fed, excepting very small areas around homesteads under traditional irrigation in some of the study *kebeles*. Rainfall variability is a major constraint to agricultural production, and drought is a frequent hazard. Food insecurity is a widespread phenomenon in parts of the study areas.

Table 1. Sample size by river basin, *woreda* and *kebele*

River basin	Region	Zone	*Woreda*	*Kebele*	Agro-ecology[1]	Sample size
Abay	Beni-shangul Gumuz	Assosa	Kurmuk	Famatsore	*Dega*	28
				Horzehab	*Woina-dega*	34
				Beshir	*Kolla*	38
	Oromia	North Shewa	Dera	Makefta Jiru	*Dega*	50
				Mamo Bukine	*Woina-dega*	30
				Menketa	*Kolla*	20
	Amhara	North Shewa	Menz Gera Midir	Negase Ameba	*Dega*	25
				Dergegne	*Woina-dega*	26
				Gragne	*Kolla*	49
	Amhara	East Gojjam	Enarj-Enawga	Mariam Tagbagne	*Dega*	25
				Tenguma Ofna	*Woina-dega*	40
				Gedeb	*Kolla*	35
Baro-Akobo	Gambella	Gambella	Abobo	Tenji	*Dega*	25
				Mender 14	*Woina-dega*	35
				Mender 17	*Kolla*	40

[1] Agro-ecology refers to the traditional zonation based on altitude and temperature; *Dega* is equivalent to cool temperate, *woina-dega* is temperate and *kolla* is hot lowland.

Source: Authors' field survey, December 2009

Data Collection and Analysis

The data required for the study were collected through a structured questionnaire survey, focus group discussion and key informant interview methods which were conducted between October and December 2009. A total of 500 randomly sampled households were interviewed from the 15 *kebeles* (Table 1) by using a detailed questionnaire. The questionnaire generated household level data on household socio-demographic characteristics, perceptions of climate change, and perceived impacts of climate change on agricultural production. In addition, focus group discussions (one from each *kebele*) and key informant interviews with individual farmers (two from each *kebele*) were undertaken by using semi-structured checklists to generate additional in-depth qualitative information. The timeframe considered to assess climate change perceptions was the past two to three decades. Descriptive statistics were used to summarize quantitative data, while χ^2 and F tests were used to test statistical significance of variations across the five *woredas*. Qualitative data were used to augment and substantiate the quantitative analysis. SPSS (statistical package for social scientists) was used for data management and analysis.

Results and Discussion

Socio-demographic Characteristics

Table 2 shows age, sex and educational composition of heads of households sampled. In all areas, male-headed households were dominant with over 90% representation. The average age of household heads was about 42 years, and the average level of educational attainment among household heads was about 2.5 years of formal education. In both indicators, there is a significant difference among households in the sample *woredas*. Family size and its composition also showed significant differences among households in the five *woredas*. The largest average family size was found in Kurmuk and the smallest in Abobo, which is partly associated with the average age of household heads in Abobo (about 37 years). The dependency ratio was also the highest in Kurmuk, which was about 46% (data not shown here).

Table 2. Distribution of sample household heads by age, sex and educational level

Variable	Indicator	Woreda					Total	χ^2 value
		Enarj-Enawga	Menz Gera Midir	Dera	Kurmuk	Abobo		
Sex of HH head (%)	Male	91	90	94	92	92	92	1.17
	Female	9	10	6	8	8	8	
Age of HH head (years)	Mean	42.2	45.5	44.4	40.5	37.4	42.0	6.17***
	Std	12.3	13.5	12.4	15.4	10.3	13.2	
Education level of HH head (years)	Mean	1.4	2.5	1.9	2.8	3.7	2.5	9.77***
	Std	2.4	2.9	2.2	3.3	3.3	2.9	
Total number of family members	Mean	5.6	5.2	5.7	6.8	5.1	5.7	5.99***
	Std	2.6	2.2	1.9	4.5	1.9	2.9	

***Significant at 1%

Source: Authors' field survey, December 2009

Livelihood Assets

Land and livestock are the key livelihood assets to people in the study areas. Ownership of these important resources among the sample households is summarized in Table 3. The average livestock ownership is about 5 TLUs (Tropical Livestock Unit) with a range from 2.2 TLUs in Kurmuk to 6.7 TLUs in Menz Gera Midir. Oxen are mainly kept for draught power, and they are traditionally used as indicators of household wealth status. The mean number of oxen owned across the *woredas* was less than a pair, which may be considered as a minimum required for a household. In Dera and Enarj-Enawga, households owned on average more than an ox. Regarding cultivated land, households in Dera, Kurmuk and Abobo *woredas* possessed, on average, slightly more than 2.0 ha of land, whereas it is less than 1.5 ha in Enarj-Enawga. There was a statistically significant difference in resource ownership among households in the five *woredas*. No significant difference was found in terms of access to irrigated land.

Table 3. Resource ownership among the surveyed households in the five *woredas*

Variable	Indicator	Enarj Enawga	Menz Gera Midir	Dera	Kurmuk	Abobo	Total	F-value
Livestock (TLU)	Mean	3.83	6.7	5.96	2.22	4.56	4.65	11.17*
	Std	3.02	7.17	5.84	3.24	5.88	5.5	
Oxen (number)	Mean	1.1	0.68	1.42	0.06	0.85	0.82	27.91*
	Std	0.87	0.78	1.08	0.6	1.32	1.06	
Rain-fed cultivated land (ha)	Mean	1.29	1.36	2.38	2.26	2.33	1.92	14.64*
	Std	0.83	1.1	1.8	1.64	1.56	1.51	
Irrigated land (ha)	Mean	0.06	0.04	0	0.03	-	0.03	0.74
	Std	0.6	0.17	0.03	0.3	-	0.31	
Total cultivated land (ha)	Mean	1.35	1.4	2.31	2.29	2.33	1.94	12.02*
	Std	1	1.12	1.82	1.68	1.56	1.54	

*Significant at 1%; TLU is calculated based on Kossila, 1988

Source: Authors' field survey, December 2009

Household income sources

Expectedly, the dominant income source is crop production followed by livestock production in the study areas (Table 4). Petty trade and casual labour were also important sources of income in all of the sites. Food or cash for work was important in Menz Gera Midir and Abobo, where 26% and 19% of households reported to have participated in food or cash for work programs, respectively.

Table 4. Household income sources in the study areas (% of respondents)

Income sources	Enarj-Enawga	Menz Gera Midir	Dera	Kurmuk	Abobo	Total	χ^2 value
Crop production	99.0	96.0	97.0	100.0	100.0	98.4	8.38
Livestock production	68.0	81.8	70.0	77.0	70.0	73.3	6.93
Food- or cash-for-work	-	26.0	-	-	19.0	9.0	77.17*
Casual labour	5.0	5.0	3.0	12.0	16.0	8.2	16.31*
Petty trade	12.0	3.0	9.0	9.0	6.0	7.8	6.51

*Significant at 1%

Note: Crop and livestock production are farm incomes and others are non-farm income sources.

Source: Authors' field survey, December 2009

Perceptions of Climate Change and Its Agricultural Impacts

Perceptions of Climate Change

Table 5 presents a summary of perceived changes in local climates as expressed in terms of changes in temperature trends, rainfall patterns, and frequency of droughts and floods. It is shown that about 89% of respondents perceived a change in temperature over the last two to three decades, without a significant difference among households in the five *woredas*. However, the direction of perceived changes varied, where 82% of respondents perceived increase in temperature while the remaining 18% perceived either decrease or fluctuating patterns. Regarding rainfall, about 96% of respondents stated that they noticed changes in rainfall. About 96% perceived overall shortage of rainfall; 97% believed that it came late and ended early, 79% perceived that it came late and with dry spells, and 22% felt that it came late but occurred with high intensities. A similar finding was reported by previous studies (Meze-Hausken, 2004; Mahmud *et al.*, 2008; Aklilu and Alebachew, 2009; Temesgen *et al.*, 2009).

Mahmud *et al.* (2008) reported that about 68% of respondents (n = 1,000) in the Ethiopian Nile basin perceived mean temperature to have increased, and 62% of respondents perceived mean annual rainfall to have declined over the a twenty-year period. Increased temperature and declining rainfall were reported to be the predominant perceptions among their surveyed households (Mahmud *et al.*, 2008). Similarly, in her study conducted in southern Tigray and northern Afar regions, Meze-Hausken (2004) found that farmers perceived a loss of the *belg* rains and shortening of the *kiremt* rains over a 20 to 30 year period. Temesgen *et al.*, (2009) also concluded that a majority of respondents covered by their survey (n = 1,000) in the Nile basin of Ethiopia were aware of climate change. The perceptions of increased temperature are also in agreement with meteorological records (NMA, 2007).

Table 5. Perceived changes in climatic elements and related hazards (% of respondents)

Indicators	Enarj-Enawga	Menz Gera Midir	Dera	Kurmuk	Abobo	Total	χ^2 /F-value
Notices change in temperature in ~20-30 yrs	89	91	91	91	85	89	2.87
Increased	82	69	78	82	98	82	56.27*
Decreased	2	8	2	15	2	6	
Fluctuated	16	23	20	2		12	
Notices change in rainfall pattern in ~20-30 yrs	95	99	99	94	91	96	11.22**
Comes late and ends early	100	95	100	95	96	97	9.95**
Comes late and with dry spells	71	98	85	69	74	79	35.28*
Overall shortage of rainfall	99	98	98	95	89	96	15.45*
Comes late and with high intensities	36	33	27	6	4	22	49.72*
Notices change in drought frequency in ~20-30 yrs	80	99	81	56	37	71	112.99*

Table 5 … cont'd

Drought recurrence interval ~20-30 yrs ago	Mean	5.63	5.91	7.21	8.23	7.30	6.66	3.58*
	Std	2.61	2.61	3.33	10.02	2.00	4.79	
	N	80	99	81	56	37	353	
Drought recurrence interval in recent years	Mean	1.89	1.45	1.75	4.46	2.92	2.25	109.58*
	Std	0.91	0.67	0.77	0.89	1.69	1.40	
	N	80	99	80	56	37	352	
Notices change in flood frequency in ~20-30 yrs		33	17	23	4	1	16	54.27*
Flood recurrence interval ~20-30 yrs ago	Mean	5.24	4.18	4.05	4.75	0	4.74	1.94
	Std	3.75	2.77	2.48	0.50	0	3.22	
	N	34	17	21	4	0	77	
Flood recurrence interval in recent years	Mean	4.09	2.47	1.48	5.00	0	3.29	5.52*
	Std	6.70	1.55	0.93	0	0	5.10	
	N	33	17	21	4	0	76	

*Significant at 1%; **significant at 5%

Source: From authors field survey, December 2009

Concerning droughts and floods, recurrence intervals appear to have shortened over the period considered in the study. On average, drought occurrence was perceived to have changed from once in about seven years to once in about less than three years. Similarly, floods occurred- as perceived by respondents- once in about five years some two to three decades ago, but increased to about once in three years presently (Table 5). Frequent occurrence of the extreme events of droughts and floods is known to be one of the major manifestations of the global climate change (IPCC 2001; 2007).

Perceived Impacts of Climate Change on Agricultural Production

Agricultural impacts of climate change are generally multifaceted. Impacts on crop production can occur due to one or more of the following: changes in spatiotemporal distribution of rainfall, soil moisture availability, length of growing period, incidence of pests and diseases, and shift in suitable growing areas. Impacts on livestock production are mainly through changes in availability of feed and water, and incidence of diseases, in addition to the direct impacts of climatic extremes. Farmers' perceptions of climate change impacts on agricultural production in the study areas are shown in Table 6. As it is shown, a large majority of respondents perceived considerable reduction in crop production (77% of respondents). Similarly, 60% of respondents observed reduction in the length of crop growing period. Change in suitable growing areas for the major crops was also mentioned by some 59% of respondents, which has forced them to change types of crops cultivated and/ or required investments on land management to maintain food production. Of respondents perceiving shift in suitable crop growing areas, about 76% reported changing types of crops produced and about 79% reported investing more on soil and water conservation in their farmlands (data not shown in the table). Obviously, any change in the crop growing period and/or suitable crop growing areas has significant implications to household food security and rural livelihoods in the areas studied. Meze-Hausken (2004) also found that respondents in the North Afar zone perceived shortened main rainy season over a three decades period considered in her study.

Regarding incidence of agricultural pests and diseases, which is one of the manifestations of climate change impacts, some 79%, 62%, 47%, and 44% of respondents perceived increased incidence of insects, plant diseases, animal diseases, and weeds, respectively. These findings were also corroborated by information from individual interviews with key informants and focus group discussions (Box I). The variations across the five *woredas* in terms of perceived impacts of climate change on agricultural production are all statistically significant at 0.001 level of significance (Table 6). These differences likely reflect differences in experienced climate variability and its agricultural impacts, and the implication is that geographically differentiated and local-scale adaptation technologies and strategies will be required.

Table 6. Perceived impacts of climate change on agricultural production (% of respondents)

Perceived changes	Type of change	Enarj-Enawga	Menz Gera Midir	Dera	Kurmuk	Abobo	Total	χ^2 /F-value
Observed change in crop production	Increase	13	29	6	6	1	12	55.01*
	Decrease	73	68	80	89	79	77	
	Mixed/ variable	15	3	14	5	19	11	
Change in length of growing period	Longer growing period	10	28	14	-	10	14	116.43*
	Shorter growing period	65	46	76	78	48	60	
	Unreliable/variable growing period	25	26	10	2	62	26	

Table 6 … cont'd

Changes in incidence of agricultural pests and diseases		83	93	87	93	65	84	40.12*
Insects	More problematic	94	82	84	71	61	79	28.27*
	Less problematic	6	18	16	29	38	21	
Weeds	More problematic	42	20	36	73	48	44	55.98*
	Less problematic	58	79	64	27	52	56	
Crop disease	More problematic	60	73	44	66	68	62	18.79*
	Less problematic	39	27	56	34	32	38	
Livestock disease	More problematic	35	37	17	85	61	47	99.16*
	Less problematic	65	63	83	15	38	53	
Shift of suitable growing areas		87	78	70	36	26	59	118.86*

* Significant at 1%

Source: Authors' field survey, December 2009

Box I. Perceived changes in local climates and its agricultural impacts (from FGDs)

Focus group discussions conducted in Enarj Enwga, Menz Gera Midir and Dera *woredas* generated very similar responses from community members. These observations/perceived changes, as narrated by respondents, are summarized as follows:

Rainfall:

- There has been a decreasing trend in amount of rainfall, and the rainy season has become short. It often starts late and ends early. These have made production of long season crops like maize and sorghum very difficult. On the other hand, in some years unseasonable rains occur in November and destroy crops.
- Change in rainfall characteristics was also mentioned such that intense rains occur in July and August that affects crop growth.

Temperature:

- Temperature has been increasing from year to year, and particularly from November to March. Participants claimed that excessive temperature is affecting even mobility of people during day times.

Land and water:

- Water availability was said to be declining as springs dried up or became seasonal.
- Intense rainfall events occurring in July and August cause accelerated soil erosion. The high temperature during the dry season was mentioned as contributing to intense soil erosion during the wet season.

Crop and livestock production:

- In previous years, maize and sorghum were planted from mid April and harvested in November and yields were much better.
- Currently main season crops are planted in July and harvested in November. The growing season has become shorter by as much as a month.
- Poor rainfall distribution and grazing land degradation have affected livestock productivity and production.

Crop pests:

- Changes in rainfall patterns were believed to have contributed to occurrence of pests that destroy crops particularly faba bean, finger millet and chick pea. When affected by pests, even animals do not feed on the crop plants.
- New pests locally called "Jebea" and "kishkish" were mentioned as having become major problems.

Source: Authors' own construction, December 2009

Perceived Impacts of Climate Change on the *Belg* Season Production

The *belg* season (short rainy season, March to May) production is a very important component of food crop production in the country, especially in areas where rainfall is bimodal. However, previous studies reported that its importance has been declining due to climate change (Riché *et al.,* 2009; Oxfam International 2010). Out of the five *woredas* covered in this study, three (Enarj-Enawga, Menz Gera Midir and Abobo) are in the *belg* season producing parts of the country. Of the total respondents, 98%, 26% and 21% in Menz Gera Midir, Abobo, and Enarj-Enawga, respectively, used to produce crops during the *belg* season some two to three decades ago (Table 7). The corresponding figures for the time of this study were 4%, 6% and 15% of respondents in Menz Gera Midir, Abobo, and Enarj-Enawga, in order of sequence. The reasons mentioned for the sharp fall in importance of the *belg* season production included decrease in amount of *belg* rainfall (85% of respondents), shortened *belg* growing season as rain started to come late (79% of respondents), increased incidence of crop pests (54% of respondents), and lack of suitable crop varieties that can adapt to the changing *belg* production trends. Overall, 91% of respondents reported that they observed some sort of change (as detailed in Table 7) in the *belg* season production. Similar results were found from key informant interviews and focus group discussions (Box II). This finding is similar to results of previous studies that reported loss or decline in importance of the *belg* season production in parts of the country (Meze-Hausken 2004; Riché et al. 2009; Oxfam International 2010). For instance, Meze-Hausken (2004) stated that 'local people in the North Afar zone gave a clear impression that they have lost one rainy season (*belg*) since their fathers' times, over some three decades'. The significant differences among the *woredas* likely reflect differences in experienced changes in the *belg* season climate and agricultural production.

Table 7. Perceived climate change impacts on *belg* season production (% of respondents)

Indicator	Enarj	Menz	Dera	Kurmuk	Abobo	Total	χ^2 value
Used to practice *belg* production	21	98	5	-	26	30	294.57*
Perceived change in *belg* production	87	97	67	-	76	91	22.63*
Current practice of *belg* production	15	4	2	-	6	5	27.01*
Belg rains are not enough for crop production	50	93	100	-	61	85	24.11*
Belg rains started to come late	50	86	100	-	50	79	14.68*
Increased crop pest incidence	33	53	100	-	67	54	5.14
Lack of suitable crop varieties	20	53	100	-	50	52	3.94

* Significant at 1%

Source: Authors' field survey, December 2009

Box II. Perceived changes in *belg* season production (key informant interview)

Abu is a 40 year old farmer (male) in Menketa *Kebele* in Dera Woreda of Oromia Region. He has lived in the same *Kebele* all his life and is currently head of a family of eight including himself and his wife. He has attended formal education up to grade six. Over the years, he has observed several climatic and related changes in his community. It is also important to note that similar observations were gathered from focus group discussions held in the same *woreda* (Dera) as well as from key informant interviews and focus group discussions in the Menz Gera Midir of Amhara Region. The observed changes are:

- Annual amount of rainfall has decreased; duration of the rainy season has become shorter; and rainfall has become more erratic and unreliable.
- The *belg* rain has almost totally disappeared, and *belg* season crop production has since recently been abandoned. In previous times, there was adequate rainfall from February to March. The farmers in the kebele used to prefer *belg* season production, but they are now forced to shift to the *meher* season (long rainy season, June to September).
- During *meher* season as well, rainfall used to start in early June and stop by the end of September, but currently it starts in mid July and stops in August.
- Crops like *teff*, sorghum, wheat, barley and red sorghum are severely affected by the late onset and early cessation of rainfall.
- Temperature is increasing from year to year.
- Scarcity of water is increasing particularly in the lowland parts of the kebele, as springs and streams are drying up.
- Crops like chick pea, field pea, millet, and faba bean have been repeatedly destroyed by pests known locally as "Jebea." This pest has appeared as a result of changes in rainfall pattern in the area. Similarly, wheat and barley are seriously attacked by rust.

Source: Authors' own construction, December 2009

Agro-ecology-based Differences in Perceptions

It is well known that climate change is global, whereas its impacts are local, as modulated by prevailing environmental, climatic and socioeconomic conditions. Hence, community perceptions, which are reflections of local impacts, can vary with variations in agro-ecological conditions. Table 8 presents agro-ecology-based differences in perceptions of climate change and its agricultural impacts.

A higher proportion of households in *dega* and *kolla* areas perceived changes in crop growing period, incidence of agricultural pests and diseases, and shift in crop growing areas as compared to households in *woina-dega*, the difference being statistically significant. This supports scientific predictions and evidence elsewhere that climate change impacts are likely to be felt more visibly in the climatically extreme areas- cold mountains or warm and dry lowland areas, compared to those in intermediate conditions. Overall, there was a statistically significant difference in the different indicators of climate change perceptions across the three agro-ecological zones.

Table 8. Agro-ecology-based differences in perceptions of climate change and its agricultural impacts (% of respondents)

Perception	Indicators	*Dega*	*Woina-dega*	*Kolla*	Total	χ^2 value
Perception of climate change	Changes in temperature	88	86	94	89	7.33**
	Changes in rainfall pattern	93	95	99	96	7.65**
	Changes in drought frequency and severity	72	61	79	71	12.76***

Table 8 … cont'd

Impacts on crop production	Change in crop production due to climate change	92	86	92	90	3.82
	Changes in crop growing period	83	65	93	81	44.07***
	Changes in incidence of agricultural pests and diseases	91	78	84	84	9.49***
	Shift of suitable growing areas	71	39	69	59	43.59***
Impacts on *belg* production	Previous use of *belg* for crop production	32	28	30	30	0.88
	Perceived change in *belg* production	85	89	98	91	4.90*
	Current use of *belg* crop production	8	4	5	5	3.33

***significant at 1%;**significant at 5% and *significant at 10%

Source: From authors field survey, December 2009

Gender-based Differences in Perceptions

Personal attributes such as level of education, occupation, experience, and access to information influence people's perceptions of environmental changes including climate change. In the developing countries such as Ethiopia, gender-based differences in individual characteristics mentioned above are considerable. Hence, one can reasonably expect gender-based differences in perceptions of climate change and its impacts. In this study, statistically significant gender-based differences were observed in perceptions of climate change and its impacts on crop production, where the proportion of females perceiving climate change was, on average, lower than that of males (Table 9). However, perceptions related to the *belg* season production did not show statistically significant differences between female and male respondents, which is likely due to more evident changes in the *belg* season climate and agricultural production.

Table 9. Gender-based differences in perceptions of climate change and its agricultural impacts (% of respondents)

Perception	Indicators	Male	Female	Total	χ^2 value
Perceptions of climate change	Changes in temperature	90	78	89	6.07**
	Changes in rainfall pattern	96	88	96	6.45**
	Changes in drought frequency and severity	71	63	71	1.11
Impacts on crop production	Change in crop production due to climate change	91	76	90	9.38*
	Changes in crop growing period	83	59	81	13.90*
	Changes in incidence of agricultural pests and diseases	86	65	84	11.99*
	Shift of suitable growing areas	61	44	59	4.39**
Impacts on *belg* production	Perceived change in *belg* production	91	91	91	0.01
	Current use of *belg* crop production	6	5	5	0.2

*Significant at 1%; ** significant at 5%

Source: Authors' field survey, December 2009

Conclusions

The aim of this study was to assess farmers' perceptions of climate change and its agricultural impacts in rural Ethiopia. A total of 500 households from 15 *kebeles* in five *woredas* in the Abay and Baro-Akobo river basins were surveyed by using a structured questionnaire. In addition, extensive in-depth qualitative information was generated from many household heads who were key informant interviewees or focus group discussion participants. The timeframe considered was the past two to three decades. Results indicate that a large majority of farmers perceived climate change as manifested in temperature and rainfall changes. About 82% of respondents perceived increase in temperature, and some 96% perceived overall shortage of rainfall. Also, about 97% of respondents believed that rainfall currently comes late and ends early, and 22% felt that it comes late and occurs with high intensities.

Regarding agricultural impacts, 77% of respondents stated having observed considerable reduction in crop production while 60% observed reduction in the length of crop growing period. Similarly, 79%, 62%, and 44% of the respondents perceived increased incidence of insects, plant diseases, and weeds, respectively. With statistically significant difference among the five *woredas,* about 59% of respondents perceived shift of suitable areas for major crops. The *belg* season production- in *belg* producing areas- has been almost totally abandoned mainly because of shortage of rainfall. A higher proportion of households in *dega* and *kolla* areas perceived changes in crop growing period, incidence of agricultural pests and diseases, and shift in crop growing areas as compared to households in *woina-dega*, the difference being statistically significant. Similarly, statistically significant gender-based differences were observed in perceptions of climate change and its agricultural impacts, where the proportion of females perceiving climate change was, on average, lower than that of males. The statistically significant differences among the *woredas* likely reflect differences in experienced climate variability and its agricultural impacts. The implication is that a geographically differentiated and local-scale adaptation technologies and strategies will be required.

A number of findings of this study generally resonate with the earlier literature (Meze-Hausken, 2004; Mahmud *et al.,* 2008; Temesgen *et al.,* 2008; Aklilu and Alebachew, 2009; Temesgen *et al.,* 2009; Riché *et al.,* 2009; Oxfam International, 2010), and are consistent with climatic records, particularly temperature trends in the country (NMA, 2007). Climate change is already affecting agricultural production in the study areas (e.g. near total loss of *belg* season production) and thereby household food security. Hence, there is an urgent need for identification and implementation of community-based adaptation measures that take into account local community perceptions and knowledge. Some of such community-based adaptation measures and interventions include community-based integrated natural resources management, promotion of improved and suitable crop varieties, promotion of crop diversification, control of pest occurrence and damages, promotion of improved water use and productivity, and promotion of small and micro-scale irrigation. In general, there is a need for mainstreaming of climate change issues in designing and implementing local development projects and programs. It is also recommended that future research should assess farmers' indigenous practices and efforts to adapt to climate change.

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