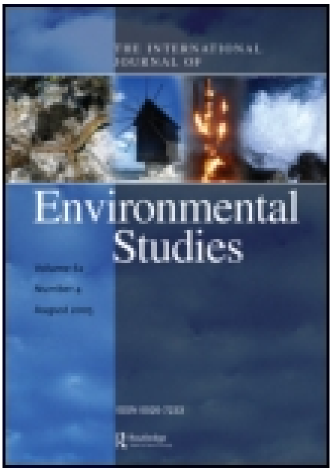

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Climate change perceptions and adaptive responses of smallholder farmers in central highlands of Ethiopia

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Climate change perceptions and adaptive responses of smallholder farmers in central highlands of Ethiopia

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This paper presents an assessment of smallholder farmers' perceptions of climate change, its impacts on agricultural production and adaptive responses in the central highlands of Ethiopia. The findings show that increased temperature and decreased rainfall are widely held perceptions; all respondents stated that they had observed increase in temperature and decrease in annual and seasonal rainfall amounts. The major impacts of climate change on local livelihoods as reported by respondents include decline in the length of growing period, increased crop damage by insects and pests, and increased severity of weed infestation. Some respondents also reported an increase in the incidence of livestock diseases. The adaptive responses by the smallholder farmers to the perceived or experienced climate change include adjustments in crop and livestock production activities, and investments in sustainable land management at household and community levels. Despite the range of autonomous adaptive responses adopted, climate change is negatively affecting smallholder agriculture, and thus rural livelihoods, in the study area, indicating the need for planned adaptation interventions.

Keywords: Climate change; Perceptions; Adaptation; Smallholders; Ethiopia

1. Introduction

Climate change is predicted to have major adverse consequences for the world's ecosystems and societies [1,2]. Although climate change is a global phenomenon, the severity of its adverse consequences will differ significantly across countries and socioeconomic groups [2]. The poor countries will suffer more and the poorest in the poor countries will suffer most. Africa is highly vulnerable to the potential impacts of climate change and Ethiopia is often cited as one of the most vulnerable and with the least capacity to respond [3]. Ethiopia already suffers from climate variability and extreme events, which have had immense social, economic, environmental and infrastructural costs [4]. For instance, interannual variation in the performance of the national economy is largely controlled by rainfall variability [5,6]. Drought is the biggest natural hazard affecting millions of people in different parts of the country almost every year. For instance, seven major droughts have occurred since the early 1980s, five of which led to famines, in addition to several localised droughts [7]. The most recent major drought was in 2002/03 when some 14.2 million

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people (over 20% of total population) needed emergency food assistance [8]. Bartel and Muller [9] indicate that the annual probability of drought occurrence is over 40% for many parts of the country. Apart from drought as such, seasonal and annual rainfall variability is a significant economic burden to Ethiopia. According to the World Bank [5], current rainfall variability costs the Ethiopian economy 38% of its growth potential.

Flood is a major problem in some flood-prone parts of the country. Major floods occurred in different parts of the country in 1988, 1993, 1994, 1995, 1996, and 2006 [7]. The 2006 flood was a major disaster; it occurred in many parts of the country and caused loss of life, property and infrastructure. For instance, infrastructure damage in Dire Dawa town (eastern Ethiopia) alone due to the 2006 flood was estimated at over 7.3 million Birr (1.0 USD ~8.40 Birr in 2006); and in Addis Ababa, estimates indicate that flood in 1994 caused loss of residential property with over 31.3 million Birr (1.0 USD ~5.88 Birr in 1994) [10]. Climate change will lead to a more frequent occurrence of such hydrological extremes and thereby an increased incidence of hazards that can lead to loss of life and livelihood.

The potential impacts of climate change in Ethiopia are superimposed on stressors such as population pressure, poverty and land degradation [11–14]. The Ethiopian population is currently estimated at 85 million; it has doubled since 1984 and it is projected to more than double by 2050 [15]. Population growth has contributed to the severe environmental degradation Ethiopia has experienced, especially in the densely populated highlands, and hence to the widespread rural poverty [16]. Ethiopia has a National Population Policy, developed in 1993, which seeks to harmonise the rate of population growth with the country's environment and socioeconomic development, by specifically aiming at reducing fertility from 7.7 children per woman to 4 by 2015 by increasing contraceptive usage from 4% in 1993 to 44% by 2015. Implementation of the policy has not been very effective however; as the government reportedly took a position that the impact of population growth on environment and development is not inherently negative or positive, but depended on the pace of economic and technological advances the country could achieve [17].

Whereas research and policy-making often consider the more dramatic hazards of floods and droughts, heavy rainstorms, strong winds and high temperatures also constitute climate hazards with more subtle impacts. Heavy rainfall events, in addition to being major causes of floods, also damage houses, infrastructure, crops and even at times cause loss of lives. Strong winds accompanying heavy rain events or occurring just beforehand often damage poorly constructed shelters in slums and squatter settlements in urban areas, including Addis Ababa city, where the urban poor are concentrated [10].

Ethiopia's National Meteorological Agency (NMA) identifies drought and flood as the major hazards in the future climate [11], and the major areas of concern are agriculture and food security [18]. Agriculture forms the backbone of the economy supporting roughly 42% GDP and 85% employment [18]. It is dominated by subsistence farmers, and is mainly rain-fed, thus highly exposed to climate variability and extremes. The major predicted impacts of climate change on Ethiopia's agriculture include frequent droughts and dry spells, shortened growing season, and increased occurrence of pests and diseases [11]. It is therefore likely that, without effective adaptation, there could be a decrease in the total area suitable for crop production and yield potential in the country. A study based on the Ricardian method predicts that net revenue per hectare will be reduced by US$177.62 and US$464.71 consequent on a unit increase in temperature during summer and winter seasons, respectively [19].

It is important to understand the nature of climate change impacts, key vulnerabilities and indigenous adaptive responses at local levels, so that there may be devised appropriate adaptation strategies at community and farm levels. 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. Similarly, local adaptive responses to climate variability and change are not well documented. Perceptions of climate change may affect how people will respond and adapt to its multiple impacts. Perceptions will affect everything.

This paper presents an assessment of climate change perceptions and adaptive responses by smallholder farmers in central highlands of Ethiopia by using *Menz Mama Midir woreda* (district) as a case study site. The specific objectives were to i) assess smallholder farmers' perceptions of climate change and its agricultural impacts, ii) describe the efforts of local people to adapt to climate variability and climate change, and iii) to recommend areas of possible interventions for climate change adaptation, with climate change mitigation benefits. The study *woreda* was selected for the research because: i) it is typical of the central highlands of the country in terms of the various environmental attributes such as topography, soils, climate, and the socioeconomic environment, and ii) no study has been carried out on the issue of climate variability and climate change and its livelihood impacts as well as coping and adaptive responses. The fact that the study is site-specific is believed to make it a valuable contribution to the much-needed local-level understanding on the problem of climate change impacts and local level responses in the country. Nevertheless, the empirical research findings are true for the conditions in much of highland Ethiopia. The following section describes the study area and methodology of the study, followed by the results and discussion in section 3. Section four presents conclusions.

2. Data and methods

2.1. Study area

The study was conducted in *Menz Mama Midir woreda* (district) in the Amhara National Regional State (figure. 1). The *woreda* covers a total area of about 102,500 ha, all of the area lying in a mountainous landscape and constituting part of the central highlands of Ethiopia. Elevation ranges from 2500 to 3500 m asl and the topographic condition is diverse. According to information from the *woreda*'s administration office, 46.7% of the *woreda* has relatively flat terrain, 27.7% is mountainous, 13.3% is characterised by undulating topography, and 12.3% is valley areas. The climatic condition in the area is generally humid. The mean annual temperature varies between 15 and 20°C and the annual rainfall varies between 1000 and 1500 mm. Highest temperatures occur between February and June, while lowest temperatures are experienced between September and November. Rainfall shows bimodal distribution, with the main rainy season between June and September, which is known as *Kiremt* or also *Meher* season, and a short rainy season between March and May, known as *Belg* season. More than 70% of the total rain falls during the *Kiremt* season.

The specific sampling sites in the *woreda* were three (out of the total 19 in the *woreda*) Rural *Kebele* Administrations (RKAs), the lowest tiers in the administrative structure of

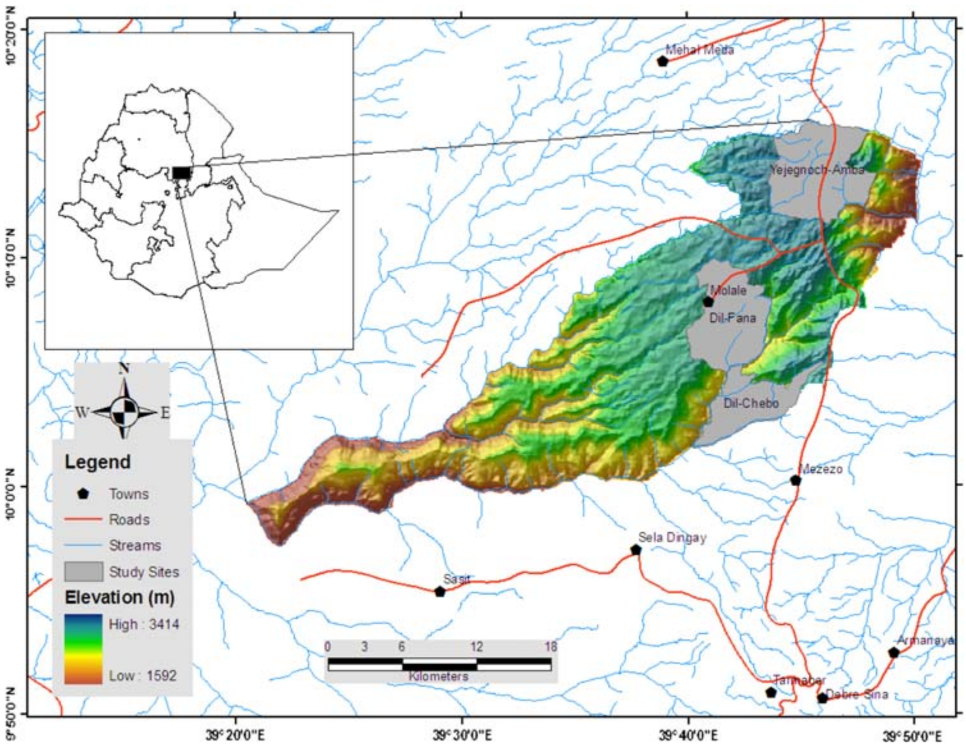

Figure 1. Location map of the study area.

Ethiopia, which were selected on purpose to represent differences in elevation and thus agro-climatic conditions in the *woreda*. Figure 1 shows the location map of the study area, and Table 1 presents some details about the sampled RKAs.

The farming system in the study area is typical of the traditional mixed farming system of the highlands, where livestock provide the draught power, crop residues are important sources of livestock feed, and household members provide the labour required for agricultural activities. The major crops cultivated include wheat and barley among the cereals and faba bean among the pulses. Crop production is almost entirely rain-fed, except for very small areas around homesteads under traditional irrigation practised by some households. Rainfall variability is a major constraint to agricultural production, and it is a frequent hazard. In addition to rainfall variability, temperature is a limiting factor to the types of crops that can be produced. Hence, there is a limited opportunity for diversification of field crops production in the area, thus increasing vulnerability to climate change impacts and other shocks.

Table 1. General information about the sample Rural Kebele Administrations

Kebele	General elevation (m)	Agro-climatic zone	Sample size
Dil-Fana	3000–3200	Upper Dega (temperate)	30
Dil-Chibo	2400–2800	Lower Dega (temperate)	30
Yejegnoch- Amba	> 3200	Wurch (sub-afroalpine)	30

2.2. Data collection and methods of analysis

The study employed a multi-stage sampling procedure that combined purposive and random sampling methods. Purposive sampling was used to select the study *woreda* and the three RKAs. The *woreda* was selected to represent the central highland eco-region of the country, and the three RKAs were selected to represent the three major agro-ecological zones in the highlands system. Then, a simple random sampling method was used for the selection of respondent household heads. In cases where the selected household heads were unavailable or too young to remember weather conditions some two decades ago, a random substitute was used as a replacement.

A total of 90 randomly sampled households, 30 each from the three RKAs, were interviewed by using a detailed questionnaire. The questionnaire generated household level data on household socio-demographic characteristics, perceptions of climate change, perceived impacts of climate change on agricultural production and adaptive responses employed to current climate variability. In addition, focus group discussions (one from each RKA) and key informant interviews with individual farmers (two from each RKA) 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 decades. The fieldwork was conducted in May 2011.

Descriptive statistics were used to summarise quantitative data, and χ^2 and F-tests were used to test statistical significance of variations across the three RKAs. Qualitative data were used to augment and substantiate the quantitative analyses. The statistical software package SPSS (statistical package for social scientists) and MS EXCEL were used for data management and analysis.

3. Results and discussion

3.1. Socioeconomic characteristics of sample households

3.1.1. Household demographics

Table 2 presents the demographic characteristics of the sample households in terms of age composition and household head's age and education. The average age of household heads was about 51.2 years, and varied between 49 years in Dil-Chibo and 54.7 years in Dil-Fana. These are relatively older ages and reflect the purposive sampling bias in favour of older respondents so as to capture experienced or perceived changes in the local climate and consequent livelihood adjustments, if any, over the past two decades. It was assumed therefore that older people have sufficient long-term experience to provide a reliable assessment of experienced climatic and environmental change in the study area. The majority of respondents were illiterate (44% of total), some 28% were able to read and write only, and the remainder had some level of formal education. There was no statistically significant difference among households in the three RKAs in terms of both age of household heads and educational attainments.

The largest average family size was found in Yejegnoch-Amba and the lowest was in Dil-Chibo. In all cases, children below 15 years of age accounted for the largest share of family sizes while elders of 65 years or older accounted for the least proportion. The age dependency ratio was highest in Dil-Chibo, which was about 45%. All of the households sampled were Orthodox Christians by religion.

Table 2. Demographic characteristics of respondents

Variable	Indicator	Dil-Fana	Dil-Chibo	Yejegnoch- Amba	Total	χ^2/F-value
Age of HH head (years)	Mean	54.73	49.07	49.77	51.19	3.97*
	Std	9.25	7.76	49.77	8.77	
Education level (% respondents)	Illiterate	33.3	56.7	43.3	44.4	6.1
	Read & write	33.3	16.7	33.3	27.8	
	Primary (< = 8)	30.0	26.7	23.3	26.7	
	Secondary (> = 9)	3.3	-	-	1.1	
Total number of family members	Mean	5.6	5.50	6.17	5.77	0.97
	Std	1.94	1.57	2.31	1.96	
Number of household members <15 years old	Mean	2.19	2.07	2.84	2.36	1.97
	Std	1.29	0.90	2.08	1.51	
Number of household members 15–64 years old	Mean	1.80	1.90	2.24	1.98	2.47
	Std	0.76	0.80	0.83	0.81	
Number of members > = 65 years old	Mean	1.38	1.50	1.00	1.29	2.61
	Std	0.52	0.71	.00	0.47	
Age dependency ratio (%)	Mean	33.9	45.4	40.5	37.1	1.09
	Std	1.516	2.145	2.145	1.65	

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels. nd = fewer samples for *F*-value to be calculated.

3.1.2. Landholdings

Land is the most important livelihood asset of households in rural Ethiopia, as it is elsewhere in the developing world. Size of land held is the primary determinant of food security of rural households. Average household landholding for the sample households from the three RKAs was about 1.5 ha, with a range from 1.3 ha in Yejegnoch-Amba to 1.7 ha in Dil-Fana (table 3). This is higher than the national average of less than 1.0 ha per household in the highland areas of the country [20]. Considering mean family sizes, average landholdings were 0.31 ha, 0.27 ha and 0.21 ha per person in Dil-Fana, Dil-Chibo and Yejegnoch-Amba, respectively. The overall average landholding was 0.26 ha per person. Of the total landholdings of households, only about a fourth of a hectare on average was under irrigation including the use of rainwater harvesting at household level. There was a statistically significant difference among the three RKAs in terms of total landholdings and the portion of land under rain-fed cultivation.

3.1.3. Household incomes

Table 4 summarises the annual average income of households by sources during the 2010/11 cropping year. It is shown that incomes from crop production range from about Birr 589 (1.0 USD ~ 17.0 Birr by then) in Yejegnoch-Amba to Birr 700 in Dil-Fana, where crop diversity is higher. Incomes from livestock production, the primary source of income to the majority of households in the sample, varied between about Birr 1304 in Dil-Chibo and Birr 1748 in Dil-Fana. Food- or cash-for-work was also an important source of income to those households which were beneficiaries of the Productive Safety Net Program (PSNP), which is a social protection program of the government being implemented in the chronically food insecure *woredas* of the country. Table 4 includes in the category of 'other incomes' such items as proceeds from the sale of honey and remittances from children and relatives living in urban areas. Some 22% of the total households earned such incomes.

There was a statistically significant difference in the annual income of households in the different RKAs from sale of trees and/ or tree products and engagement in cash- or food-for- work activities as well as total incomes from the different livelihood strategies. In all cases, the high values of standard deviations show the variability in the incomes and the skewness of the distributions.

The household income sources presented in Table 4 can be grouped into three categories: farm, non-farm and direct natural resource-based sources. As shown in Table 5,

Table 3. Landholdings of households in the three sample Kebeles

		Dil-Fana	Dil-Chibo	Yejegnoch-Amba	Total	*F*-value
Rain-fed land (ha)	Mean	1.5833	1.2250	1.1078	1.3076	3.90*
	Std	0.7666	0.5958	0.6762	0.7054	
	N	30	30	29	89	
Irrigated land (ha)	Mean	0.2639	0.2667	0.2500	0.2596	0.64
	Std	0.000	0.000	0.0000	0.00	
	N	18	30	30	78	
Total land (ha)	Mean	1.7417	1.4917	1.3208	1.5181	2.89*
	Std	0.7564	0.5853	0.6946	0.6967	
	N	30	30	30	90	

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels. nd = fewer samples for *F*-value to be calculated.

Table 4. Average annual income of households in Birr by source (1.0 USD ~ 17.0 Birr by then)

Income source	Stat	Dil-Fana	Dil-Chibo	Yejegnoch-Amba	Total	*F*-value
Crop production	Mean	700.0	681.3	588.9	669.0	2.51
	Std	487.7	283.4	214.7	364.7	
	N	17	16	9	42	
Livestock production	Mean	1748.1	1303.7	1503.7	1518.5	0.78
	Std	1815.6	804.1	677.4	1210.0	
	N	27	27	27	81	
Selling trees/tree products	Mean	758.3	400.0	3000.0	892.9	3.32*
	Std	633.1	-	-	846.2	
	N	12	1	1	14	
Food or cash for work	Mean	2350.0	2918.2	2550.0	2685.7	3.36*
	Std	931.1	685.3	300.0	729.6	
	N	6	11	4	21	
Petty trade	Mean	800.0	1000.0	700.0	800.0	0.25
	Std	1044.0	-	424.3	695.7	
	N	3	1	2	6	
Casual labour	Mean	550.0	550.0	633.3	577.8	0.33
	Std	70.7	173.2	152.7	139.4	
	N	2	4	3	9	
Other income	Mean	466.7	606.0	670.3	562.6	nd
	Std	244.9	413.7	674.0	435.2	
	N	9	5	6	20	
Total income	Mean	3000.0	2827.7	2214.1	2680.6	2.60*
	Std	2062.6	890.8	922.4	1427.3	
	N	30	30	30	90	

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels. nd = fewer samples for *F*-value to be calculated.

livestock provide the primary source of household incomes to the majority of households in all of the RKAs, followed by crop production and involvement in the food-for-work program of the government. Selling of trees, wood and charcoal also constitute important source of income in Dil-Fana, where 40% of the sample households generated some income from this source. Statistically significant differences were observed among the three RKAs in terms of the number of households generating incomes from crop production, food-for-work activities and selling of trees and tree products. These differences reflect the differences in the local agro-climatic and ecological circumstances. The dominance of livestock rearing over crop production is mainly due to the importance of sheep in the total income of households in these *Dega* agro-ecological areas. Crop production is generally the main source of income in the *Woina-Dega* agro-ecological zones of the country. Participation in food-for-work or cash-for-work is an important source of income to some households, as the *woreda* is one of the food insecure *woredas* covered by the PSNP. Engagement in casual labour was found to be important source of income in Dil-Chibo in particular because of its proximity to a small town called Molale (Figure 1).

3.3. Farmers' assessment of local climate change and its impacts

3.3.1. Farmers' assessment of local climate change

Respondents were asked about their observations of changes in the local climatic conditions over the past two decades. Unexpectedly, all of the respondents stated that they had noticed changes in the local climate, *viz.*, an increase in temperature and a decrease in annual total rainfall. Similarly, all respondents stated that the *Belg* season rainfall declined

Table 5. Proportion of households generating income from the different source categories in the three RKAs (% of respondents)

Category	Income source	Dil-Fana	Dil-Chibo	Yejegnoch- Amba	Total	χ^2 - value
Farm income	Crop production	56.7	53.3	30	46.7	5.20*
	Livestock production	90.0	90.0	90.0	90.0	0.09
Non-farm income	Food- or cash-for-work	20	36.7	13.3	23.3	4.77*
	Casual labour	6.7	13.3	10	10	0.75
	Petty trade	10	3.3	6.7	6.7	1.11
Direct natural resource based	Selling trees/ tree products	40	3.3	3.3	15.6	19.88***

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels.

over the past two decades. With regard to *Kiremt* rainfall, 6.5% of respondents believed that there was no change in the seasonal amount while the rest stated that they had observed a decline. In addition to a decrease in the seasonal amount, many respondents also stated that *Kiremt* rainfall currently starts late in the season and ends earlier than it used to do in the past. Changes in total amounts and temporal patterns of both *Belg* and *Kiremt* had, according to respondents, increased drought frequency. Nearly 87% of respondents in Dil-Fana and all respondents from the other two RKAs believed that drought had become more frequent compared to the situation before two decades ago. Findings from key informant interviews and focus group discussions also confirmed that there are widely held perceptions of increased temperature and decreased rainfall, along with other local environmental changes (Box 1).

A study that covered 500 households in five sample *woredas* in two river basins (Abay and Baro-Akobo) of Ethiopia reported a similar finding. A majority of respondents perceived increase in temperature (82% of total respondents) and decrease in annual rainfall (96% of total) [21]. Similarly, a previous study undertaken in the Nile basin of Ethiopia that covered 1000 households also reported a similar finding that a majority of respondents perceived that there was increase in temperature and decrease in annual and seasonal rainfalls [22]. A study that was conducted in the southern lowlands of the country [23] also found that 88% and 93% of respondents (n = 359) perceived decrease in rainfall and number of rainy days, respectively, while 93% of respondents perceived increase in mean temperatures.

Studies in other parts of Africa have also reported the widely held perceptions of climate change: an increase in temperature and decrease in precipitation. For instance, a study that surveyed 710 households in different parts of Kenya [24] reported that a large majority of the farmers perceived an increase in average temperatures (94%) and a decrease in average rainfall (88%) over the last 20 years. Similarly, in a World Bank study, Maddison [25] summarised studies conducted in 10[1] sub-Saharan African countries on perceptions of and adaptation to climate change that altogether covered a total of over 9500 smallholder farmers. Maddison [25] found that significant numbers of farmers across the 10 countries studied believed average temperatures had increased. The same study [25] also noted that the results for rainfall show a similar uniformity of opinion across the 10 countries; in six out of the 10 countries the majority of farmers believed rainfall levels had decreased. Merz *et al*. in their study in the Eastern Saloum, Senegal [26] reported that 82% of respondents (n = 25) believed annual rainfall had decreased and the same proportion of respondents (82%) believed dry season temperature had increased. On the other hand, Akponikpè [27] surveyed a total of 234 farmers in five[2] sub-Saharan West

African countries with approximately 47 farmers per country in a total of 78 villages and found that climate change perceptions depended on geographical areas and prevailing climates; more respondents living in drier environments reporting increased temperatures and decreased rainfalls than those living in more humid environments.

People's perception of increased temperatures is consistent with what is shown by meteorological records in many parts of the country [21]. The perceived decline in rainfall may, however, show an increased intra-seasonal rainfall variability or increased demand for water and soil moisture associated with the increase in the human population and the possible decline in soil water holding capacity due to soil degradation caused by erosion, as annual and seasonal rainfall amounts obtained from meteorological records do not show declining trends in many parts of Ethiopia [11]. Meze-Hausken [28] had a similar conclusion in her study in southern Tigray and northern Afar regions; she found that farmers perceived 'a loss of the *Belg* rains and a shorter *Kiremt* season' since 'their father's time' (20–30 years ago) which was not supported by local meteorological records in terms of annual and seasonal rainfall amounts. This suggests that a detailed examination of intra-seasonal rainfall variability and trends including dry spell analysis is important to interpreting any changes in daily rainfall behaviour that may have influenced farmers to believe that rainfall had decreased.

Box 1. Perceived climatic and related changes, elderly key informant from Yejegnoch-Amba

Mr Tena is a 53-year-old farmer (male) in Yejegnoch-Amba. He has lived in the same village all his life and is currently head of a family of six including himself and his wife. Over the years, he reported that he had observed the following climatic and related changes:

- Annual rainfall amount and duration of the rainy season has decreased. We used to produce twice in a year, during *Belg* and *Meher* seasons. Now we have abandoned the *Belg* season production as the rain often comes late and it is insufficient for crop production. In some years it rains in November and destroys crops.
- Frost and pest frequently affect our crops, and this has affected production levels. As a result, many people have become beneficiaries of the safety nets program unlike in the past.
- Sudden interruption of rainfall by the end of the rainy season and occurrence of rains in November in some years leads to occurrence of crop pests that destroy crops like faba bean.
- Temperatures are increasing year by year, and in consequence crops like faba bean and wheat that were not grown in the *Dega* part of this area have now started growing.
- The number of people in my village has increased at the rate that the available agricultural land cannot support.

3.3.2. Farmers' assessment of climate change impacts on agriculture

Climate change affects crop production in many ways. Changes in length of growing period, moisture stress and occurrence of pests and diseases are the major effects. Table 6

Table 6. Changes in crop production due to climate change in the three RKAs (% respondents)

Indicators	Response	Dil-Fana	Dil-Chibo	Yejegnoch-Amba	Total	χ^2-value
Change in length of *Belg* growing period	Increase	3.3	-	-	1.1	2.02
	Decrease	96.7	100	100	98.9	
	No change	-	-	-	-	
Change in length of *Kiremt* growing period	Increase	-		-	-	2.02
	Decrease	96.7	100	100	98.9	
	No change	3.3	-	-	1.1	
Change in water availability	Increase	3.3	-	13.3	5.6	33.22***
	Decrease	23.3	73.3	13.3	36.7	
	More variable	3.3	-	13.3	5.6	
	No change	70	26.7	60	52.2	
Change in crop damage by insects and pests	Increase	100	100	100	100	-
	Decrease	-	-	-	-	
	No change	-	-	-	-	
Change in crop diseases	Increase	96.7	96.7	100	97.8	1.02
	Decrease	-	-	-	-	
	No change	3.3	3.3	-	2.2	
Change in the problem of weeds	Increase	6.7	36.7	30	24.4	8.06*
	Decrease	-	-	-	-	
	No change	93.3	63.3	70	75.6	
Any shift in suitable growing areas	Yes	100	93.3	13.3	68.9	65.11***
	No	-	6.7	86.7	31.13	
Change in livestock diseases	Increase	3.3	60.0	43.3	35.53	22.21***
	Decrease	-	-	-	-	
	No change	96.7	40.0	56.7	64.47	

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels.

presents respondents' observations of climate change impacts on crop production in the study area. Nearly all respondents had observed decline in the length of crop growing period during both *Belg* and *Kiremt* seasons. Any change in the crop growing period is a real challenge as it considerably affects farmers' decisions on what and when to plant. With statistically significant differences among the RKAs, about 38% of total respondents reported decline in water availability, while 52% believed that there was no change in water availability.

Respondents observed an increased incidence of agricultural pests and diseases as one of the manifestations of climate change by respondents (table 6). All respondents stated that there was increased crop damage by insects and pests, and about 24% believed that there was increase in the severity of weed infestation caused by climate change. Findings from focus group discussions also corroborate the information from individual interviews. A shift in suitable growing areas for major crops was observed by all respondents from Dil-Fana, 93% of respondents in Dil-Chibo and only 13% of respondents in Yejegnoch-Amba, with a statistically significant difference among the three RKAs. In Yejegnoch-Amba, there is a limited range for shifting crop growing areas because of the high altitude and normally low temperatures. With a statistically significant difference among the RKAs, about 36% of respondents reported an increase in the incidence of livestock diseases, while the rest observed no change in the occurrence of livestock diseases. Shortage of livestock feed was also mentioned but was related mainly to the increasing scarcity of grazing lands due to human population growth, rather than to climate variability or climate change.

3.3.3. Belg season production

The *Belg* season production is a very important component of annual crop production and food security in Ethiopia, especially in areas with bimodal rainfall [29]. Its importance has recently been declining due to increased climate variability during the season [21,29]. All respondents used to produce during the *Belg* season in the past, but have now reportedly abandoned the practice. The main reason for abandoning *Belg* production was stated by all respondents to be that the seasonal rainfall was not sufficient to support crop production (Table 7). Other reasons included a shift in the *Belg* season rainfall pattern, the incidence of crop pests and a lack of suitable crop varieties for the shortened growing season. With a statistically significant difference, 76% and 23% of respondents believed that *Belg* rains now come late and the incidence of crop pests during *Belg* season has increased compared to what it was some two decades ago.

3.4. Farmers' adaptive responses to climate variability and change

Farmers' reported adaptive responses to the experienced climate change were classified in two broad categories: adjustments in crop and livestock production, and responses through natural resources management.

3.4.1. Adaptive responses in crop and livestock production

Different types of adaptation measures have been used by the farmers to overcome the challenges of climate variability and climate change in crop and livestock production activities. The adaptation measures implemented in crop production include: i) changes in the types of crops produced (57% of respondents), ii) increased diversification of crops produced (64.4% of respondents), iii) adjusting the agricultural calendar or dates of planting and harvesting (92.2% of the respondents), iv) use of early maturing varieties for the crops traditionally produced (1.1% of the respondents), v) use of pest tolerant varieties (1.1% of the respondents), and vi) planting high value fruit trees (29% of respondents) (table 8). Statistically significant differences were observed among the three RKAs in terms of some of the adaptation measures used: changing crops grown, crop diversification and adjusting of cropping calendars. It can be seen that options for agricultural adaptation are limited in Yejegnoch-Amba, compared to the other two, because of the prevailing agro-climatic conditions.

In the livestock sub-sector, adjustments made reportedly due to climate change related problems include: i) changing the types of animals reared from cattle to small ruminants (20% of respondents), ii) reducing the number of animals kept (71% of respondents), iii) keeping improved animal breeds (23% of respondents in Dil-Fana only), and iv) producing

Table 7. Reasons for abandoning *Belg* season production in the three RKAs (% of respondents)

Indicators	Dil-Fana	Dil-Chibo	Yejegnoch- Amba	Total	χ^2–value
Belg rains are not enough for crop production	100	100	100	100	-
Belg rains started to come late	53.3	96.7	76.7	75.57	34.11^{***}
Crop pest incidence	46.7	13.3	10	23.33	13.79^{***}
Lack of suitable crop varieties for shortened *Belg* season	3.3	-	-	1.1	2.02

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels.

Table 8. Adaptation measures in crop and livestock production (% of respondents)

Adaptation measures	Dil-Fana	Dil-Chibo	Yejegnoch- Amba	Total	χ^2-value
Crop					
Changing the type of crops produced	76.7	86.7	6.7	56.7	46.4***
Increasing the number of crops produced (diversification)	93.3	93.3	6.7	64.4	65.6***
Adjusting date of planting and harvesting	76.7	100	100	92.2	15.2***
Use of early maturing crop varieties	-	-	3.3	1.1	2.02
Use of pest tolerant crop varieties	-	-	3.3	1.1	2.02
Planting high value fruit trees	33.3	20	33.3	28.87	1.73
Livestock					
Changing the type of animals kept	36.7	23.3	-	20	12.9**
Reducing the number of animals kept	90	43.3	80	71.1	17.6***
Keeping improved animal breeds	23.3	-	-	7.77	15.2***
Practicing improved animal feed production/planting trees for animal feed	73.3	46.7	63.3	61.1	4.6

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels.

livestock feed including planting trees for animal feed (61% of respondents) (table 8). The distribution of respondents by adaptation measures shows statistically significant difference among the RKAs, showing the spatial variability in locative responses in the livestock sub-sector of agriculture.

Crop and livestock diversification is a widely used adaptation strategy in many parts of Africa as well [24,26,27,30–34] . For instance, Merz *et al.* [26] found in Senegal that a wide range of new crops were taken up by farmers in response to climatic variability and climate change, the most important new crop being water melon (*Citrullus lanatus*). Changes in sowing date, crop density and crop variety were found to be important adaptation measures in five sub-Saharan countries of western Africa [27]. A study in four communities in north-east Africa [30] found that farmers in each of the four communities use from three to 12 named types of pearl millet, from six to 22 of sorghum, and from 14 to 42 of other cultivars as adaptive mechanisms to the prevailing climate variability with implications for adaptation to future climate change.

3.4.2. Adaptive responses through natural resources management

Natural resources management activities have been undertaken at household and community levels to adapt to the changing climatic conditions and local environmental change more broadly. Community level interventions include forestation and reforestation activities, soil and water conservation and water harvesting through construction of community ponds as well as stream diversions (table 9). A majority of households participated in these interventions that created important community assets. All of these community level interventions were supported and administered by the *woreda*'s office of agriculture and rural development. Natural resources management is perhaps the most commonly used method for adaptation to climate change elsewhere in Africa, as indicated by the studies cited elsewhere above. AMCEN [35] also underlines natural resources management as the most important strategic element for climate change adaptation in Africa.

At the household level, farmers implement different types of soil and water conservation measures including planting of trees and rainwater harvesting. Table 10 shows the different types of soil and water conservation measures implemented by the surveyed households. As

Table 9. Adaptation through natural resource management: community asset creation (% of households)

Adaptation measure	Dil-Fana	Dil-Chibo	Yejegnoch- Amba	Total	χ^2-value
Participating in forestation/ reforestation with the community	90	100	90	93.3	3.2
Participating in soil and water conservation with community	93.3	100	93.3	95.5	2.09
Participating in pond construction with the community	60.0	10	20	30.0	20.0***
Participating in river diversion with the community	6.7	3.3	-	3.3	2.07

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels.

can be seen, 81%, 97% and 55% of respondents implemented crop rotation, stone bunds and soil bunds in order of sequence. Similarly, 38%, 96%, 83% and 60% of respondents respectively used grass strips, water ways, fallowing and mulching for soil and water conservation purposes. Household level rainwater harvesting was undertaken by 28% of households, and tree planting was practised by 10% of households in Dil-Fana and 6.7% of households in Dil-Chibo. Tree planting is constrained by the normally cold temperatures in Yejegnoch-Amba. Statistically significant differences were observed among the three RKAs in some of the conservation measures applied. This was because the types of measures used apparently depended on locally available resources and micro-climates of the RKAs.

3.4.3. Intensity of adaptive responses at the household level

An aggregate indicator of the intensity of adaptation measures in response to the perceived or experienced climate change could be estimated by summing up the total number of adaptations with which each household is engaged in (Table 11). A total of 24 adaptation measures were used by the sample households as a whole. This means that the intensity of adaptation could range from zero to 24, where zero represents households without any adaptation measure and 24 represents the maximum number of adaptation measures a household could adopt. Actual adaptation measures implemented by the surveyed households ranged from one to 19, and the average was 11.7 measures.

On average, a household was using seven different types of adaptation measures. The highest intensity of adaptation was observed in Dil-Fana (about 14 adaptation measures) followed by Dil-Chibo (about 12 adaptation measures). Households were classified

Table 10. Soil and water management measures used in own farms (% respondents)

Conservation measure	Dil-Fana	Dil-Chibo	Yejegnoch- Amba	Total	χ^2-value
Crop rotation	96.7	93.3	53.3	81.1	22.77***
Stone bunds	96.7	96.7	96.7	96.7	–
Soil bunds	56.7	70	36.7	54.5	6.81*
Grass strips	50.0	30	33.3	37.8	2.93
Water ways	93.3	96.7	96.7	95.6	0.5
Planting trees	10	6.7	-	5.6	2.97
Fallowing	73.3	93.3	83.3	83.3	4.32
Mulching	60	70	50.0	60.0	2.50
Household level rainwater harvesting	63.3	6.7	13.3	27.8	28.7***

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels.

Table 11. Intensity of household level adaptation to climate change in the three kebeles

Indicator		Dil-Fana	Dil-Chibo	Yejegnoch- Amba	Total	χ^2/*F*-value
Average number of adaptation measures	Mean	13.6	11.9	9.7	11.7	15.36***
	Std	3.0	1.94	2.9	3.09	
	N	30	30	30	90	
Intensity of adaptation (% of respondents)	Low	20	40	80	46.7	22.5***
	High	80	60	20	53.3	

Note: *** indicates significance at < 0.001, ** at < 0.01 and * at < 0.05 probability levels.

somewhat subjectively into low and high intensity adaptation categories by taking the mean number as a cutoff point. That is, households who used 11 or fewer were classified as low intensity adopters and those with more than 11 were classified as high intensity adaptors. With this classification, abut 47% of the total sample households were in the low intensity adaptation category while the rest were in the high intensity category. This assumes that the different adaptation measures had equal importance for the mitigation of climate change impacts.

4. Conclusions

Ethiopia already suffers from climate variability and extreme events, and future climate change constitutes a major development challenge. It is important to understand the nature of climate change impacts, key vulnerabilities and indigenous adaptation practices at local levels in order to identify and implement appropriate adaptation strategies at community and household levels. This paper presents an assessment of the perceptions of climate change by local people, perceived impacts of climate change on agricultural production and local adaptive responses to climate variability and change. The timeframe considered to assess climate change perceptions and adaptive responses was the past two decades. The specific sampling sites for the study were three RKAs, which were selected on purpose to represent differences in elevation and thus agro-climatic conditions in the study area. In all of the sites, local people mainly depend on small scale, rain-fed mixed agriculture and thus on sources of livelihood which are highly sensitive to climate. Data were generated through questionnaire survey (a total of 90 households, 30 each from the three sites), focus group discussion and key informant interviews.

Unexpectedly, all of the respondents stated that they had observed increase in temperature and decrease in annual and seasonal rainfall amounts. About 87% of respondents from one of the sites (Dil-Fana) and all respondents from the other two believed that drought had become more frequent compared to the past (some two decades ago). Key informant interviews and focus group discussions also confirmed the survey findings that increased temperature and decreased rainfall were widely held perceptions. The major impacts of the experienced or perceived climate change on local livelihoods as reported by the farmers include: decline in the length of crop growing period during both *Belg* and *Kiremt* seasons (mentioned by nearly all respondents), increased crop damage by insects and pests (all respondents), and increased severity of weed infestation (24% of respondents). All of the respondents used to produce crops during the *Belg* season in the past, but have now abandoned the practice. The reasons mentioned were shortage of the seasonal rainfall to support crop production, shift in the seasonal rainfall pattern, and increased incidence of crop pests during the season.

The farmers have been adapting to the changing climate. The important adaptation measures implemented in crop production include changes in the types and varieties of crops produced, increased diversification of crop production, and adjusting the agricultural calendar. In the livestock sector, important adjustments have been the shift from cattle to small ruminants, reducing the number of animals kept, and producing livestock feed including planting of fodder trees. The third category of adaptive responses is investments made in natural resources management. These are implemented at household and community levels and include soil and water conservation with physical and biological measures, water harvesting, and afforestation and reforestation activities. All in all 24 different types of adaptation measures were implemented by the households surveyed, and a household on average used 11.7 measures, with a range from one to 19. More than half of the sample households (>53% of total) used more than 11 of the adaptation measures. Statistically significant differences were observed among the three RKAs in terms of some of the adaptation measures used. It was also found that options for agricultural adaptation are influenced by the prevailing agro-ecological conditions and available environmental resources.

Despite the range of autonomous adaptive responses that the farmers have employed, the farmers reported that improving agricultural production and achieving food security have increasingly been constrained by climate change. This suggests that there is a need for planned interventions to identify and support effective adaptation options. Some of the key interventions, as suggested by the findings of the study, will include investments in integrated natural resources management, water harvesting for micro- and small-scale irrigation, crop diversification, dissemination of improved and suitable crop varieties, integrated pest control, and gradually reducing dependence on climate sensitive livelihood sources by diversifying into non-agricultural employment opportunities. Such interventions should build on farmers' knowledge by following farmer-participatory processes. It is also recommended that future research should identify determinants of farmers' choice and the use of adaptation measures.

Notes

1. The ten countries covered by this study are Burkina Faso, Cameroon, Egypt, Ethiopia, Ghana, Kenya, Nigeria, Senegal, South Africa and Zambia.
2. The five countries covered by this study are Benin, Burkina Faso, Ghana, Niger and Togo.

References

[1] IPCC (Intergovernmental Panel on Climate Change), 2007, *Climate Change 2007: The physical Science Basis; Contribution of Working Group I to the 4th Assessment Report of the IPCC* (Cambridge: Cambridge University Press).
[2] IPCC (Intergovernmental Panel on Climate Change), 2007, *Climate Change 2007: Impacts, Adaptation and Vulnerability; Contribution of Working Group II to the 4th Assessment Report of the IPCC* (Cambridge: Cambridge University Press).
[3] Thornton, P.K., Jones, P.G., Owiyo, T., Kruska, R.L., Herrero, M., Kristjanson, P., Notenbaert, A., Bekele, N. and Omolo, A., 2006, Mapping climate vulnerability and poverty in Africa. Research report, ILRI, Nairobi.
[4] Zeleke, G., Bewket, W. and Alemu, D., 2010, Economics of adaptation to climate change: Ethiopia case study: Learning from past experiences with extreme climate events. Unpublished report, Addis Ababa.
[5] World Bank, 2006, *Ethiopia: Managing Water Resources to Maximize Sustainable Growth* (Washington, DC: World Bank).
[6] World Bank, 2007, *Ethiopia: Accelerating Equitable Growth, Country Economic Memorandum* (Washington, DC: World Bank).
[7] World Bank, 2010, Ethiopia: Economics of adaptation to climate change. Synthesis report. World Bank, Washington, DC.

[8] EEPRI (Ethiopian Economic Policy Research Institute), 2003, Quarterly report on the macroeconomic performance of the Ethiopian economy. Unpublished report, EEPRI, Addis Ababa.
[9] Bartel, P. and Muller, J., 2007, Horn of Africa natural hazard probability and risk analysis. Humanitarian Information Unit, research report, US Department of State, Washington, DC.
[10] Epsilon International, 2011, Climate change impacts and the need for adaptation in urban settlements of Ethiopia. Unpublished report, Addis Ababa.
[11] NMA (National Meteorological Agency), 2007, Climate change: National Adaptation Program of Action (NAPA) of Ethiopia. Ministry of Water Resources, Addis Ababa.
[12] Asmamaw, L.B., 2010, Challenges and responses to agricultural practices in Gerado area, South Wello, Ethiopia. *International Journal of Environmental Studies,* **67**, 583–598.
[13] Asmamaw, L.B., Mohammed, A.A. and Lulseged, T.D., 2011, Land use/cover dynamics and their effects in the Gerado catchment, northeastern Ethiopia. *International Journal of Environmental Studies,* **68**, 883–900.
[14] Bewket, W., 2011, On being climate ready: climate change strategy for Ethiopia. Policy Brief No. 4, Ethiopian Civil Society Network on Climate Change, Addis Ababa.
[15] IFRC (International Federation of Red Cross and Red Crescent Societies), 2012, Long-term planning framework Ethiopia 2012–2015. Available online at: www.ifrc.org/docs/Appeals/annual12/SP164_LTPF12.pdf (accessed April 2012).
[16] Sonneveld, B.G.J.S., 2002, *Land Under Pressure: The Impact of Water Erosion on Food Production in Ethiopia* (Maastricht: Shaker Publishing).
[17] Haile, S., 2004, Population, Development, and Environment in Ethiopia. ECSP (Environmental Change and Security Program) Report No. 10, Woodrow Wilson International Center for Scholars, Washington, DC.
[18] FDRE (Federal Democratic Republic of Ethiopia), 2011, Climate Resilient Green Economy: Mission Statement. FDRE, Addis Ababa.
[19] Deressa, T. 2007, Measuring the economic impact of climate change on Ethiopian agriculture: Ricardian approach. Policy research working paper 4342, World Bank, Washington, DC.
[20] Tafesse, A.S., Dorosh, P. and Asrat, S., 2011, Crop production in Ethiopia: regional patterns and trends. Ethiopia Strategy Support Program II (ESSP II) Working Paper No. 0016, International Food Policy Research Institute (IFPRI), Addis Ababa.
[21] Bewket, W. and Alemu, D., 2011, Farmers' perceptions of climate change and its agricultural impacts in Ethiopia. *Ethiopian Journal of Development Research,* **33**, 1–28.
[22] Deressa, T., Hassan, R.M. and Ringler, C., 2008, Measuring Ethiopian farmers' vulnerability to climate change across regional states. Discussion paper, IFPRI, Washington, DC.
[23] Amsalu, A. and Adem, A., 2009, *Assessment of Climate Change-induced Hazards, Impacts and Responses in the Southern Lowlands of Ethiopia* (Addis Ababa: Forum for Social Studies.
[24] Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., and Herrero, M., 2011, Adapting agriculture to climate change in Kenya: household and community strategies and determinants. Research Report, World Bank, Washington, DC.
[25] Maddison, D., 2007, The perception of and adaptation to climate change in Africa. Policy research working paper No. 4308. World Bank, Washington, DC.
[26] Mertz, O., Mbow, C., Reenberg, A. and Diouf, A., 2009, Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental Management,* **43**, 804–816.
[27] Akponikpè, P.B.I., Johnston, P. and Agbossou, E.K., 2010, Farmers' perception of climate change and adaptation strategies in sub-Saharan West Africa. Second International Conference on Climate, Sustainability and Development in Semi-arid Regions, 16–20 August 2010, Fortaleza-Ceará, Brazil.
[28] Meze-Hausken, E., 2004, Contrasting climate variability and meteorological drought with perceived drought and climate change in northern Ethiopia. *Climate Research,* **27**, 19–31.
[29] Rosel, S. and Holmer, B., 2007, Rainfall change and its implications for *Belg* harvest in South Wollo, Ethiopia. *Geografiska Annaler Series A,* **89**, 287–299.
[30] Mortimore, M.J. and Adams, W.M., 2001, Farmer adaptation, change and 'crisis' in the Sahel. *Global Environmental Change,* **11**, 49–57.
[31] Nhemachena, C. and Hassan, R., 2007, Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion Paper No. 00714, Washington, DC.
[32] Cooper, P.J.M., Dimes, J., Rao, K.P.C., Shapiro, B., Shiferaw, B. and Twomlow, S., 2008, Coping better with current climatic variability in the rain-fed farming systems of sub-Saharan Africa: an essential first step in adapting to future climate change? *Agriculture, Ecosystems and Environment,* **126**, 24–35.
[33] Deressa, T., Hassan, R.M., Alemu, T., Yesuf, M. and Ringler, C., 2008, Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. IFPRI Discussion Paper No. 00798, IFRI, Washington, DC.
[34] Hassan, R., 2008, Determinants of African farmers' strategies for adapting to climate change: multinomial choice analysis. *African Journal of Agricultural and Resource Economics,* **2**, 83–104.
[35] AMCEN (African Ministerial Council on the Environment), 2011, Addressing climate change challenges in Africa: a practical guide towards sustainable development.