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Perception and Response to Climate Change by Small Farmers: The Case of Mareko District, Southern Ethiopia

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Abstract: Climate change and variability is one of the common challenges of rainfall dependent economic activities like agriculture. In this study, we assessed the perception of small landholders on the impact of climate change and their adaptation strategies in Mareko district in southern Ethiopia. Data were collected from a total of 120 small farmers from two villages in Elala Gebiba and Hobe Jare Dembeka. The results obtained from meteorological data of three decades (1986-2015) show an increase in temperature by 0.39ºC and rainfall fluctuations over the last 30 years. Perceptions of these farmers on climate change depend on the level of vulnerability to the extreme events like drought and flooding. The perception of local communities on climate change indicated that there was an increase in temperature (98.3%) in the study area that had a potential impact on their livelihoods. Local people perceived that, the hazards induced by climate change like drought, extreme heat, livestock disease and floods affected their livelihood. The results of this study indicate that changing cropping date, practicing soil and water conservation, shifting from cattle to goats and sheep, income source diversification, growing drought tolerant crops like false banana, millet, sorghum and quicker-maturing crops like haricot bean and vegetables are the major adaptation options in the study area. Thus, this research contributes to the knowledge gaps on potential existing climate change adaptation strategies for those dependent on rain-fed agriculture for their food and livelihoods.

Keywords: Adaptation, climate change, climatic hazards, Ethiopia, Mareko district, vulnerability.

Introduction

Climate change is recognized as one of the greatest challenges in our planet with harmful effects on the world's ecosystems, economies, and the wellbeing of the societies. The developing countries are generally recognized as the most vulnerable to climate change. The negative consequences of climate change in Africa are already taking place in the form of frequent floods, droughts and shift in marginal agricultural systems (Collier et al., 2008). These extreme events may cause loss of human life and domestic animals. For instance, temperature in Africa is projected to increase much faster than the world average increase throughout 21st century (James and Washington, 2013). Study conducted by Chenung and Senay (2008) indicates that rainfall shortage and decline as well as frequent droughts have had enormous impacts on livestock production and pastoralist's livelihoods in Ethiopia (Wako et al., 2017). Climate change increases incidence of livestock disease (Bewket, 2012), which will reduce farmer's wealth by increasing vulnerability (Pettengell, 2010).

Agricultural production and food security of smallholder farmers are likely to be severely compromised by climate change in Ethiopia (Tadesse, 2007). Farmers are often the first to confront climate change in order to adapt to new climatic conditions (Swe et al., 2015). A study conducted by Hameso (2018) indicates that farmers who depend on rain-fed agriculture are seriously affected by climate change which requires adaptation strategies for practical intervention. The Ethiopian economy, especially the agriculture sector is one of the most vulnerable to climate change, potentially exposing millions of people to recurrent food shortages and episodic famines (World Bank, 2003). In Ethiopia, climate change is negatively affecting crop yields which lead to food security (Muluneh et al., 2017).

The increasing temperature eventually reduces yields of desirable crops on one hand and encourages weed and pest proliferation on the other hand (Bewket, 2012). Small farmers in Africa who depend on rain-fed agriculture are most vulnerable to the impacts of climate change (Gemeda, and Sima 2015). Under dry-land conditions, where the biological productivity is low and the majority of the people are poor, climate change is occurring not only as temperature increment, but it also affects water availability (Middelkoop et al., 2001). Accepting the adaptations being practiced and factors which determine decision in adoption is important in designing viable strategies (Gadgil et al., 2002; Asfaw et al., 2018 and Habte Mariam et al., 2016). Therefore, understanding small landholders perception at local level is particularly important for designing adaptation strategies for those dependent on climate-sensitive economic sector like agriculture.

Materials and Methods

Study Area

The study was conducted in Mareko district, Gurage zone, southern nations nationalities and peoples regional state (SNNPRS) in Ethiopia. Geographically, the district is found between 7° 55' and 8° 0' 4" N latitude and 38° 26' and 38° 33' E longitude. The district has 81,891 populations, of which 40,187 are males and 41,704 females. The household heads of the district are 16,712 of which 11,534 are males and 5,178 females. The agro ecology of Mareko district is dry with temperature between 15-27^{0}c, and its rainfall amount varies between 457-1042 mm with 730 mm mean annual rainfall. Similar to other regions in Ethiopia, the highest temperature occurred from January to the end of May, while the lowest temperature is observed between September and November each year with possibilities of temperature fluctuations. The study area shows bimodal rainfall distribution, with the main rainy season from June and September and other short rainy season occurs from the month of March to May.

Sampling Technique and Size

Mareko district was purposively selected for the study, from 13 districts found in Guraghe zone based on successive drought and other natural hazards. In the second stage, two villages were selected by using simple random sampling techniques among 25 rural villages of Mareko district. In order to get sufficient information about the past and current climatic condition of the study area, the respondents should be a minimum of 35 years age and lived at least for 30 years and above in Mareko district. To determine the sample size (n) of respondent household's head, the formulas of Cochran (1963), (Hejase and Hejase, 2013) were adopted.

$$n_0 = [Z]^2 pq/ (d\text{^}2) \quad (1)$$

$$n_1 = [n_0] / \left(1 + \frac{(n_0 - 1)}{N}\right) \quad (2)$$

According to Hejase and Hejase (2013), "n_0", is the sample size with Z [degree of confidence], p and q are estimated proportions of household heads being males and females, d is desired level of precision, "n_1" sample size after correction for population size N. The total household heads found in two villages were 897, which included 573 in Hobe Jare Dembeka village and 324 in Ilala Gebiba village. Based on the above formula, a total of 120 household heads were selected for household surveys.

Data Source and Data Analysis Method

Thirty years of meteorological data were used for this study. In addition, to climate data, small farmers' perceptions and response towards climate change by were investigated using household surveys and focused group discussions. Furthermore, key informant interview and field observations were conducted in this study. Both primary and secondary data sources were analyzed by using qualitative and quantitative methods. The qualitative information gathered through focus group discussions was analyzed by using a qualitative technique. Whereas, the quantitative data obtained through household surveys were analyzed by using descriptive statistics (mean, frequency, percentage, standard deviation). For statistical data analysis, the Statistical Package for Social Sciences (SPSS) software version 2.0 was used.

Table 1. Source of climatic information to households in the study area.

Parameter	Response	Gender		X^2	P-value	Education		X^2	P-value
		M	F			UE	E		
Sources of climatic information	Radio	48	7	1.75	0.88^{ns}	38	17	9.65	0.088^{ns}
	DA´s	39	7			31	15		
	Community discussion	8	1			6	3		
	Friends	4	0			4	0		
	Both radios and DA´s	3	0			1	2		
	Observing nature	3	0			0	3		
Types of climatic information	Temperature and rainfall	54	8	1.22	0.54^{ns}	43	19	1.83	0.39^{ns}
	Cause and impact of climate change	26	2			20	8		
	both	25	5			17	13		

Note that: M=Male, F=Female, UE=Uneducated, E=Educate

Results and Discussion

A total of 120 household heads were included in this study, of which 105 (87.5%) were males and 15 (12.5%) females. The age distribution of respondents ranges between 35-72 years for Elala Gebiba and 37-70 years for Hobe Jare Dembeka villages. Of 120 household head respondents, 51 (42.5%) of the respondents are between 35-44 years old, 34 (28.3%)

Table 2. A 30 years' annual average rainfall (1986-2015).

Year	Annual RF	Year	annual RF	Year	Annual RF
1986	541.2	1996	912.1	2006	776.5
1987	552.9	1997	848.6	2007	803.6
1988	700.6	1998	756.2	2008	1042.1
1989	951.5	1999	545.5	2009	728.7
1990	689.4	2000	704.3	2010	863.3
1991	801.6	2001	725.7	2011	672.9
1992	794.2	2002	457.6	2012	696.3
1993	958.9	2003	850.8	2013	704.2
1994	517.3	2004	773.6	2014	742.9
1995	564.0	2005	842.1	2015	467.9

Source: NMA (2016).

between 45-54 age, 26 (21.7%) between 55-64 old age and 9 (7.5%) are above 65 years.

Household's Sources of Climatic Information

The small landholders in the study area receive climate information from various sources which includes radio, government experts, community discussions, friends and nature observation (Table 1). There is no significant difference between male and female about the source of climatic information (x^2=1.75, p.v=0.88^{ns}) and educated respondents were better towards sources of information, but there is no significant difference between uneducated and educated respondents (x^2=9.65, p.v=0.088^{ns}).

Rainfall and Temperature Trend and Variability

The recorded annual rainfall of thirty years in the study area varies from a minimum of 457.6 mm in 2002 and maximum of 1042.1mm in 2008 (Table 2), which shows inter-annual variability over the study period. According to focus group discussions, years that show rainfall above the average are not sufficient to grow crops, forage and overcome shortage of water for irrigation, animals and domestic use. The analysis of linear trend showed that the amount of annual rainfall changed more between 1986 and 2015. Other study conducted by Chenung and Senay (2008) shows that a significant amount of rainfall decreases from the month of June to September around Baro-Akobo, Omo-Ghibe, Rift Valley regions and in southern Blue Nile Watersheds of Ethiopia.

The results of meteorological data analysis for the 1st decade show an increase in temperature by 0.37^0c while in the 2nd and the 3rd decades, it increased by 0.02^oC and 0.39^oC respectively (Table 3).

Farmers Perception on Climate Change

According to the information obtained from households about the change of climate at household level, 98.3% of the respondents perceived change in local climate, mainly in terms of increased temperature and decreased rainfalls. This study is in line with (Bewket, 2012) and unexpectedly, almost all of the respondents at central highlands of Ethiopia understand the increases in temperature and decreasing annual amounts of rainfall. About 98% of the

Table 3. Maximum temperature of three decades (1986-2015).

Year	1986-1995	1996-2005	2006-2015
	27.2	27.2	27.5
Average	27.9	27.7	27.5
Annual	27.6	28	27.1
Temperature	26.8	27.8	28
	27.3	27.5	27.4
	27.5	27.4	27.8
	27.2	28.5	27.6
	26.7	27.9	27.6
	27.5	27.8	27.8
	27.9	27.5	29.2
Total	273.6	277.3	277.5
Average	27.36	27.73	27.75
difference b/n mean	0.37	0.02	0.39
difference b/n total	3.7	0.2	3.9
t-test	0.05	0.93	0.10

Source: NMA (2016)

respondents perceived that the number of hot days increased, while about 96.7% of respondents agreed that the number of cold days decreased in the study area. These findings show that climate change is real and is happening in the area and disturbs the community livelihoods. The majority of respondents noticed a decrease in annual rainfall (85.8% of the total) and (13.3%) noticed change in time of rain. According to FGDs conducted in both villages, farmers were reported observing a shortening of the rainy seasons, rains start later than it used to be in the past. There is no significant difference between male and female and also educated and uneducated respondents' perception about the characterization of weather conditions in terms of temperature and precipitation. Male and female and educated or uneducated respondents have similar feelings about increasing trends of hot days over the years and decreasing trends of cold days over the year.

Small farmers in the study area perceived that loss of plant species like Mareko fana hot pepper, change in timing of rain, decline of agricultural yield, decreased water availability, prevalence of new human and animal diseases, introduction of new plant species and dry up of water resources are some of the indicators of climate change. The result of the study indicates that drought is one of the main climatic hazards affecting the communities in the study area. Whiles, flood, extreme heat, and livestock diseases are other significant hazards affecting the community livelihood. The prevalence of drought contributes for crop failure, food insecurity, increased conflict over scarce resources, migration of people in search of labor work and increased school dropout in the study area. Most of the respondents, about (55%) argued that the impact of drought on physical resources led to cracking of ponds, which lower their carrying capacity for future. Middelkoop et al. (2001) has also found that the change in hydrological system will increase the risk of flooding in summer season, while low flows during winter affects inland navigation which led to shortage of water resources for agricultural and homestead consumptions (Table 4).

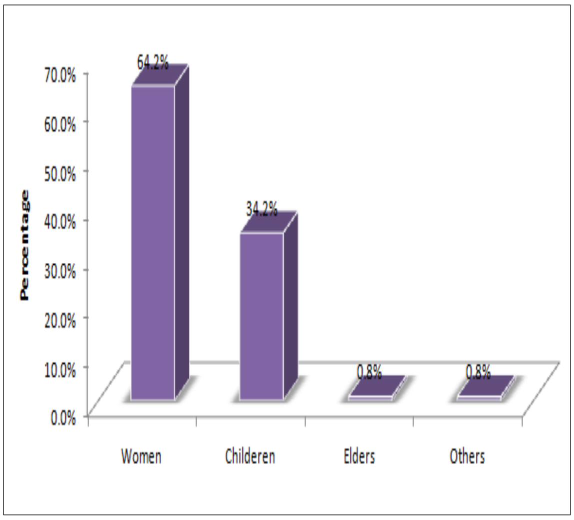

Fig. 1 Vulnerable segments of the community group.

Vulnerable Segments of Communities

The results obtained from the respondents show that 64.2% and 34.2% of them are women and children which are the most vulnerable social groups, respectively (Fig. 1). While, others like elders, landless farmers, poor farmers and disabled are also vulnerable. This is in line with IPCC (2007) which shows that the impact on livelihood of different wealth categories and social groups is not the same.

In the study area, women are more vulnerable to the impact of climate change, since they are more responsible than anyone else in the society in providing water for domestic use as well as wood for energy in order to prepare the required daily consumptions of the household members. According to participants of FGDs, women have several household responsibilities and household burden, for instance, caring for children and elders during harsh times in the family. Drought induced migration, therefore, causes gender and age specific experiences where women, children and the elderly tend to suffer while men migrate to towns to escape drought and search for a better life.

Table 4. Respondents perception of local climate change in Mareko district.

Parameter	Response	Gender		X^2	P-value	Education		X^2	P-value
		M	F			UE	E		
Characterizing weather in terms of temperature and precipitation change	Yes No	103 2	15 0	0.29	0.59^{ns}	78 2	40 0	1.01	0.31^{ns}
Trend of hot days over the year	increasing No change	103 2	15 0	0.29	0.59^{ns}	79 1	39 1	0.25	0.61^{ns}
Trend of cold days over the year	Decreasing No change	102 3	14 1	0.59	0.44^{ns}	78 2	38 2	0.51	0.47^{ns}
Trend of annual rainfall over the year	Decreasing Change time of raining Do not know	89 15 1	14 1 0	0.83	0.66^{ns}	68 11 1	35 5 0	1.72	0.94^{ns}

Note that: M=Male, F=Female, UE=Uneducated, E=Educated.

Household Adaptation Strategies to Climate Change

In order to reduce the negative effects of climate change, the farmers with small land holdings in the study area develop their own strategies. The results of educated respondents have a better understanding than uneducated ones (x^2=4.45, p.v=0.04). Respondents have a better understanding towards some adaptation options like changing a cropping date.

Table 5. Adaptation to climate change used by sampled households

Parameters	Responses	Gender		X^2	P-value	Education		X^2	P-value
		M	F			UE	E		
Early and late planting /changing sowing period	Yes	105	15			80	40		
	No	0	0			0	0		
Soil and water conservation	Yes	85	9	3.39	0.07[ns]	63	31	0.03	0.87[ns]
	No	20	6			17	9		
Shift from cattle to goats and sheep	Yes	39	0	8.25	0.004*	23	16	1.53	0.22[ns]
	No	66	15			57	24		
Income source diversification	Yes	32	5	0.05	0.82[ns]	21	16	2.36	0.12[ns]
	No	73	10			59	24		
Growing drought tolerant crops	Yes	78	13	1.09	0.29[ns]	56	35	4.45	0.04*
	No	27	2			24	5		
Sowing short season growing crops	Yes	91	14	0.54	0.45[ns]	72	32	1.50	0.22[ns]
	No	14	1			8	8		

Note that: M=male, F=Female, UE=Uneducated, E=Education

FGDs indicate that the local communities have their own indigenous adaptation strategies such as changing from livestock rearing to small ruminants, cut and feed, livestock selling and feeding. Other adaptation strategies include farmers engaged on firewood and charcoal selling, which is especially in Elala Gebiba village, as well as labor migration towards nearby towns and areas where irrigation is highly practiced. Petty trading has also become common in Hobe Jare Dembeka, pond preparation for water harvesting, shifting cattle towards another area for search of water etc.

Livelihood diversification through the integration of livestock rising, and fish production in rice paddies are also existing strategies to adopt climate change. This study is supported by (Tazeze et al., 2012) adaptation strategies used by farmers include; adjusting planting date, implementation of soil and water conservation techniques, use of improved drought resistant crop varieties, crop diversification and the use of crop diversification. As indicated in Table 5, changing cropping date (early and late planting) is the most commonly used method and used by 100% of respondents, whereas income diversification and shift from cattle to goats and sheep gets a little consideration among the major adaptive methods identified in the area.

There is no significant difference between male and female towards adaptation options except shifting from cattle to goats and sheep, that the male had a better understanding than female towards shifting from cattle to goats and sheep (x^2=8.25, p.v=0.004). There is no significant difference between uneducated and educated respondents' understanding about adaptation options except growing drought tolerant crops, that

Conclusion

Climate change differently affects developed and developing countries because of adaptation capacity. Developed countries have high adaptation capacity while developing countries have less adaptation capacity because of economy (wealth). The magnitude of actual effects will be dependent upon the level at which a given country depends their economy on rain-fed agricultural activities. A climate fluctuation, particularly temperature and rainfall is influencing livelihoods of the small landholders farmers in Mareko district in southern Ethiopia. Therefore, it is crucial to propose the most effective and efficient climate change adaptation strategies for the small farmers in the study area and beyond.

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