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'MANIFESTATIONS AND EXTENT OF CLIMATE CHANGE'. THE CASE OF MERTI DISTRICT, ARSI ZONE, OROMIYA REGION, ETHIOPIA

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ABSTRACT

Climate change threat has got a pronounced impact throughout the world. This study assessed the manifestations and extent of climate change in Merti district, Arsi zone, Oromia Regional state, Ethiopia. The study examined the indicators and perceptions of climate change by local farmers, and climate trend of the area. The study was based on key informant interviews, focus group discussions, household survey questionnaire and time series meteorological temperature and rainfall climate data. Respondents confirmed the variability in rainfall frequent delay, showing irregular patter both at the start and end of the rainy season which usually begin latter or end up earlier , unreliable distribution, erratic a general decreasing trend of rainfall was observed and an increasing warming trend with respect to temperature and abnormal conditions like occurrence of unseasonal, unusual and extreme high and low rain, occurrence of extreme hot and cold temperature, and frequent happening of drought and flood, forest and vegetation cover destruction and diminishing formerly existing wild animals, crop cultivation and livestock production decline are indicators of climate change and variability and burning issues for all the communities in the study area. The recorded time series meteorological temperature and rainfall climate data (1990–2014) also showed an increasing trend in temperature and high inter-annual and intra-seasonal rainfall variability.

Contribution/ Originality: This research will give baseline information for other researchers, practitioners, development actors, and research organizations by assessing and assembling existing information about the manifestations and climate change in Merti and determinants factors in undertaking possible climate change response mechanisms at the smallholder farming household level.

1. INTRODUCTION

Climate change threat has got a pronounced impact throughout the world particularly on social and natural environments, including forest cover and species bio-diversity [1]. According to different empirical studies disclose that the global change in climate is presenting major threats for developing countries, in which case the extent is being manifested and magnified by natural and human activities [2]. Developing countries like Africa being the most vulnerable as a result of various stress causing situations and due to the fact that it's state of low adaptive horizon [3]. The continent is already affected by the current sever threat of climate change especially climate dependent activities and indirectly social system such as poverty, conflict, education and health [4]. High risk areas like lowland, arid and semi arid areas are highly sensitive to the impacts of climate change. Those households found around such types of areas are supposed to be poor and economically incapable [4] and more recurrently prone to frequent and adverse occurrence of events like drought, flood situations, increase in temperature, decrease and unreliability of precipitations and other related events which are the manifestations of climate change in Africa present a multitude of effects on natural resources, water resource, food security, human health, infrastructure and development, particularly on agriculture [5]. Ethiopia, which is one of the sub-Saharan African countries, is frequently vulnerable to climate change. Climate change indicators and manifestations in Ethiopia have already being observed in the recorded history of the country. Such as increasing and recurrent happening of drought and flood situations occurrence of climate shifts for instance in every ten years a 0.2 0C increase in annual temperature have been observed in the last 5 decades, whereas in every year to two years unreliable and insufficient rainfall, showing erratic pattern in its onset and offsets particularly presenting a livelihood challenge in the lowland part of the country [6]. High risk areas of the country lowland, arid and semi-arid areas characterized by high rainfall unreliability which has lead to elongated period of drought, being cause for dramatic yield reduction in agricultural crops even a complete failure, a grater deal of stress on agro biodiversity, problem of food security and health, and societal disturbance or otherwise displacement are the most pressing issue [6]. Merti is now being vulnerable Districts in Arsi zone Oromia region to climate change. Farmers in Merti being smallholder are highly dependent on climate sensitive agricultural activities which are rainfall dependent and largely influenced by the effect of climate change. So many climate related problems are occurring in the area rainfall is decreasing from time to time, temperature is increasing, bio-physical phenomena's are aggravating such as drought, flood, reduction and failures of crop yield and livestock production, heat sensitive animal disease, pest and insect outbreaks, vegetation and forest cover destructions and huge influence on soil properties like land degradations, erosion, and soil crumbling are among some of the factors now clearly observed in the area. Actually wider spread researches have been done on climate change. Furthermore, little even no similar research issues have been done in the area. So these brought my attention to undertake this peculiar research in the area. Thus, this study therefore attempts to assess the 'Manifestations and Extent of climate change"; the case of smallholders in Arsi Zone of Oromia region, Ethiopia.

1.1. Objectives of the Study

1.1.1. General Objectives

- The overall objective of this study is 'to assess the manifestations and extent of climate change' in the area

1.1.2. Specific Objectives

The specifically, the objectives of this study are stated as follows:

- To identify the indicators of climate change noticed by local farmers in the area.
- To assess local people's perceptions of climate change.
- To identify the trends in climate in the area.

2. METHODOLOGY

2.1. Methods of Data Collection

The data used for the study were collected in February, 2016. The research employed both qualitative and quantitative data types gathered from primary and secondary sources.

2.1.1. Primary Data

The primary data sources were generated by the researcher in order to measure the independent variables. The primary data was collected by using various techniques such as key informants, focus group discussion and household survey.

Key Informant Interviews

Key informants selected for the study was people who are supposed to be knowledgeable of the locality and have a good knowledge of the area. These key informants thus mainly included elderly men and women, religious and opinion leaders in the community. These data collection techniques were employed mainly to collect qualitative data at community level concerning the changes in the environment, indicators, manifestations, extent and perceptions of climate change in general in the area, and using the information obtained in questionnaire designing processes.

Focus Group Discussion

The focus group discussions were made with a group of community representatives (eight to ten members) comprised of elders, men, women, the youths and government employee's, those who are directly or indirectly engaged or involved in agricultural service with farmers and administrative bodies. A checklist that included relevant information on indicators, manifestations, perceptions and impacts of climate change in the study area were the main points prepared to guide the discussion.

Household Survey

Structured questionnaires were developed to collect majority of the required quantitative data. The primary data regarding environment, indicators, manifestations, extent and perceptions of climate change was collected using semi- structured questionnaires.

2.1.2. Secondary Data

The secondary data were collected from relevant offices at zonal levels and district levels. Data collected on annual socio-economic reports, time series data sets on weather variables in the locality for at least 24 years of time series climate variable data i.e. is temperature and rain fall data from Meteorological Stations, damage reports, related documents from NGOs and mass organizations working in the community. The secondary data and information about common climate extreme events and related information on the impacts on agriculture sector and the consequences from related departments and institution were also collected. Different literatures including books, journals, reports and technical working papers were reviewed to identify the current situation of climate variability and impact on agricultural productivity (crops and livestock).

2.2. Data Analysis

The data collected was analysed by using Statistical Package for Social Science (SPSS, version 20) and Microsoft Excel Software (Version 10), and data was organized; results were presented in various statistical data analysis techniques such as descriptive analysis (frequency distribution tables showing the number of households corresponding to their answers usually expressed in percentages, mean, standard deviation) and chi-square tests were employed.

3. RESULT AND DISCUSSION

3.1. Indicators and Manifestations of Climate Change in Merti Woreda

3.1.1. Climate Related Indicators

The survey result indicated that, majority of the respondent household perceived the existence of climate change indicators in the study area (Table 1). Most of the respondents about (92.7%) perceived increasing temperature, as well as 96.3% perceived that rainfall is decreasing with a great deal of variability at the start and end of rain season. As the survey result showed 78.3% of respondents witnessed the rain begin later than usual and also 85.3 % said rainfall end up earlier than usual. This study is in line with works of Biazen [7] who has stated that the increase in temperature attributed to the dry season to be longer and the main wet season to be shorten even fail, as well as the staring and the ending of rainy season becoming more intermittent as it may happen early or late, may supposed to stop early, even complete failure of both short and main wet seasons and become part of the dry season, sometimes in short period heavy rainfall followed by high rate of runoff,, erosive as result of poor vegetative cover.

Table-1. Overall relative frequencies of trends in the environmental factors

No	Indicator	Trend	Frequency	% across sample
1	Temperature	Increase	177	92.7
2	Rainfall	Decrease	176	92.1
3	Rainfall pattern	Begin later than usual	149	78
		End up earlier	163	85.3

Source: Computations from field survey, 2016

3.1.2. Bio-Physical Indicators

Some sorts of physical environmental indicators like drought occurrence and flood situations are nowadays presenting a challenge for farmers in the study area (Table 2). Farmers in the survey result have showed that drought and flood problems are increasing from time to time. For this 81.7% and 77.5% of the respondents respectively said as they are facing challenges from increasing incidence of the above mentioned environmental shocks. These environmental shocks being most incidence of the present day climate related natural hazards affecting the country from time to time which is actually global issue however not sever as the countries like in developing countries in general, Ethiopia in particular [8]. In the present study area with regard to crop production and livestock productivity, the descriptive result depicted that 90.1% and 88.0% respectively confirmed decreasing trend of the two agricultural practices in the area. The various climate related shocks again resulting in an alarming crop yield decline. The rise in temperature impacted the crop growing seasons leading to increased food insecurity, causing an increasing rate of livestock disease vectors transmission and distribution. At the time of prolonged drought as a result of delay in the onset of rain crop land lost its moisture and unable to tillage, range land and forage biomass deficit which act as a consequence of livestock mortality, and lack of precipitation disrupt cultivation, making uncertain agricultural production, negatively impacting farmers.

Table-2. Overall relative frequencies of trends in the biophysical environmental factors

No	Indicator	Trend	Frequency	% across sample
1	Drought situations	Increase	156	81.7
2	Flood situations	Increase	148	77.5
3	Crop yield and variety	Decrease	172	90.1
4	Livestock production	Decrease	168	88.0
5	Soil fertility	Decrease	191	100

Source: Computations from field survey, 2016

With regard to the biotic components the survey identified vegetation covers, forest cover and the presence or existence of wildlife as indicators and manifestations of climate change in the area (Table 3). The survey result coincides with the knowledge gathered from the KIs. According to the KIs eye witness tree species like Podocarpus (Zigba), Olea (Woyra), Hagnea (Kosso), Lol were now in the present time said to be disappeared, Wild animals such as Bushbuck (Agazan), Tiger (Nebir), Monkey (Zinjaroo), Calabus monk (Gureza), Warthog (Karkaro) were among wild animals now diminished from the area. Forage species Hyperrenemia (Sembelet), Bermuda grass (Serdo), Akirma, Muja, were forage grass species now disappeared from the area. Accordingly, 62.8, 71.2 and 65.5% of the respondents were observed that vegetations, forest and wildlife in the area were diminished and the rest of the respondents 37.2, 28.8 and 34.6% also convinced that vegetations, forest and wildlife found in the area were decreased.

Table-3. Overall relative frequencies of trends in the biophysical environmental factors

No	Indicator	Trend	Frequency	% across sample
1	Vegetation cover	Decrease	71	37.2
		Diminished	120	62.8
2	Forest cover	Decrease	55	28.2
		Diminished	136	71.2
3	Wildlife	Decrease	66	34.6
		Diminished	125	65.4

Source: Computations from field survey, 2016

3.2. Local People's Perception of Climate Change Indicators and Manifestations

3.2.1. Temperature

The trend of temperature in the study area as the result showed was typically increasing as we go from top to down altitudinal basis. It is actually true that the low land part sense more the increase in temperature. In the lowland part of the area, 98.5% of the respondents perceived that the temperature is increasing alarmingly (Table 4). Depending what is now happening and what was also before in the midland and highland, respondents in the midland and highland 90.9 percent and 88.2%, respectively, agreed that the current temperature in their local environment is completely different from the previous environmental condition, this is actually from their experience of knowing the area through comparing the past and the present.

3.2.2. Rainfall

Rainfall distribution logically varies from place to place from time to time and from season to season. Variability in the rainfall amount including its onset time and offset is indicative of climate change in Ethiopia in particular in the study area. The result of sample household interview reviled that there was a decrease in rainfall in the area over the last decades (Table 4). Depending on the agro-ecological basis 83.8% of respondents in the highland and 94.5% in the midland witnessed a decrease in rainfall in the area. However: severity of rainfall fluctuation and decrease highly manifested in the lowland which as 98.5% of the respondents.

Table-4. Agro ecological difference among sample households in perceiving climate change

Variable	Category	% within Agro climatic zone			Pearson X^2_ value	P_ value
		highland	midland	lowland		
Rainfall	decrease	83.8	94.5	98.5	11.219	0.024**
	no change	10.3	3.6	0.0		
	unpredictable	5.9	1.8	1.5		
Temperature	Increase	88.2	90.9	98.5	6.908	0.141
	No change	7.4	3.6	0.0		
	Unpredictable	4.4	5.5	1.5		

Source: Own data (2016). Note: ** signifies level of significance at 5%.

3.2.3. Drought

Drought problem in many parts of the African continent particularly in sub-Saharan African countries is common. For instance, Ethiopia is commonly affected by the problem of recurrent drought. Drought in the study area varies according to the agro ecology. Although the problem occurs in the area, the lowland part is strongly affected by the phenomena. Accordingly, 97.1 percent of the respondents in the lowland observed that drought has become a challenge for their livelihood (Table 5). Following the lowland, real problem of drought is also now affecting the midland and highland as such 80 and 67.6% respectively of the respondents observing the problem in their locality. In general, a higher proportion of respondents in the lowland area have perceived an increase in drought and flood occurrences whereas a substantial proportion of respondents in the highland areas reported no change for both.

Table-5. Agro ecological difference in sample households in perceiving climate change

Variable	Category	% within Agro climatic zone			Pearson X^2_ value	P_ value
		highland	midland	lowland		
Drought	Increase	67.6	80	97.1	19.901	0.001***
	No change	26.5	16.4	0.00		
	Unpredictable	5.9	3.6	2.9		
Flood	Increase	69.1	78.2	85.3	6.974	0.137
	No change	26.5	14.5	11.8		
	Unpredictable	4.4	7.3	2.9		

Source: Computations of field survey (2016). *** Signifies 1% level of significance

3.2.4. Natural Vegetation Cover

Another way of describing the extent of climate change in Merti was looking at the natural vegetation cover. According to the respondents' observation of the area, the natural vegetations now are being converted in to crop land through deforestation because of population increase. Accordingly, 55.9% of the respondents agree that the natural vegetation cover in the highland has decreased while 44.1 % said it has totally diminished. The manifestation as we go from top to down is even worse. Concerning the midland agro-ecology, majority (69.1%) had observed that the natural cover has already diminished. The rest 30.9% also agree that it has decreased. The survey result showed that, the problem is manifested highly in the lowland, 76.5% of the respondents viewed that the vegetations diminished and 23.5% said it has decreased compared to what it used to be in the past.

3.2.5. Forest Cover

Forest availability is a problem in the world today. Respondents who are enough elderly were talk confidentially that the area lost its forest coverage completely (Table 6). The problem of agriculture intensification followed by the population increment is mentioned as a greatest challenge for the forest of the area. Majority were responding by diminished for the availability of forest cover in the area such as 63.2, 67.3 and 82.4% respondents in the highland, midland and lowland respectively which is just clear indicative of the change of environment in the area.

With respect to the wild animals in the area under study as the descriptive result from the formal survey revealed that majority of the respondents in all the three agro ecological zones concluded as wild animals in the area are being diminished (Table 7). Availability of streams is also completely diminished in the lowland and 94.5% and 92.6% of the respondents in the midland and highland agreed that number of streams were being diminished (Table 7).

Table-6. Response of sample households regarding the vegetation and forest cover of the area

Variable	Category	% within Agro climatic zone			Pearson X^2_ value	P_ value
		highland	midland	lowland		
Vegetation cover	Decrease	70.5	67.3	22.1	46.919	0.000***
	No change	1.5	0.0	0.0		
	Diminished	23.5	32.7	77.9		
Forest cover	Decrease	8.8	5.5	1.5	3.712	0.156
	Diminished	91.2	94.5	98.5		

Source: Computations of field survey (2016).

Note: *** = statistical significance at 1%.

Table-7. Agro ecological difference in sample households in perceiving climate change impacts

Perceptible impact	%within Agro ecology difference						X^2-value
	Highland		Midland		Lowland		
	Decrease	Diminished	Decrease	Diminished	Decrease	Diminished	Asym. Sig
Wild animals	17.6	82.4	0.0	89.1	8.8	91.2	0.272
Number of streams	7.4	92.6	5.5	94.5	0.0	100.0	0.087*

Source: Computed from field survey (2016).

Note: * signifies level of significance at 10%.

From the highland 80.9 percent witnessed extreme high temperature where as 70.6 percent of the respondents said there is extreme low temperature occurrence while 94.5 and 49.1% responded occurrence of extreme high and low temperatures respectively in the midland where as in the lowland 100 and 29.4% perceived extreme high temperatures and low temperatures respectively (Table 8). For the occurrence of extreme low and high rainfall 54.4, 85.5 and 95.6 and also 70.6, 72.7 and 79.4 percent in the highland, midland and lowland respectively perceived the case. Concerning the occurrence of dry wind being as indicator for climate variability and change in the study area respondents 64.7, 87.3 and 92.6 in the highland, midland and lowland respectively were felt this condition year after year. X^2 test indicated significant difference among households regarding their perceptions across the agro ecologies.

Table-8. Agro ecology differences in perceiving extreme climate conditions

Perceptible impact	Mean Agro ecology difference in %						Pearson X^2_ value	Asym.sig
	Highland		Midland		Lowland			
	1=Yes	2=No	1=Yes	2=No	1=Yes	2=No		
Is there a time/season where you feel extreme high temperature?	80.9	19.1	94.5	5.5	100.0	0.0	17.05	0.000***
Is there a time/season where you feel extreme low temperature?	70.6	29.4	49.1	50.9	29.4	70.6	23.072	0.000***
Is there a time/season where you feel extreme high rainfall?	70.6	29.4	72.7	27.3	79.4	20.6	1.494	0.474
Is there a time/season where you feel extreme low rainfall?	54.4	45.6	85.5	14.5	95.6	4.4	36.101	0.000***
Is there a time/season where there is occurrence of dry win?	64.7	35.3	87.3	12.7	92.6	7.4	19.246	0.000***

Source: own data (2016).

Note: **** signifies the level of significance at P<1%.

Human activities in the study area create greater causes of climate change impacts. Human activity is often directly related to the natural environment. Therefore to explain the link with climate change based on the study results in the area, for example, climate change might result in frequent crop failure and death of livestock so that people are forced to go to the forest to cope with the income crises, or, due to decrease in agricultural crop production, more and more people are getting a substantial part of the income from selling forest products which increase the pressure on the forest, or due to low productivity of agriculture local people need to cultivate larger farms to adequately supply their needs which increases the pressure on forestlands leading to higher rate of deforestation, or higher dependence on charcoal making increases the incident of forest fire in the area. More of the above explanations indicate the information from key informant in this regard which is in line with the survey result (Table 9). The table below shows the most important human activities that are considered to be challenges to natural resources in Merti. However: respondents in the midland and highland practice production of timber while the lowlanders do not. This is because some forest cover is found in the highland and midland but not in the lowland known to do most charcoaling activities.

Table-9. Anthropogenic climate change impact on vegetation, forest, wild animals & rangeland.

Anthropogenic impacts	% Across agro climatic zone		
	Highland	Midland	Lowland
Deforestations	100.0	100.0	100.0
Agricultural expansions	100.0	100.0	98.5
Population increase	100.0	100.0	100.0
Fuel wood	100.0	100.0	100.0
Timber production	58.8	65.5	0.0
Charcoal production	22.1	36.4	98.5

Source: Computed from field survey (2016).

3.3. Patterns and Trends of Local Climate from Meteorological Records

3.3.1. Climate Trend Analysis

The trend of climate change and variability in the study area was gradual. The compiled climate records of the local rainfall and temperature for Arsi Abomsa Merti station from 1990 to 2014 were obtained from the national meteorological agency, Adama branch. The daily maximum and minimum temperatures were converted in to monthly maximum and minimum then to mean annual monthly temperature finally to annual average temperature while the total monthly rainfall finally converted to average annual rainfall. The distribution of monthly average temperature and total monthly rainfall plotted in figure 1. The monthly average temperature as projected from the figure shows rate of increasing alarmingly whereas intensity and frequency of total monthly rainfall found to dropdown in an alarming rate from time to time. As shown by figure 1, the analysis result from Merti district Metrological station recorded data (1990-2014), stated that the average monthly precipitation trend of the area has shown dramatic decline, and the monthly average temperature has shown an alarming rate of increase from (1990-2014).

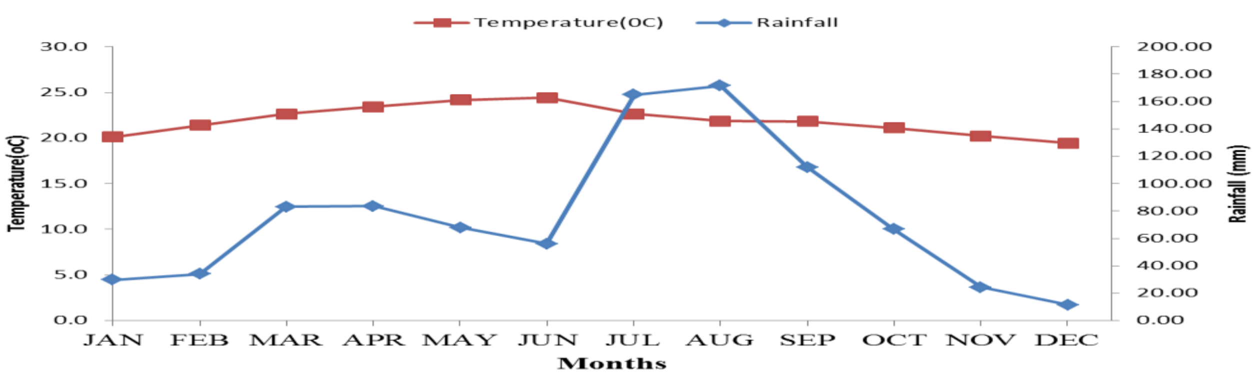

Figure-1. Average monthly distribution of Temperature and Rainfall of Merti district (1990-2014).

Data source: NMA, Adama branch (2016)

3.3.2. Rainfall Variability and Its Trend

Ethiopia is known by intricate patterns of rainfall [9]. The rainfall in the study area is highly variable both in amount and distribution. The study area has experienced frequent climatic shocks, extended drought and delay in the onset of rain, erratic and low precipitation, and heavy and un-seasonal rainfalls. Most of the rains in Ethiopia received between the months March and September comprising the seasons Belg and Kiremt. As shown by figure 2 the intensity, duration, frequency and distribution of rainfall decreased from time to time. According to Merti Metrology Station recorded data (1990-2014), the precipitation trend of the area has shown dramatic decline. Historically recorded time serious regular temperature and rainfall data for 24 consecutive years starting from the year 1990 to the year 2014 for Abomsa stations in Arsi Zone Merti district showed the year-to-year variation of rainfall for the periods among 1990 to 2014 over the district expressed in terms of normal rainfall average for the district.

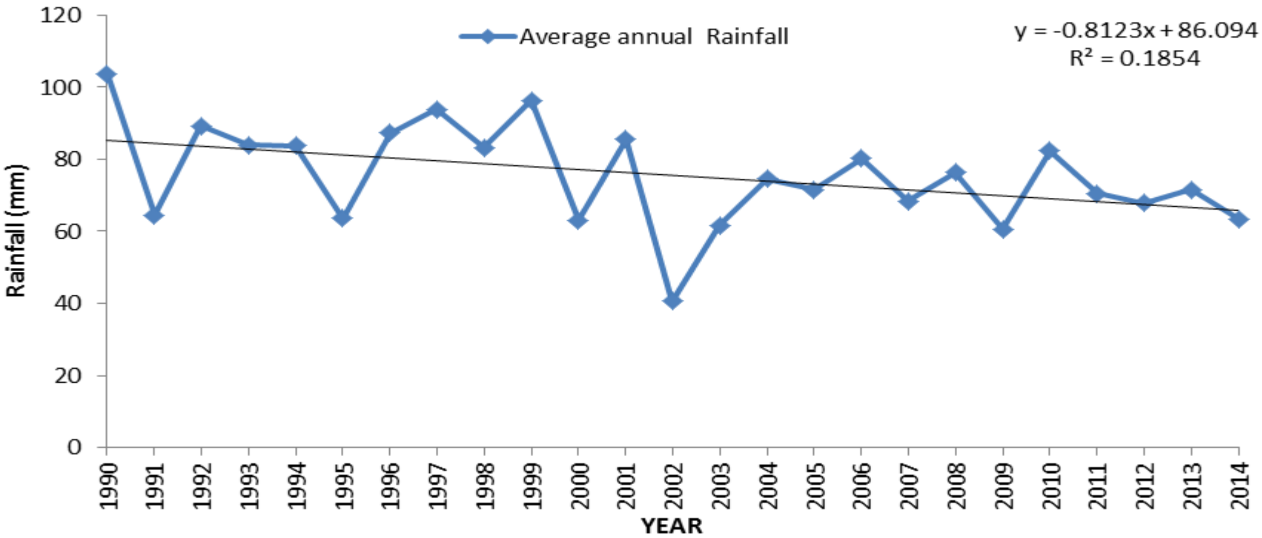

Figure-2. Year to year variability in annual average rainfall and its trend over the last 24 years (1990-2014) in Merti district.
Data source: NMA, Adama branch (2016)

As can be seen from figure 2, the district has experienced years of a general decrease in average rainfall amount over the past 24 years. That is, 1991, 1995, 1998, 2000, 2002, 2005, 2007, 2009, 2011, 2012, 2013 and 2014 were concluded as the years with minimum average annual rainfall while the years 1990, 1997 and 1999 were said to be periods of maximum average rainfall of the districts irrespective of the years 1992, 1993, 1994, 1996, 2001 and 2010 with a constant linear plot in the graph were times of regular precipitation. As a result, during the periods 1991, 1995, 2000, 2002 and 2003, the district has experienced highly decreased amount of rainfall with a great deal of irregularity which could be mentioned as unseasonal or erratic showing high fluctuation and distribution across the district with a convergent exception in 2002 which follows extra alarming decline in rainfall which also showed serious drought challenge. Ahead of 2004 it was the years of decrease constantly in rainfall pattern in the district.

3.3.3. Rainfall Variability and Its Trend across the Seasons

Ethiopia is known by it's by modal rain. The rainfall varies across the seasons in different part of the country. Therefore; generally speaking the country comprises of four seasons namely spring (tsedey) include three months September, October and November, Winter (Bega) a season known to be the most dry and hot including months December, January and February, autumn (Belg) the second most important season next to Kiremt in receiving rainfall and consist of March, April and May, and summer (kiremt) a season comprising of June, July and August, where most of the rain in the country received.

1. Rainfall Variability in the spring (Tsedey[1]) Season

According to Ethiopian calendar category Spring (Tsedey) is the first annual category of the seasons. During this season the minimum amount of rainfall was (17.43 mm) recorded during 2002 and the maximum amount of rainfall was (147.97 mm) which was recorded in 1997 (Figure 3). While the total amount in this was 1694.28mm.

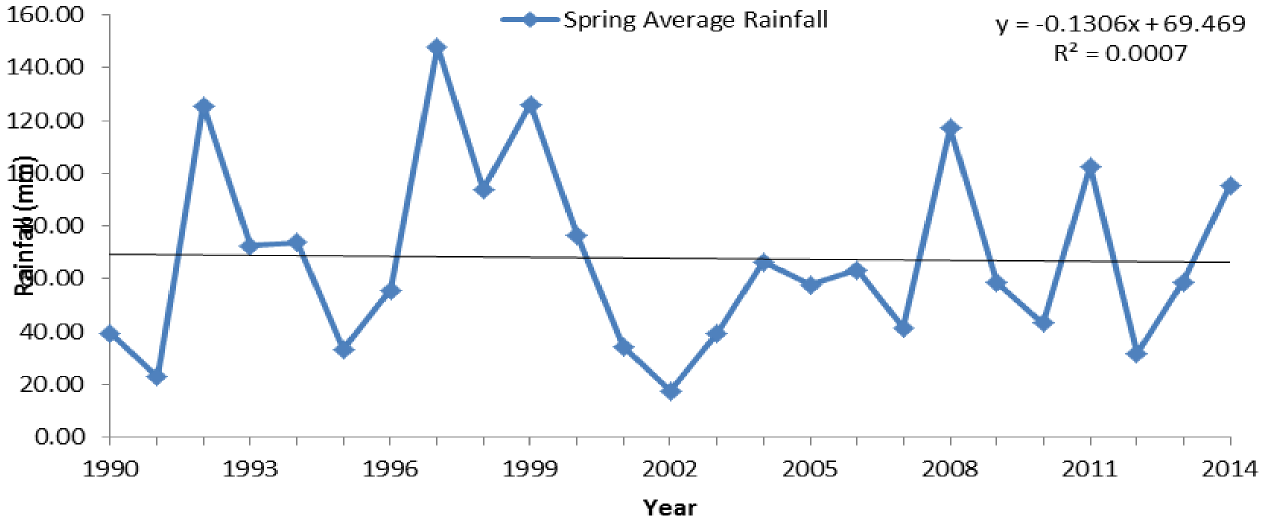

Figure-3. Year to year variability in annual Spring Rainfall Average of Merti district (1990-2014).

Data source: NMA, Adama branch (2016)

2. Rainfall Variability in the Dry (Bega[2]) Season

According to Ethiopian calendar category dry (Bega) is the second annual category of the seasons. The season also characterized by long dry season. During this season the minimum amount of rainfall was (0.0 mm) recorded during 2014 and the maximum amount of rainfall was (119.6 mm) which was recorded in 1997. While the total amount in this season was 628.83 mm. As the figure below describe a higher variability in rainfall was observed in this season with a standard deviation of 0.225. The season's average annual rainfall generally shows a decreasing trend (Figure 4).

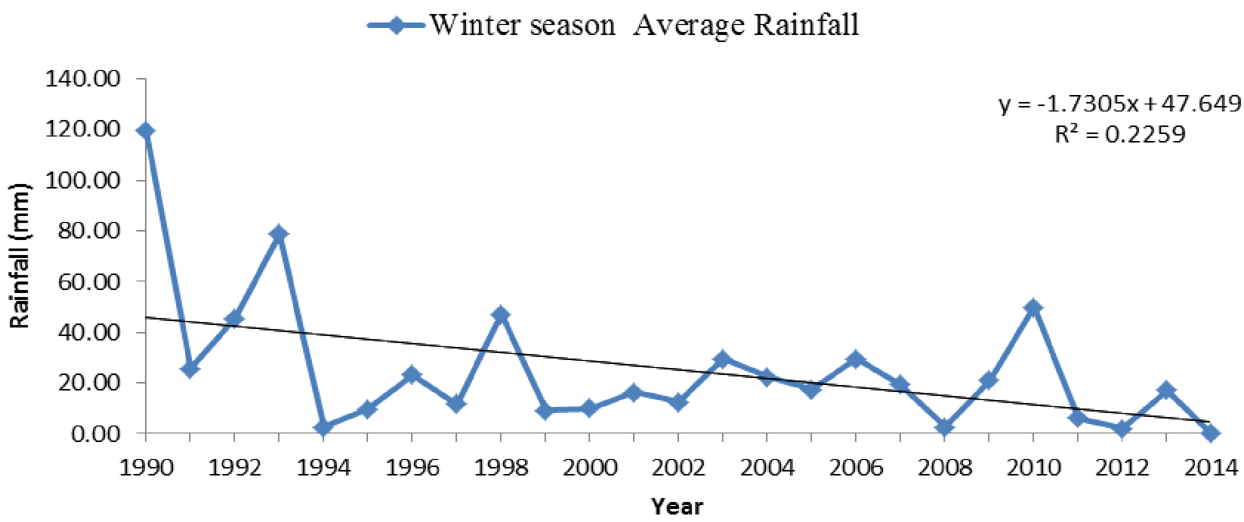

Figure-4. Year to Year variability in annual Winter Rainfall averages of Merti district (1990-2014).

Data source: NMA, Adama branch (2016).

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[1] Local language to mean spring

[2] Local language to refer dry season in Ethiopia (winter)

3. Rainfall Variability in the autumn (Belg[3]) Season

The third most important season of the year in Ethiopia is autumn (Belg) (March-June). This season is also known as short rainy season, the season before the summer season. The season Ethiopia receives most of its rain next to summer season. During this season the minimum amount of rainfall was (45.43 mm) recorded during 2009 and the maximum amount of rainfall was (136.80 mm) which was recorded in 1990. While the total annual rainfall during the season 1957.13 mm. As the figure below describe a higher variability in rainfall was observed in this season with a standard deviation of 0.126. The season's average annual rainfalls generally show a decreasing trend (Figure 5).

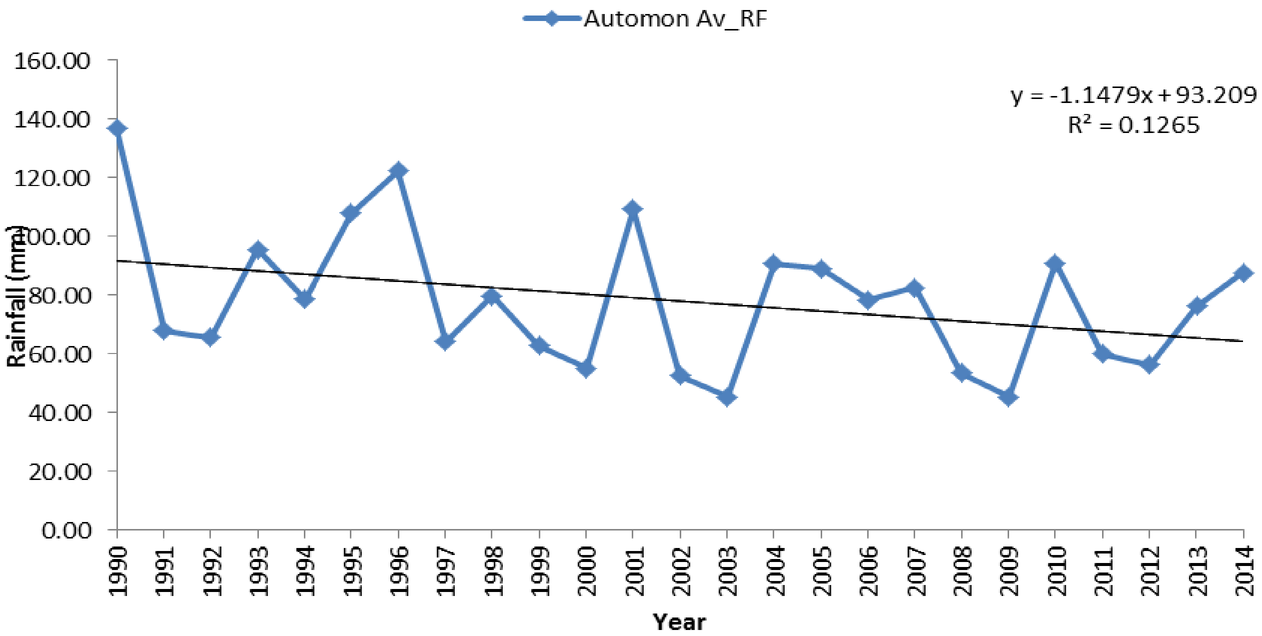

Figure-5. Year to year variability in annual Autumn Rainfall average of Merti districts (1990-2014).
Data source: NMA, Adama Branch (2016).

4. Rainfall Variability in the summer (Kiremt[4]) Season

The most important rainy season of Ethiopia is Summer (Kiremt) (June- September), the season before spring and next to autumn comprising of months June, July and August, which is most agricultural activities of the country done here. This season is also known as long (main) rainy season. Summer average rain of the area is supposed to decline annually since 1990-2014. During this season the minimum amount of rainfall was (70.4 mm) recorded during 2014 and the maximum amount of rainfall was (187.43 mm) which was recorded in 1999. While the total annual rainfall during the season 3273.07 mm. As the figure below describe a higher variability in rainfall was observed in this season with a standard deviation of 0.003. The season's average annual rainfalls generally show a decreasing trend (Figure 6).

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[3] Local language to refer Autumn

[4] Local language to refer the main rainy season in Ethiopia (Summer)

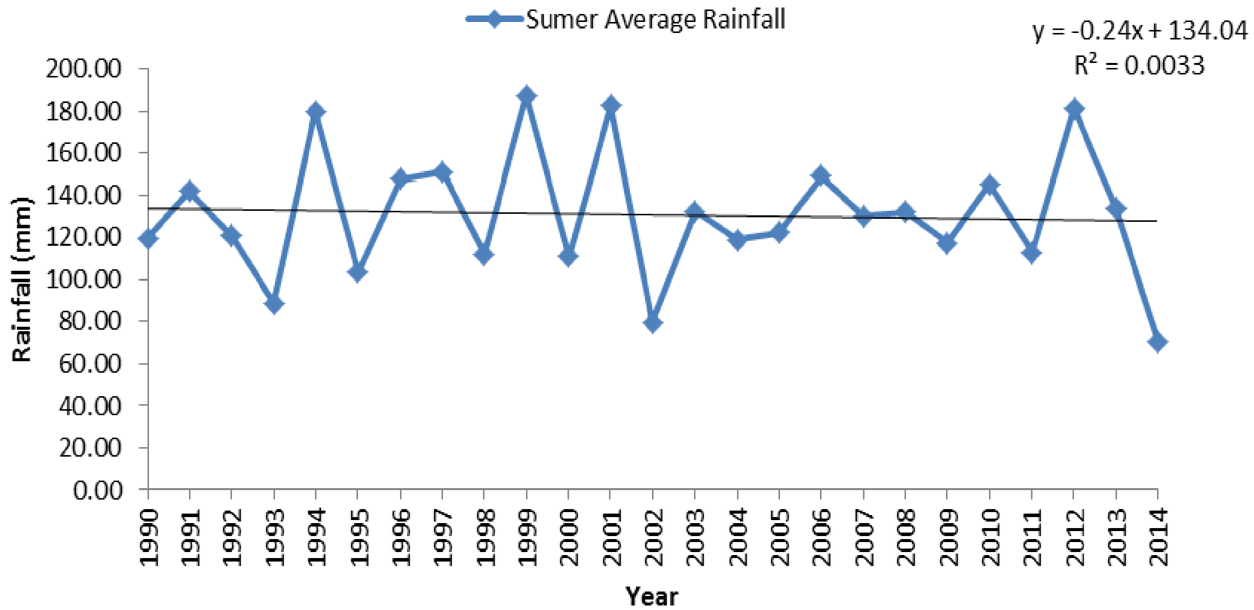

Figure-6. Year to year variability in annual Summer Rainfall averages of Merti district (1990-2014).
Data source: NMA, Adama branch (2016).

As figure 7 depicted that the trends of decreases almost somehow similar with the three trends of rainfall averages in Merti from 1990 – 2014. For instance, the annual average rainfall, and spring and winter average rainfall the three together show a decreasing trends by the year 1991. There has been more rainfall received during the long dry or winter season which is 119.6 mm by the year 1990 than the annual average rainfall by the same year which is 103.84 mm.

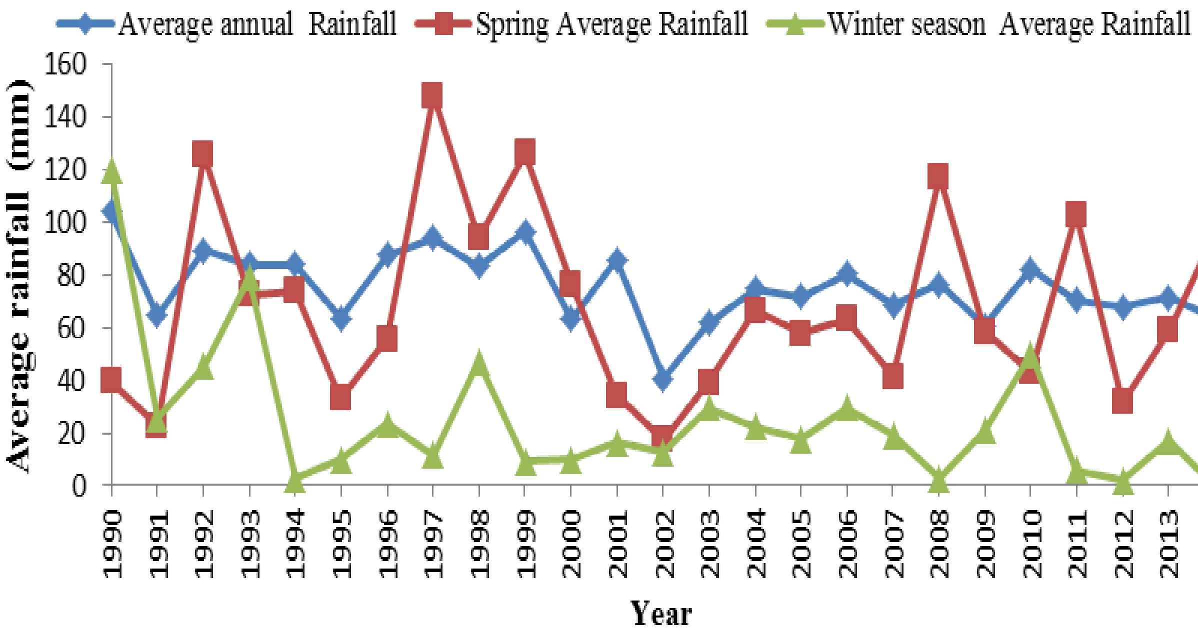

Figure-7. Average annual, spring and winter rainfall of Merti (1990-20144).
Data source: NMA, Adama branch (2016).

Similarly figure 8 below shows the patterns of rainfall distribution with regard to the annual average rainfall and, winter autumn season average annual rainfall somewhat the association indicated the same pattern.

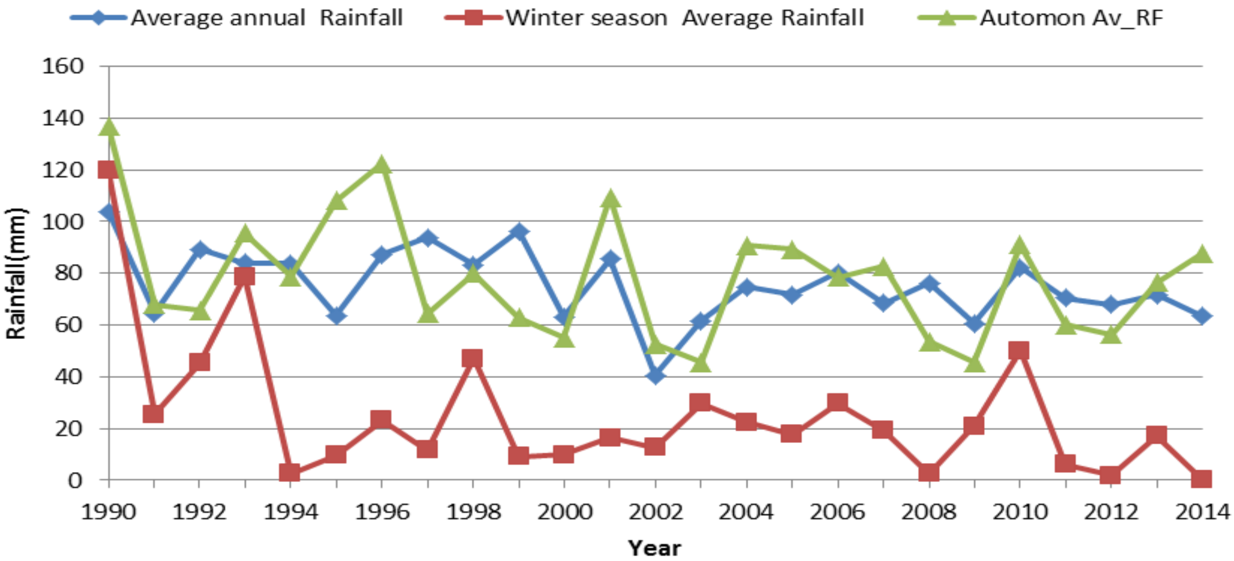

Figure-8. Average annual rainfall, winter and autumn average rainfall of Merti district (1990-2014).
Data source: NMA, Adama branch (2016).

For instance, the winter annual average rainfall is far apart from the annual average rainfall and autumn average annual rainfall throughout the last 24 years (1990 – 2014). Similarity in the three (annual average rainfall and, autumn and winter annual average rainfall), the maximum annual average rainfall is recorded during the year 1990 and in this time the long dry season average rainfall exceeds the annual average rainfall amounts. So that almost similar trends were observed in the annual average, autumn and winter average annual rainfall in Merti from 1990 – 2014.

Generally speaking in the three cases (Figure 7, 8 and 9), the station data reveal that the seasons annual average rainfall and the total annual average rainfall in the Merti district within the periods 1990- 2014 show a decreasing trend. In this aspect it can be concluded that in the last 24 elapsed period's of years the annual average rainfall in the Merti district as shown in the figures above (Figure 7 and 8) and below (Figure 9), found to coincide with the seasons average rainfall of the area in the entire cases show decreasing trend.

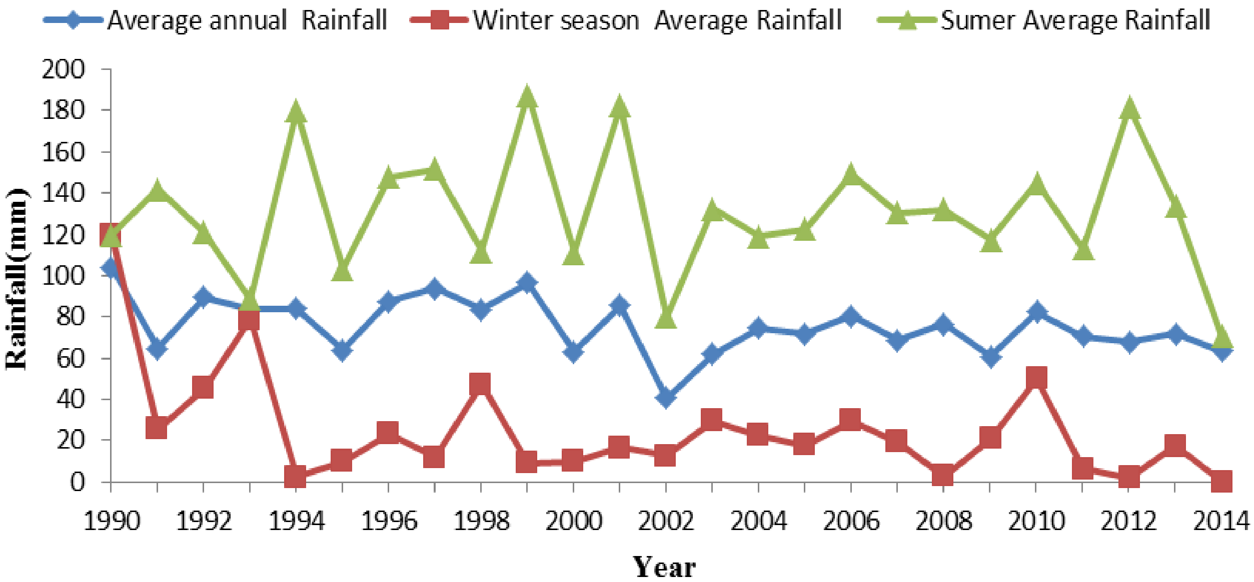

Figure-9. Average annual rainfall and, summer and winter seasons' annual average rainfall (1990-2014) of Merti district.
Data source: NMA, Adama branch (2016).

According to the station data there has been a decreasing trend in the four seasons' average annual rainfall over the last elapsed periods of 24 years from 1990 - 2014. As shown in figure 10 below, the four seasons' average annual rainfall for the study area coincides with each other.

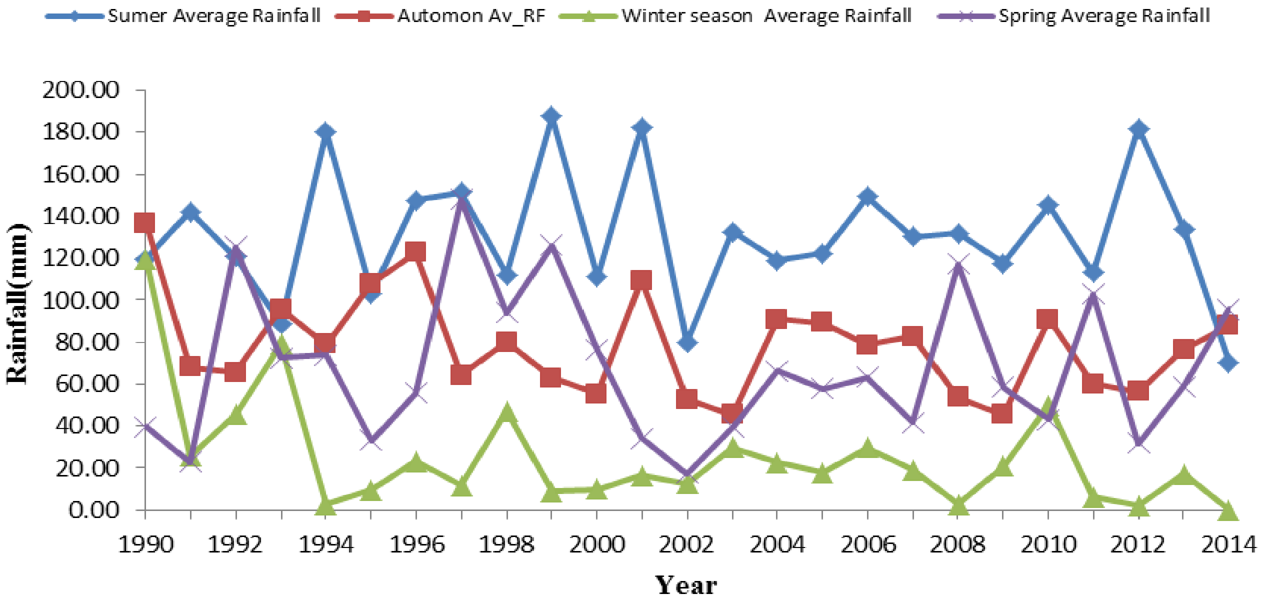

Figure-10. Spring, winter, autumn and summer seasons' annual average rainfall of Merti (1990-2014).
Data source: NMA, Adama branch (2016).

3.3.4. Temperature Variability and Its Trend

1. Mean annual Temperature Variability and Its Trend

The mean annual variability in temperature as the result obtained from the analysis of meteorological station data gathered from the district revealed greater year to year temperature variability. As the figure (Figure 11) below tell us the local temperature once go up while it go down in the other occasion for some of the years even though it shows continuous general increase. There is a 0.05 ^{0} C increase in the annual average temperature since the last 24 years (1990-2014). The district would probably remained cool during the years 1990, 1993 and 1994 whereas 1991, 1995, 1998, 2003, 2005, 2006 and 2007 were warmer seasons comparing with the years 2002, 2009, 2010, 2011, 2012, 2013 and 2014 showing warmest weather conditions in the district. The temperature trend analysis for the lately occurring years ahead of 2009 showed that an increasing local temperature which involves the district's existence in an increasing warming situations when we compare with the years long ago to the beginning of the data. Generally speaking, average temperature of the study site can be concluded as just showing absolute increase in an alarming rate although some sorts of similarities in recorded value observed during the time periods of 1992, 1997, 1999, 2001, 2004 and 2008, the average temperature of the study site shows almost similar records constant with a constant increase while the rest of the years depicted inconsistency.

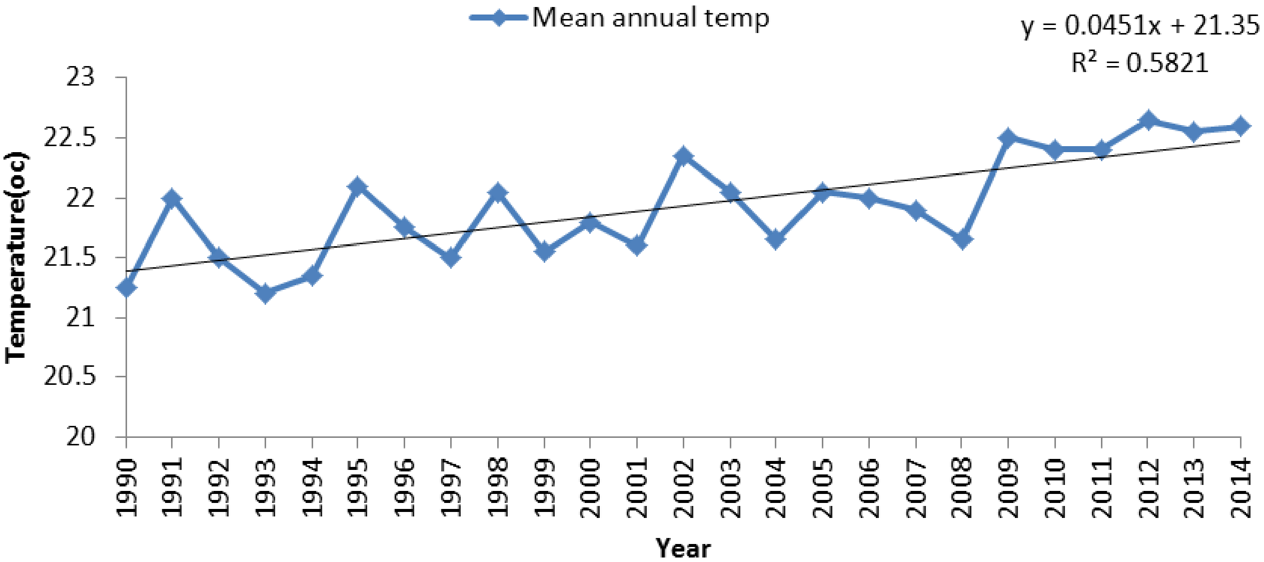

Figure-11. Year to year variability in annual average temperature and trends over the last 24 years (1990-2014) in Merti district.
Data source: NMA, Adama branch (2016).

The average annual maximum temperature trend over the Merti woreda as indicated in the following figure (Figure 12) is increasing over the last 24 (1990-2014) years. As the station data revealed the annual average maximum temperature showed there is a 0.07 ^{0} C increase since the last 24 years (1990-2014).

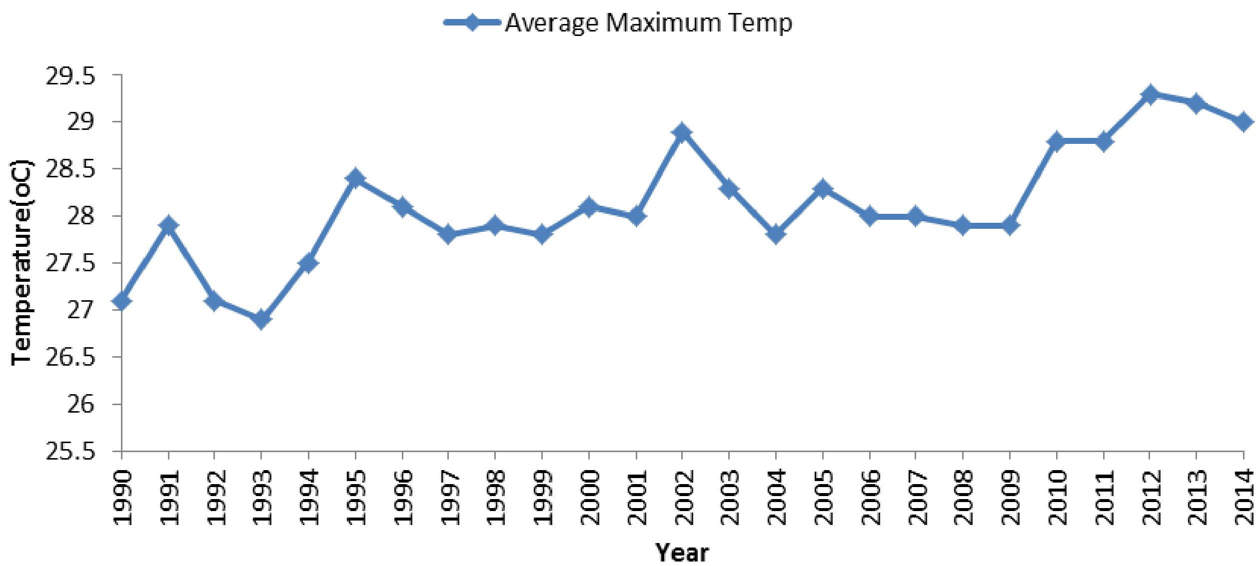

Figure-12. Year to year variability in average annual maximum temperature of Merti district (1990-2014).
Data source: NMA, Adama branch (2016).

In addition to the increase in the maximum temperature the minimum temperature over the district also show increasing trend as well (Figure 13). There is a 0.03 ^{0} C increase in the Marti's minimum annual average temperature since the last 24 years (1990-2014).

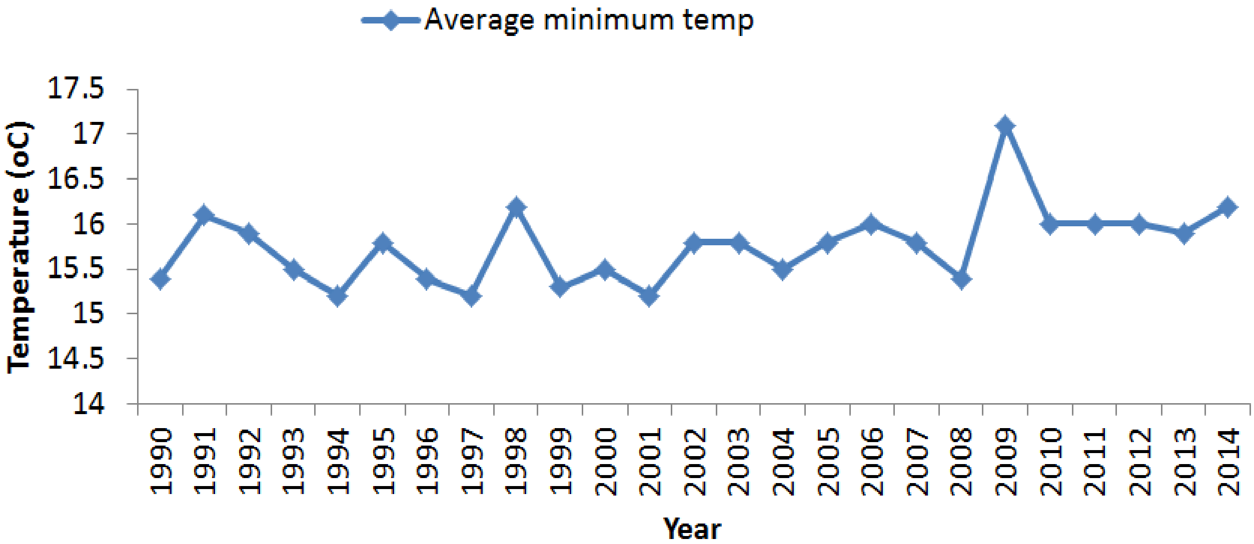

Figure-13. Year to variability in average annual minimum temperature of Merti (1990-2014).
Data source: NMA, Adama branch (2016).

The station data also disclose a warming trend in the annual maximum and minimum temperature over the last 24 years. As figure 14 below shows, the mean annual maximum and minimum temperatures for the study area coincides with mean annual temperature of the area in the entire three cases show increasing trend. In the local district, the years 1990, 1993 and 1994 were considered as minimum temperature whereas 1991, 1995, 1998, 2002,2003, 2005, 2006, 2007, 2009, 2010, 2011, 2012, 2013 and 2014 were recorded maximum temperature seasons.

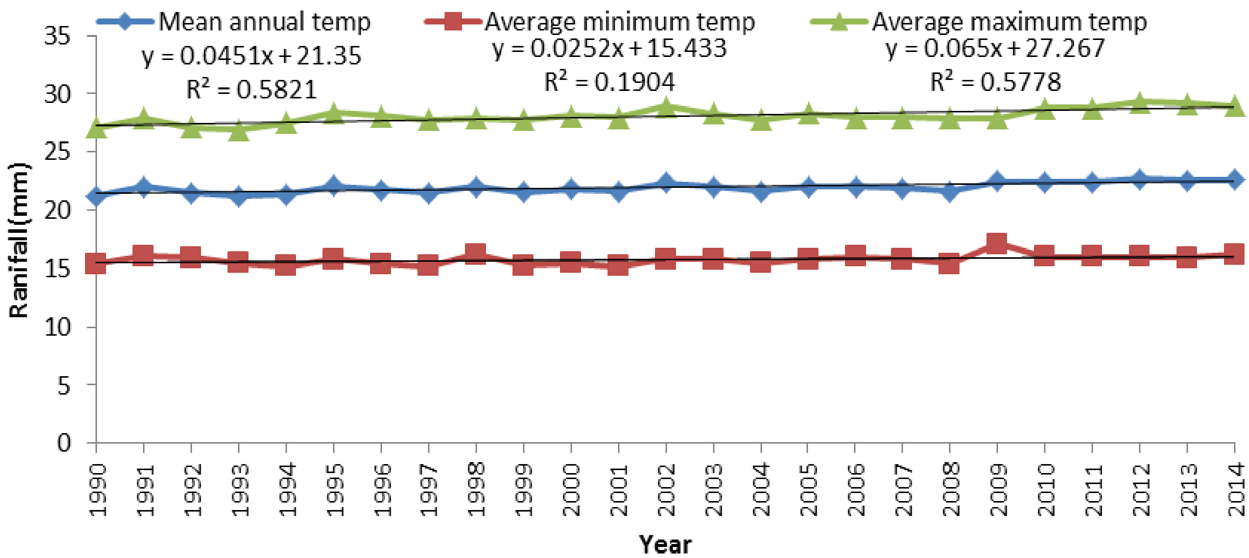

Figure-14. Year to year variability in annual average temperature, minimum and maximum annual average temperature of Merti (1990-2014).
Data source: NMA, Adama branch (2016).

The year to year variability in temperature across the district considering the annual mean minimum, maximum and annual average temperature is given in the following figure with the data representing each of them (Figure 15).

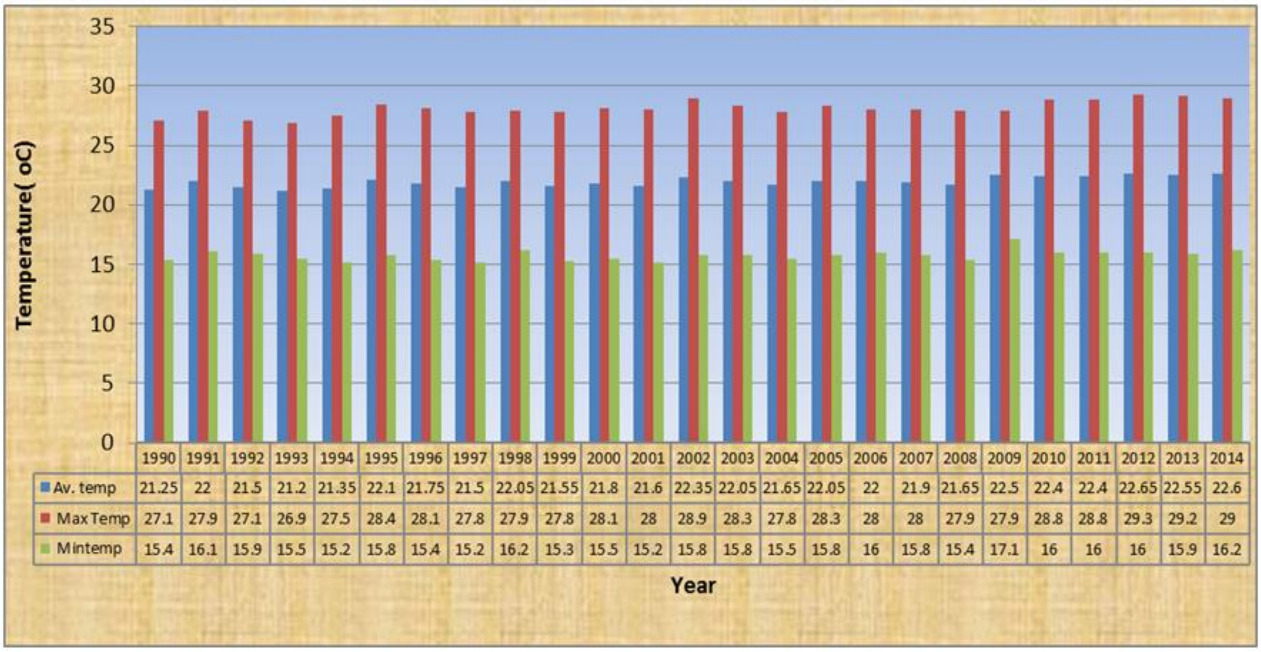

Figure-15. Average annual temperature and, minimum and maximum annual temperature variability of Merti district (1990-2014).
Data source: NMA, Adama branch (2016).

In general, the recorded climatologically data of the 25 year in the District confirmed the report from the survey result from the respondents. The meteorological data result revealed the fact that the area is experiencing a greater variability in rainfall pattern across the district which generally confirmed with the fact obtained from the respondents. Majority of the respondents reported that temperature is increasing alarmingly, increased variability in rainfall pattern in most case begin latter and ending up earlier than usual showing a general decrease .The intensity and duration of drought aggravated, decreased soil fertility causing crop production and yield to drop down. The reduction in agricultural yield cause the peoples to search other income source utilizing the vegetation and forest in different forms like charcoaling, timber production, wood etc.

4. CONCLUSION

The study found the increasing extent of climate change in Merti. The gradual change of the local environment in the area is now accelerating and impacting the local people's livelihood. The local environment suffered from increasing trend of temperature which causes substantial warming across the district, and decreasing rainfall trend being more unreliable, erratic and unevenly distributed causing incidence of recurrent drought, flood, abnormal weather conditions extreme hot and cold temperature and rainfall, reduction in the agricultural production scheme, diminishing of wild animals were the most common indicators of manifestations and extent of climate change in the area. The result revealed that about 92.7 percent of the respondents perceived increasing temperature and 96.3 percent perceived decreasing rainfall with a great variability including at the start and end of rainy season in which case majority were witnessed as the rain begin later and end up earlier than usual. The interaction among varicose bio-physical environmental indicators also showed a drastic trend of decline. Respondents 90.1 and 88.0 percent respectively confirms a decreasing trend of both crop and livestock production in the area. As well as 81.7 and 77.5 percent of the respondents corroborate the fact that increasing trend of drought and flood situations from time to time. Therefore; community based participatory technology is most important, capacitating the local peoples with valuable immediate information, constraints like technological, institutional needs to be avoided, agriculture sensitive strategies need to be an integral part of government policies to assist farmers to adapt to the impacts of current and future climate change.

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REFERENCES

[1] S. Schubert, R. Dole, H. van den Dool, M. Suarez, and D. Waliser, "Prospects for improving forecasts of weather and short-term climate variability on subseasonal (2-Week to 2-Month) time scales," NASA Technical Report Series on Global Modeling and Data Assimilation, NASA/TM-2002-104606, 2002.

[2] W. Cline, *Global warming and agriculture: Impact estimates by country*. Washington DC: Peterson Institute, 2007.

[3] IPCC, "Climate change impacts, adaptation and vulnerability," The Working Group II Contribution to the IPCC Fourth Assessment Report. Retrived from http://www.ipcc-wg2.org/, 2007.

[4] V. A. Orinda and L. Murray, *Adapting to climate change in East Africa: A strategic approach. Gatekeepers Series 117*. London: International Institute for Environment and Development, 2005.

[5] IPCC, "Climate change 2001: Impacts, adaptation, and vulnerability: Contribution of working group II to the," Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, 2001.

[6] NMA, "National adaptation programme of action of Ethiopia (NAPA)," Final Report. National Meteorological Agency, Addis Ababa, 2008.

[7] M. Biazen, "The effect of climate change and variability on the livelihoods of local communities: In the case of central rift valley region of Ethiopia," *Open Access Library Journal*, vol. 1, pp. 1-10, 2014. *View at Google Scholar* | *View at Publisher*

[8] G. Feyissa, "Climate variability and its role on Malaria prevalence in gonder Town Woreda," Unpublished Senior Essay Submitted to Department of Geography, University of Gondar, Gondar, 2006.

[9] Livelihoods Integration Unit, "The livelihoods atlas for Ethiopia." Retrived from http://www.feg-consulting.com/spotlight/complete-atlas/Atlas%20Final%20Print%20Version%20June%2029%202011.pdf. Accessed December 15, 2011, 2010.