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Climate Variability, Causes and Consequences Percieved by Smallholder Farmers of Soro Woreda, Hadiya Zone, Southern Nations', Nationalities'and Peoples' Region, Ethiopia

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Abstract

Climate change has become environmental, social, institutional and economic threats to the world. People in developing countries have also been facing serious challenges due to environmental strains.This study was focused to assesse climate variability, causes and consequences perceived by smallholder farmers in Soro woreda of Hadiya zone, Southern Nations', Nationalities'and Peoples'Region. The study was conducted in 4 sample kebeles that were puroposely selected based on their accessibility, agro-ecological zone and population. Accordingly, 189 sample respondents were identified using simple random and systematic sampling. The primary data were collected using household survey,key informants interview, focus group discussions, and field observation. Secondary data on rainfall and temperature data from 1995 to 2014 were collected from National Meteorological Service Agency. Discriptive statistics, rainfall coefficient, coefficient of variation, linear regression and deviations of annual and monthly means from weighted mean were employed for data analyses. The results indicated presence of climate variability:increasing temperature, decreasing rainfall, and increasing seasonality of rainfall in the study area. The wettest and driest years were 1997 and 1998, and 2001 and 2004, respectively. Moreover, seven big rain months (MAMJJlAS) with moderate concentration, four dry months (NDJF), and one small rain month (O) were identified. Summer (34.%) and Spring (31.4%) seasons were with highest rainall contribution to annual rainfall. Nearly 2/3rd of sample respondents perceived human intervention as major causes of climate variability. Natural factors and Creater punishments due to human sin were perceived causes of climate variability by 18% and 10% of the respondents, respectively. Major consequences of climate variability perceived by smallholder farmers include increase in loss of agricultural outputs, loss of soil fertility, rill or gully erosion, decrease in ground water table, extinction of indigenous crops and trees, and human, crop, livestock and plant diseases, decrease in crop and livestock production, disintegration of social institutions and networks such as edir, equb and debo among others. Thus, it calls for proper insurance system, improvement of human and livestock health facilities, crop protection technologies, integrated irrigation and rain water harvesting technologies as well as livelihood diversitification towards sustainble agricultural production and livelihood development in Soro woreda in paricular and related areas at large.

Key words: Climate Variability, Smallholder Farmers' Perception, Hadiya, Soro, SNNPR

Introduction

Climate change is generally recognized as one of the greatest challenge of the 21st century (Van *et al*., 2009). The threat of climate change is real, happening nowadays, and is expected to hit developing countries the hardest (UN, 2007). These developing countries already faced social, economic and environmental stresses and resource constraints that limited their ability to adapt to climate change; these in turn are likely to be exacerbated by climate change (Kinyangi *et al*., 2009; FAO 2007). Hundreds of millions of people in developing nations will face natural disasters, water shortage and hunger due to the effects of climate change. Extreme weather events and climate variability are likely to become intense and frequent, while higher global temperatures could affect crops and water supplies and in turn spread disease.

However, Africa's total contribution to emissions of greenhouse gases is less than 7% of the world's greenhouse emissions (IPCC, 2007). The food security threat posed by climate change is greatest for Africa, where agricultural yields and per capital food production have been steadily declining, and population growth will double the demand for food, water and forage in the next 30 years (Anthony, 2005). African countries like Ethiopia are prone to greater impacts of climate change and variability mainly due to their low adaptive capacity and high sensitivity of their socio-economic systems (Olsen, 2006; Kurukulasuriya and Rosenthal, 2003). The impacts of increased temperature from global warming and reduced and variable percipitation is expected to reduce agricultural production, depress crop yields and put further pressure on marginal land that is currently under crop production and livestock grazing (FAO, 2007; Kinyangi *et al*., 2009).

Ethiopia is one of the developing countries which are vulnerable to climate change and variability (FAO, 2007). Low level of socio-economic development, inadequate infrastructure, lack of institutional capacity, and high dependency on natural resources made the country vulnerable to climatic factors including climate variability and extreme climate events (Agrawala and Fankhauser, 2008). Current climate variability is imposing a significant challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and sustainable development efforts, as well as by causing natural resource degradation and natural disasters. Likewise, agricultural production, water resources, agriculture, natural resources and biodiversity, and human and animal health are the most sensitive and highly at risk to climate variability in Ethiopia (Haakansson, 2009). However, there are spatio-temporal variation as the country has very diverse biophysical and socio-economic features. Thus, conducting study in areas like Soro woreda is mandatory for developement of better understanding and combat the impacts of climate variability. Therefore, this study was to assess climate variability, causes and consequences as perceived by smallholder farmers in Soro woreda, Hadiya Zone, Southern Nations', Nationalities'and Peoples'Region (SNNPR).

Materials and Methods

Description of the study area

Soro Woreda is one of ten woredas and one town adminstration in Hadiya zone, SNNPR. Astronomically, it is located from $7^{0}30'$ to $7^{0}43'$ North Latitudes and from $37^{0}35'$ to $38^{0}05'$ East Longitudes (Fig 1). Acording to the relative location, it is situated in the southern-tip of the zone, and bordered by Gombora woreda in the North; Oromiya Region and Yem Special woreda in the West; Dawro Zone, Kambeta Timbaro (KT) Zone, and Duna woreda in the South and Southeast; and Lemo woreda in the Northeast and East. The administrative center for Soro Woreda is Gimbichu, about 264 km South of Addis Ababa, and 200 km from Hawasa town, the capital of the SNNPR. The mean annual temperature is about 19^{o}C while that of rainfall is about 1260mm. It has two rainy seasons, *Belg* and *Kiremt*. *Belg* (short rainy) season extends from March to May while *Kiremt* (longest) rainy season is usually very intensive and extends from June to September, but some times varies to extend from July to August (Kibamo, 2011).

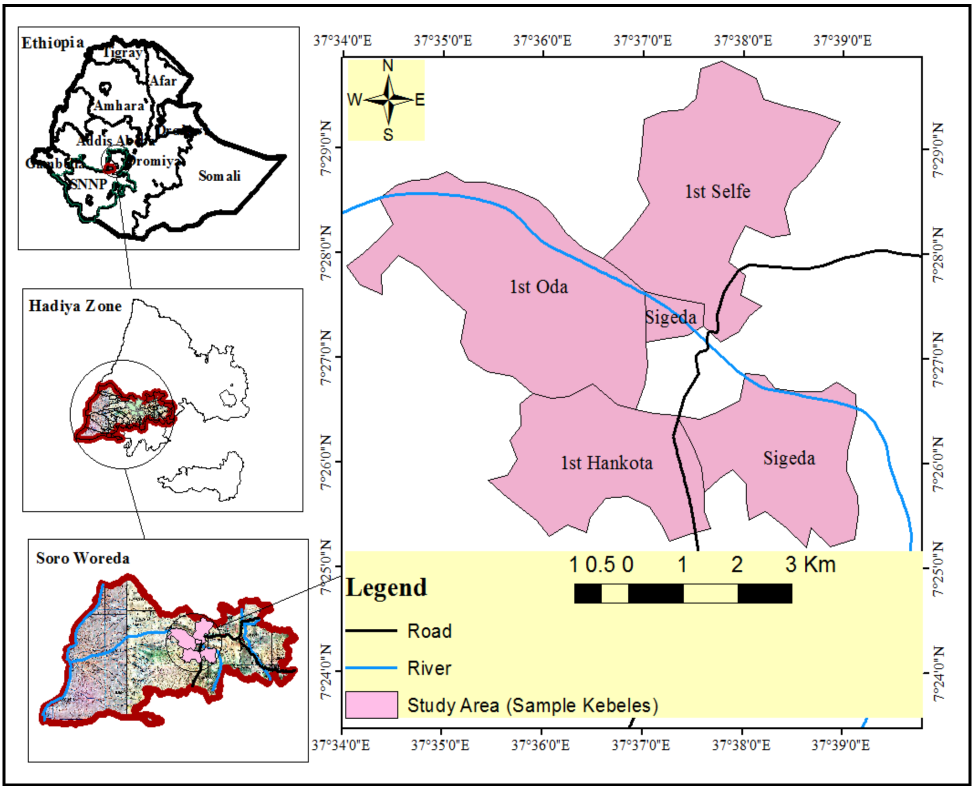


Fig 1. Location map of the study area

According to SWARDO (2014), the total area of the study is about 57,141 hectares, of which flat and moderately steep slope topography accounts for 35% and 65%, respectively. Its altitude ranges from 840 to 2850masl. Agroecologically, the woreda has typically 3 zones: namely, *dega* or humid (8%), *woina-dega* or subhumid (55%) and *kola* or dry (37%). The entire area has drained by trbutaries of Omo River including *Lintala, Ajacho* and *Gamunna* streams. The vegetation cover includes remnants of indigenous tress and recent plantation of exotic species such as eucalyptus species, mainly *Eucalyptus globules*.

Mixed agriculture is the major economic activity of smallholding farmers in *Soro* woreda of *Hadiya* zone, SNNPR. Dominant crops cultivated include wheat, *teff* (*Eragrostis tef*), maize *(Zea mays),* sorghum, oat, barley, potatoes, beans, peas, vegetables, bannana and Enset (*Enset ventricosum).* Enset (*Enset ventricosum)* is cultivated mostly by smallholder farmers. It is the staple food items for both human and animals feed and fiber in the study areas. It is also a source of income.

Methods of Data Collection and Analysis

The study employed mixed research design where both qualitative and quantitative methods were concurrently used for better undestanding through triangulation, convergneces, differences and some interfaces of data (Creswell, 2012).

The sample respondents were identified by using systematic sampling techniques based on the registration lists of each sample kebele. Numerous focus group discussions (FGDs) and key informant interviews (KIIs) were conducted by purposive sampling based on their work place, *kebele* representation, and wealth ranking. The total households residing in the study area was 2654. Out of this, 189 samples were selected by using the formula with a 93% confidence level and with 0.07 errors (Israel, 2012) stated as under:

$$n = \frac{N}{1 + N(e)^2}$$

Where; n= sample size

N = the total house hold head

e = Level of Precision

Table 1. Background of Sample Kebeles and Sample Households

No	Sample Kebeles	Agro-Climate Zone		No of population	Number of households		Sample households	
		Amharic	Hadiyssa		No	%	No	%
1	First Hankota	*Woyina dega*	*Hansaw/Kalaa*	3786	858	32	61	2.5
2	Sigeda	*Woyina dega*	*Hansaw/Kalaa*	4141	717	27	51	2.3
3	First Oda	*Kola*	*Kalaa*	5157	117	5	8	1.9
4	First Selfe	*Kola*	*Kalaa*	4365	962	36	69	0.3
	Total	**4**	**4**	**17449**	**2654**	**100**	**189**	**7.0**

In this study, four sample kebeles, out of 46 total *kebeles,* were puroposely selected based on their agro-ecological zone, accessibility and population size. The sample *kebeles* are First *Hankota, Sigeda,* First *Oda,* and First *Selfe*. They were stratified into two agro ecological zones: Midland (*Woinadega*) and Lowland (*Kola*), respectively. The share of sample respondents from each sample kebele was determined based on the sample determining formula (Burns ,1994) and the results were depicted in Table 1.

K=N/n

Where; K=the sample frame
N=the total number of households
n=the sample size

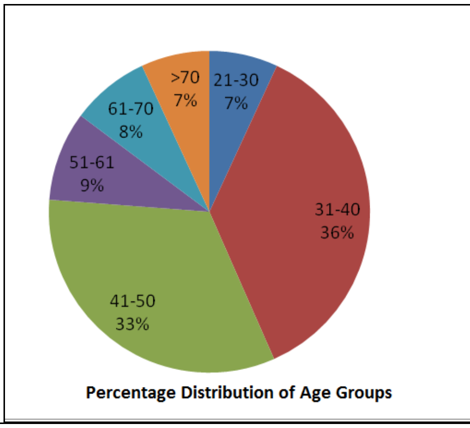
The study used both primary and secondary data. The primary data were obtained through semi-structured questionnaire, KIIs, FGD_S and field observations that were conduced from September 2013 to January 2015. Secondary data were obtained from various published and unpublished sources from web sources, archives and records to qualifty data collected from primary sources.

Time serious rainfall and temperature data ranging from 1995 to 2014 were collected from the National Metrological Agency (NMA), and Hossana and Adama Meteorological Service stations.The data collected through questionnaire, FGD_S and KIIs were analyzed using simple descriptive statistical analysis like frequency, mean, and percentages. The meteorological data were analyzed using rainfall coefficient (RC), coefficient of variation (CV), linear regression and deviations of annual and monthly means from weighted mean were computed using Statistical Package for Social Sciences (SPSS) version 16 and Microsoft Excel 2007 software. Then, collected and analyzed data were presented using figures, plates, and tables.

Result and Discussions

Respondents' Background Demographic Characteristics

Out of 189 sample respondents, (91%) are male household heads and the remaining (9%) were female household heads. With regards to their age composition, over 3/4 (76%) fall under 21-50age catagory (Fig 2). Educational status of the sample respondents indicated that 39.2% can not read and write, while 61.8% attended educational system ranging from primary to secondary education (Fig 2) as opposed to the report from the same area by Kibamo (2011) and Dereje (2014). This might indicate that remarkable number of the community has at least primary and secondary educational background that can be used as important input for agricultural and community development information exchange and thereby for climate information and early warning systems.



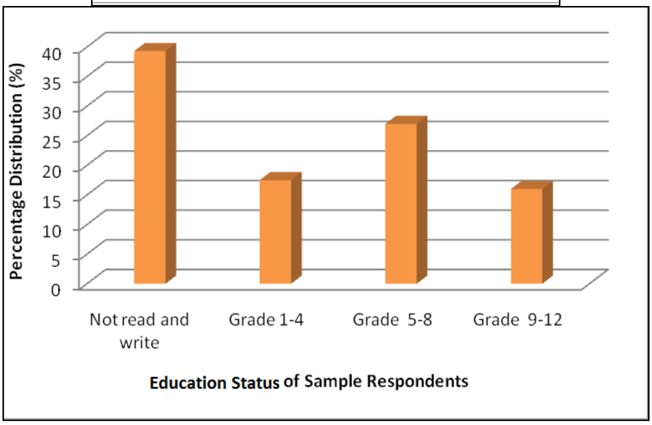


Fig 2. Distribution of Sample Respondent by Age (left) and Education Status (Right)

Among the sample respondents, about 89.4% respondents were married and the remaining 10.6% were separated due to divorce and widow. The family size ranges from 1 to over 21 and the largest share (68.5%) constitute those from with 6-10 family size followed by those with 11-20 family size that account for about 24.9%. This implies that the study area is among those with largest family size and hence any impact on the main livelihood would have severe negative repercussions on the smallholder farming community as the lion's share of them have family size ranging from 10 to >20.

Socio-Economic Characteristics of the Sample Respondents

Landholding among households ranges between 0.20 ha and 3.50 ha and the average land size is being 0.95 ha. This conforms with that of the average 0.85 ha ranging between 0.12ha and 5.70ha reported by Kibamo (2011) and Dereje (2015) in the nearby woredas. Access to farmland in the study area takes place in three ways: inheritance, gift and land distribution. Most of the sample households agree that there is scarcity of farmland in the study area. Two dominant causes of land scarcity reported by 70% and 30% of sample respondents were population growth and land degradation, among others, respectively.

The farmlands were situated on different slopes. Sample respondents indentified that about 19%, 47.5%, and 33.5% of their farmlands have flat, gentle and steepy slopes, respectively. This was also confirmed during KIIs and FGDs with different stakeholders. Acccoring to traditional classification of farmland soils based on color and fertility, there are three types of soils includng red, reddish brown and black. Accordingly, about 56.6% of the soil of *Soro woreda* identified as very infertile, 27% as relativily fertile soil, and 16.4% as fertile soil (Table 2). Farmers perceived dark soil as very fertile since it provides high yield unlike the reddish brown and red soils. Furthermore, almost all farmers confirmed that soil fertility was declining from year to year. The major indicators of decline in soil fertility were reduction in soil productivity, decline in crop yield, high demand for agricultural inputs and land management, changes in soil color, texture and structures, land degradation and rock outcropping. Kibamo (2011) also identified the above major indicaters as contributing factors to the decline in soil fertility in the area.

Table 2. Land Size, Soil Types and Crop Productivity

Land size	Percent (%)
<u><</u>0.5	57.5
0.5-1.0	26.5
1.0-1.5	7.6
1.5-2.0	6.3
<u>></u>2.0	2.1
Total	**100.0**

Soil type	Percent (%)
Black	16.4
Red-Brown	27.0
Red	56.6
Total	**100.0**

Land Productivity	Percent (%)
High	4.8
Medium	43.8
Low	51.4
Total	**100.0**

The respondents revealed that the average annual livelihood income ranges from 30,000.00 to 10,000.00 Ethiopian Birr. The income ranges seemed relatively equivalent with the report from Kuni and Haramaya districts in Hararghe highlands (Solomon ,2013). The average annual total income of the resource poor, middle and high ranking household heads was estimated as Birr 10,500.00, 15,750.71, and 29,650 per year, respectivily. In the study area, the major sources of income include crop sale, livestock and livestock products, petty trade, rural and urban wage labour, land rent, handicraft, rent income from animals such as donkey and remittances (Fig 3). From the above sources of income, mixed farming activities accounts for the largest portion as responded by nearly 3/4th of the respondents while the remaining 1/4th of the respondents got their earning from off- and/or non-farm activities including petty trade, handicraft, urban daily work, and rural daily wage labour. The data indicated that agriculture dominantes the livelihood of the community. As identified during the FGDs and KIIs, most of the resource poor and middle income portion of the community were pushed into non-farm sector due to lack of access to oxen, farmlands, agricultural inputs as well as impacts of climate variablity. The role of off-farm and non-farm activities such as income from labour work , petty trade, and handcrafts recently continued to support the livelihoods of the community (Dereje, 2015).

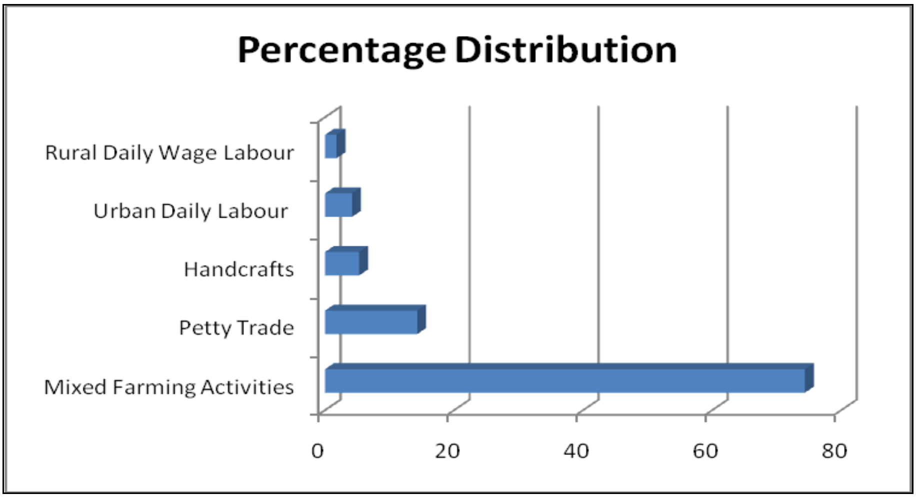


Fig 3. Percentage Distribution of Sample Households by Livelihood Actitivties

Features of Climate Variability

Temperature Variability

This section discussed the major features of temperature including monthly, seasonal and annual distribution as well as trend and variability . As disclosed in Fig 4, the trend equation and R value imply significant variations in the maximum and mean annual temperature since their respective R values were 0.74 and 0.54 (which is $\geq$ 0.5) while that of minimum annual temperature was insignificant as R is 0.19 (which is below 0.5). This could be substantiated by the study carried out in the nearby Woliso area (Getachew *et al.,* (2014) . However, it should be noted that since this data was based on only two decades' meteorological information, it requires further investigation and confirmation.

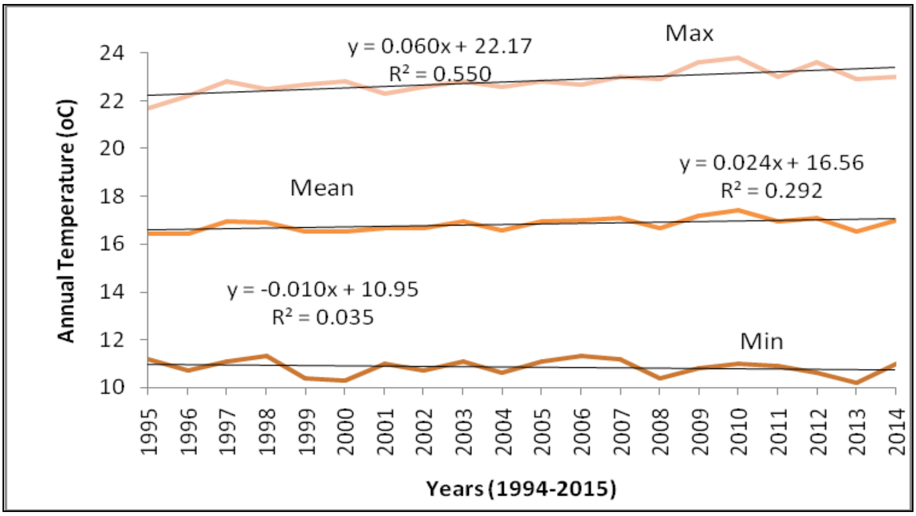


Fig 4. Trend Analysis of Annual Temperature of Hossana Station

Rainfall variability

The general annual mean rainfall distribution of the last two decades indicated relatively similar amount of rainfall, which is about 1136.8mm ranging from 546.5mm (2001) to 1556.4mm (1998) as displayed in Fig 5.

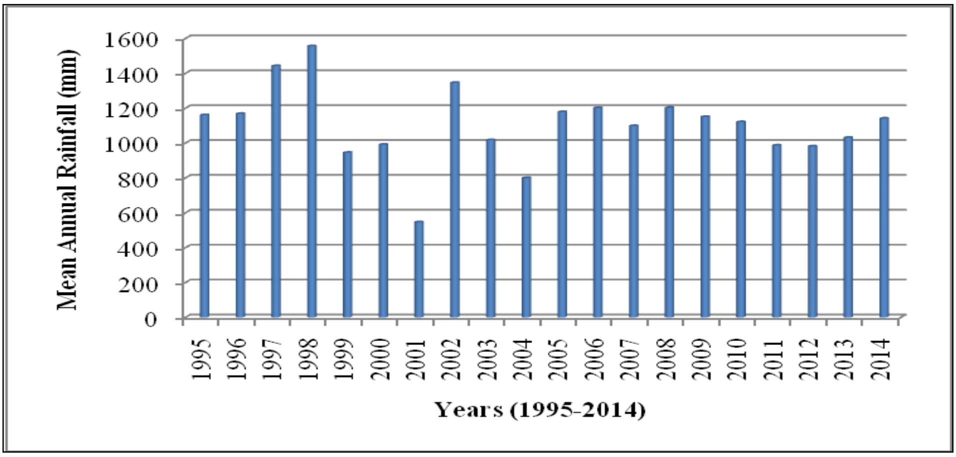


Fig 5. Annual Total Rainfall Distribution of Hossana Station for a period of nineteen years (1995-2014)

Table 3. Rainfall Designation Based on Mean Monthly Rainfall around Soro Woreda

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
RC[1]	0.36	0.48	1.09	1.48	1.53	1.33	1.77	1.84	1.63	0.8	0.29	0.44
Design[2]	Dry[3]	Dry[3]	BRM[5]	BRM[5]	BRM[5]	BRM[5]	BRM[5]	BRM[5]	BRM[5]	SR[4]	Dry[3]	Dry[3]

Source: Computed based on Monthly mean rainfall (1995-2014, NMSA) and Daniel (1977); **NB:** RC[1]= Rainfall Coefficient; Design[2]= Designation of rainfall coefficient per month; Dry[3]= Dry months; SR[4]= Rainy month but with small rain; BRM[5]= Rain months with big rain of moderate concentration.

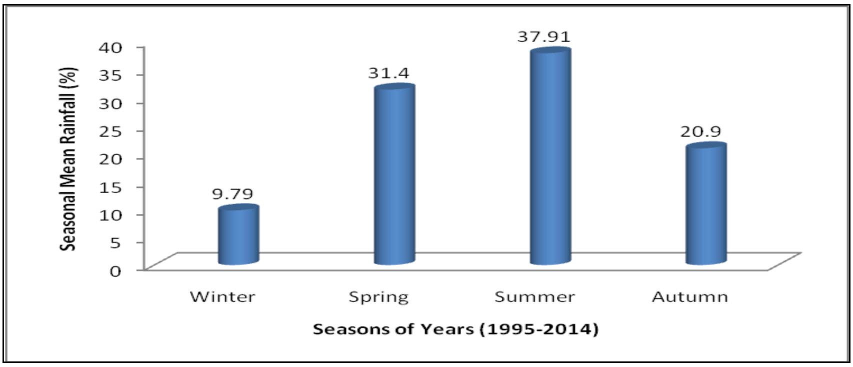


Fig 6. Percentage Distribution of Seasonal Mean Rainfall Amount for a period of nineteen years (1995-2014)

As revealed in Fig 6, the seasonal distribution of rainfall for the last two decades showed highest share for Summer (37.91%) followed by Spring (31.4%) while the lowest amount of rainfall was in winter (9.79%). The respondents also perceived that summer (*kiremt*) is the main rainfall season although they underlined its irreguarities and variability; Some times the rain comes late and lasts for shorter period of time. On the otherhand, the dryness of the winter season can be confirmed from the computation of RC in Table 3.

The overall trend of mean annual rainfall distribution in Soro woreda was found slightly negative as the linear equation is Y=-7.029x +1177 but statistically insignificant as R^2= 0.036 (where R value is 0.19, i.e., below 0.5; Fig 7). The trend showed decline in rainfall in the last two decades. The study report from Woliso area also indicated similar result (Getachew *et al.*, 2014) . Similarly, anather study revealed that there was rise in rainfall from 1965 to 1984 but declined until 2009 (Seiler *et al.*, 2013).

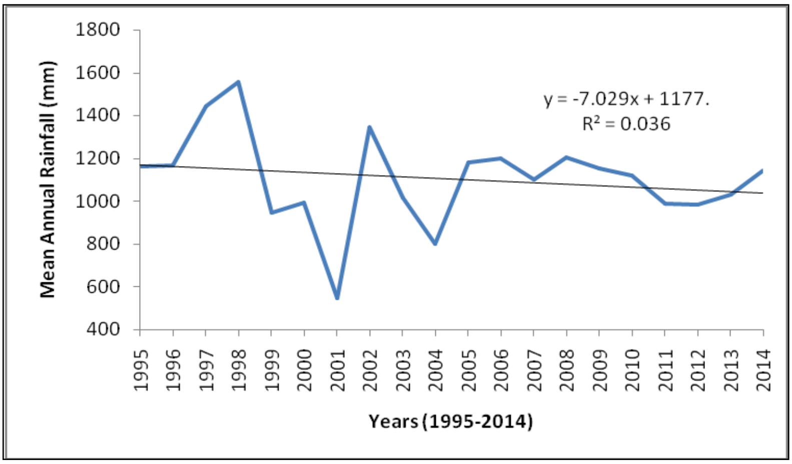


Fig 7. Percentage Distribution of Seasonal Mean Rainfall

Based on the deviations of the actual annual or monthly rainfall from the statistical mean, the month or the year that receives over 25% or -25% is categorized as wet and dry month or year respectively (Raju 2012 cited in Solomon 2013). Accordingly, four wettest months were identified including May, July, August and September while four driest months including November, December, January and February were identified (Fig 8) ; these findings were also approved by Getachew *et al.,* (2014). Similarly, 1997 and 1998 were the wettest years while 2001 and 2004 were found to be the driest years (Fig 8).

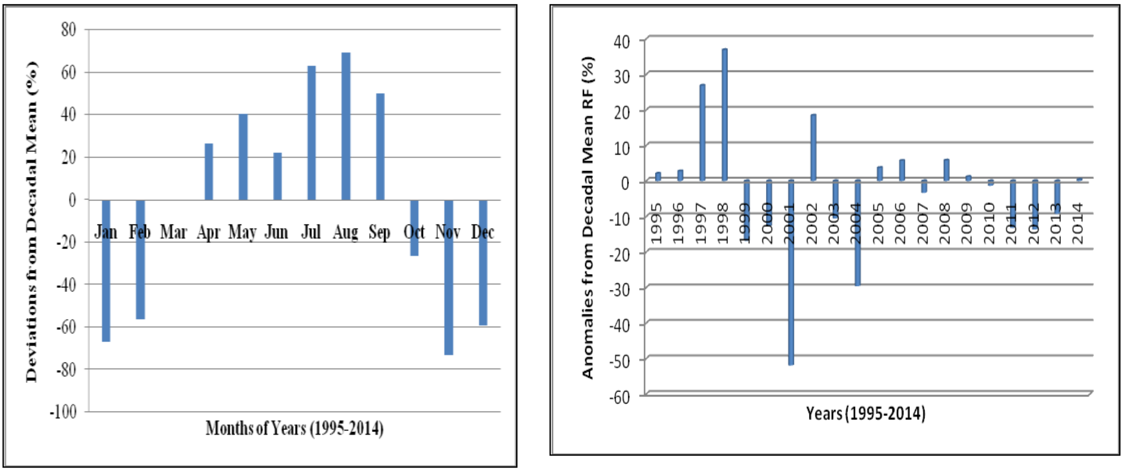


Fig 8 . Deviations in Monthly(left) and Annual Rainfall (right) of Hossana Station

Farmers' Perception on Temperature and Rainfall Variability

The study indicated that 97.4% of the respondents agreed on the increase in temperature while the remaining 2.6% of the respondents agreed on decrease in temperature in the study area. Similar cases were reported from Adiha area of Tigray region (Dejen , 2011) and Woliso area (Getachew *et al.,* 2014). With reagrd to the present study, 95.2% of the respondents perceived variability in the amount and distribution of rainfall in the last few decades in *Soro woreda* of *Hadiya* zone, SNNPR. Specificially, about 2/3rd (66.67%) of the respondents perceived rainfall period comes late and goes early. While, neary 1/4th (24.34%) of tthe respondents indicated that the rain period comes late and goes late. However, 5.82% of them percieved that rain comes earily and goes earily (Fig 9). This seems to coincide with the computation that justified rainfall variability presented in the preceding section.

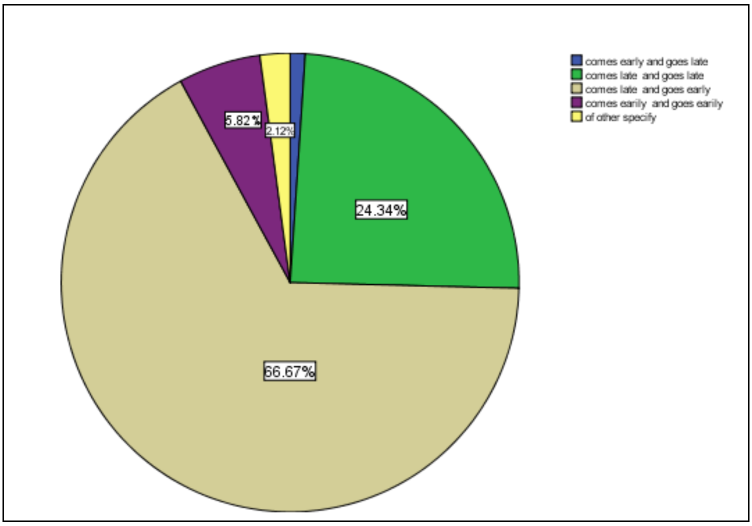


Fig 9. Percentage Distribution of Farmers Perception on Rainfall Variability

Farmers' Perception on Causes and Consequences of Climate Variability

According to 2/3rd of the respondents, farmers' perception on causes of climate variability was associated with human induced factors. However, 18% and 10% of the respondents perceived that punishments from God/Allah due to human malaction (sin) and natural factors were the causes of climate variability respectively (Table 4).

Table 4. Causes of Climate Change Perceived by Sample Respondents

Causes of Climate Change	Frequency	Percent (%)
Human actions	123	64.9
Punishement from God/Allah	34	18.0
Natural process	19	10.0
Both human and natural action	13	7.0
Total	**189**	**100.0**

Almost all of the respondents perceived that climate variability caused land degradation and loss of agricultural productivity in the study area. The identified lists of major consequences of climate variablity perceived by smallholding farmers include increase in loss of agricultural production, loss of soil fertility, rill or gully erosion, decrease in ground water table, extinction of indigenious crops and trees, decrease in rainfall amount, rise in temperature, deforestation, and decrease in livestock production (Table 5).

Table 5. Distribution of Consequences of Climate Variability by Sample Respondents (No= 189)

Perceived Consequences of Climate Variability	Percent (%)
Loss of agricultural production	96
Soil fertility loss	89
Rill or gully erosion developement	90
Decrease in ground water table	70
Extinction of indigenious crops and trees	92
Decrease in rainfall amount	95
Temperaturerise rise	99
Deforestation	86
Decrease in livestock production	94

Participants of FGDs and KIIs listed the major consequences recently prevalent in *Soro* woreda of *Hadiya* zone of SNNPR. These include human disease, plant disease, livestock disease, low annual rainfall, high temperature, and unwanted plant species. According to the elders group participated in FGDs, new and exotic diseases began to affect people in the study area after prevalent occurrence of climate variability.

In the study area, *Enset* disease, localy known as *Aloyaa*, is a very serious problems due to lack of curable medicine. This disease usually attacks all the varieties of *Enset* plants both in the midland and low lands of the study area (Dereje , 2015). Similarily, bannana plant is also affected by this disease and it is the distractive disease that leads to complet wilt of the plant. Moreover, coffee disease (locally known as *Bunni kosha)* affected coffee production and productivity especially in the low land of the study area. On the otherhand, erosive and intensive short rainfall in *Soro woreda* enhanced soil erosion from the gentle and steep slope areas. Recently, there are frequent formation of gully and rills along crop fields, roads, and gardens (Fig 10) which was also reported by Kibamo (2011) and Dereje (2015).

Fig 10. Eroded Land in Sigeda Kebele in Soro Woreda, Hadiya Zone, SNNPR

Conclusion

The study revealed that there was slight variability in temperature and rainfall in Soro Woreda, Hadiya Zone, in the last two decades. Human and natural factors were perceived the major causes of climate variability. Socio-economic and environmental problems due to climate variability include human disease, plant disease, livestock disease, low annual rainfall, high temperature, soil degradation, unwanted plant species, and low agricultural output. Therefore, the socio-economic challanges and environmental strains as aresult of climate variability in Soro Woreda,Hadiya zone, calls for proper insurance system, improved human and livestock health facilities,improved crop protection technologies, integrated irrigation and rain water harvesting technologies as well as diversitified livelihood towards sustainble agriculture production and livelihood development.

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