Temperature and Precipitation Trend Analysis in Adama City over the Last 31 Years (1979 - 2009) E.C.

BY: Tesfaye Negash

Thesis Submitted to Adama Science and Technology University in Partial Fulfillment of the Requirements for the Degree of Masters in physics

Advisor: Abebe Belay(phD)

Adama, Ethiopia

September, 2018

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Declaration

I hereby declare that this MSc. thesis is my original work and has not been presented for any partial fulfillments requirements for degree of masters in any other universities and that all sources of materials used for the thesis have been properly acknowledged greatly.

Name Tesfaye Negash

Signature ……………………….

As a thesis research advisor, I hereby certify that I have read and evaluated this thesis prepared under my guidance by Tesfaye Negash entitled Temperature and Precipitation Trend Analysis in Adama City Over the Last 31 Years (1979 - 2009) E.C. I recommend that it will be submitted as fulfilling thesis the requirement.

Name Abebe Belay (PhD)

Signature ………………………

Date of submission …………………..

Approval Sheet

Adama Science and Technology University

School of Applied Natural Science

Applied Physics Program

This is to certify that the thesis prepared by Tesfaye Negash entitled Temperature and Precipitation Trend Analysis in Adama City over the Last 31 Years (1979 - 2009) E.C. Submitted in partial fulfillment of the requirement for degree of Masters of Science in physics complies with regulation of the university and meets the accepted standards with respect to originality.

Signed by the examination committee

Abebe Belay(phD)	………………	………….
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Chair person	signature	Data ………
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Internal Examiner	Signature	Date ……..
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External Examiner	signature	Data ……….

Final approval and acceptance of the thesis is contingent upon the submission of final copy of the thesis to school of graduate studies (SGS) through the departmental or school graduate committee (DGC or SGC) of the candidate.

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Dedication

I dedicate this thesis manuscript to God and for the peoples who helps me to accomplish this Thesis and also thanks to my family as well.

Biographical Sketch

The author was born in Wereda Mereb-Leke , (Rama town) in 1980 E.C. He was attended his primary education in Bihiza Primary and Junior school and his secondary education in Rama and Nigiste- Saba(Adwa) high school. He did his Bachelor of Science (B.Sc) degree in physics at Hawassa-University in 2003. After three years of teaching experience in Governmental secondary school, he was joined the Department of Physics, at Adama Science and Technology University, for his M.Sc degree in physics in the year 2006 E.C.

Acknowledgments

I would like to express my sincere thanks to my advisor and instructor Dr.Abebe Belay for his guidance, assistance, supervision and contribution of valuable suggestions. His scientific excitement, integral view on research and overly enthusiasm, has made a deep impression on me. My heartiest gratitude also goes to Adama Science and Technology University School of Applied Natural Science Department of Physics.

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I will like to say thanks to my friends and as well as families for providing encouragement and support in the accomplishment of this thesis work.

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List of Acronyms

IPCC-Intergovernmental Panel of Climate Change

NMA -National Meteorological Agency

Sw-Southwest

NAPA-National Adaptation Programmer of Action

UNFCCC- United Nation Framework Convention On Climate Change

ENSO- Eli No of Southern Oscillation

SST-Sea Surface Temperature

CFC-Chloro Floro Carbon

GHG-Green House Gas

LPG-Liquid Petroleum Gas

CO_2-Carbon Dioxide

CV-Coefficient of Variation

CS- Coefficient of Skewness

Ck- Coefficient of Kurtosis

Std.Dev-Standard Deviation

Mean .Dev-Mean Deviation

EEPCO-Ethiopian Electric Power Corporation

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Abstract

Temperature and precipitation are the basic climatic elements of the Earth. Large areas of the Earth indicated variability of climatic elements as part of their normal climate condition over short and long time periods. The variability of climatic intensity distribution of our country suffers and affects the population by different factors such as, economic instability, drought extension, famine, and construction and health problems. There are review literatures about temperature and precipitation trend analysis throughout the world in general and in some areas in Ethiopia. However, in Adama city, there is a lack of information about the trend analysis of temperature and precipitation. So, the objective of this research is to analyze precipitation and temperature trends in Adama city for the period of 1979-2009 E.C, using data collected from Adama city meteorological station. The data were analyzed using statistical methods. The analysis indicated annual and monthly precipitation were 904.59 mm and 7.18 - 244 mm respectively. The monthly coefficient of variation (C.V) lies between 28.79- 205 %. Similarly the mean monthly maximum and minimum Temperature ranges 25.94-30.79 ^{o}C and 11.94-16.82 ^{o}C respectively. The maximum and minimum coefficient of variation obtained in February and August respectively. In general the study indicated slowly increase in precipitation, maximum and minimum temperature in Adama city over the last 31 years.

Key words: precipitation, Temperature, trend Analysis of Adama City.

1. Introduction

1.1. Background of the study

Climate is the synthesis of the weather in a particular region. It can be defined quantitatively using the expected values of the meteorological elements at a location during a certain month or season. The expected values of the meteorological elements can be called the climatic elements and include such variables as the average temperature, precipitation, wind, pressure, cloudiness, and humidity. In defining the climate we usually employ the values of these elements at the surface of Earth [1].

The importance of climate is so basic that we sometimes overlook it. If the climate were not more or less as it is, life and civilization on this planet would not have developed as they have. The distribution of vegetation and soil type over the land areas is determined primarily by the local climate. Climate affects human lives in many ways; for example, climate influences the type of clothing and housing that people have developed. In the modern world, with the great technological advances of the last century, one might think that climate no longer constitutes a force capable of changing the course of human history. It is apparent, on the contrary, that we are as sensitive now as we have ever been to climate fluctuations and climate change [1].

Because food, water, and energy supply systems are strained to meet demand and are optimized to the current average climatic conditions, fluctuations or trends in climate can cause serious difficulties for humanity. Moreover, since the population has grown to absorb the maximum agricultural productivity in much of the world, the absolute number of human lives at risk of starvation during climatic anomalies has never been greater. In addition to natural year-to-year fluctuations in the weather, which are an important aspect of climate, we must be concerned with the effects of human activities in producing long-term trends in the climate [1]

It is now clear that humans are affecting local climate and our influence on global climate will increase in the future. The actions of humankind that can influence the global climate include altering the nature of Earth's surface and the composition of Earth's atmosphere .The surface climate of Earth is varied, ranging from the heat of the tropics to the cold of the polar regions, and from the drought of a desert to the moisture of a rain forest. Nonetheless, the climate of Earth is favorable for life, and living creatures exist in every climatic extreme [1].

The climate of a region depends on latitude, altitude, and orientation in relation to water bodies, mountains, and the prevailing wind direction. The climate of Earth is defined in terms of measurable weather elements. The weather elements of most interest are temperature and precipitation. These two factors together largely determine the species of plants and animals that survive and prosper in a particular location. Other variables are also important, of course. The humidity, the amount of water vapor in the air, is a critical climate factor that is related closely to the temperature and precipitation [1].

Cloudiness influences the amount of solar radiation that reaches the surface and the transmission of terrestrial radiation through the atmosphere. The occurrence of clouds is important in itself for aviation and other activities, but clouds also play a role in determining both precipitation and surface temperature. The mean wind speed and direction are important considerations for local climate, air-pollution dispersion, aviation, navigation, wind energy, and many other purposes. The climate system of Earth determines the distribution of energy and water near the surface and consists primarily of the atmosphere, the oceans, and the land surface. [1]

Climate of the Earth varies throughout the planet. Large areas of the earth represent variability as a part of their normal climate condition over short and long time periods. Climatic variability can be described as the annual difference in values of specific climatic variables within averaging periods. These climatic variations will have unexpected consequences with respect to frequency and intensity of precipitation and temperature variability for many regions of the Earth [2].

Air temperature and precipitation are principle element of weather systems, so that examination of their behavior is important for understanding of climate variability. Both temperature and precipitation are highly varying quantities spatially and temporarily at different local, regional and global scales of the Earth [2]. For the prediction of future climate conditions, level of variability of these two weather elements must be examined and understood. Therefore, recently the focus on climate variability bases mostly on the detection of trends in instrumental records of precipitation and temperature. Several researches of climatic trends have recently been conducted on rainfall and temperature data at different period of records throughout the world [2].

Climate is a statistically significant variation in that persists for decades (intergovernmental panel climate change). Globally climate change induces redistribution of precipitation and threaten human life. The IPCC has noted that the average land surface temperature data's calculated by linear trend, shows warming of 0.65c^o to 1.06c^o over the period of 1880-2012 [3].

It is projected that summer precipitation would decreased in the northern Europe and the Mediterranean and some part of the central and Eastern Europe would experience drought. The increased frequency and intensity of drought in Asia are due to temperature rise and the manifestation of the change and effects of climate varies from place to place. Climate variability has varied impacts on communities or regions. These variation the IPCC projects that an increase of 2c^o in temperature poses a risk to both fauna and flora and causes, an increase in annual economic losses due to flood and drought [3]. According to the World Meteorological Organization, climate variability represents variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. The term is often used to denote deviations of climatic statistics over a given period of time (e.g. a month, season or year) from the long-term statistics related to the corresponding calendar period [4].

Variability may be due to natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability). On the other hand, climate change is the change within the statistical distribution of the metrological events over certain periods of time. This can range from centuries, decades or even millions of years. It refers to shifts in the mean of the climate or in its variability, persisting for an extended period [4].

The effects of climate change and variability such as rising temperature and changes in precipitation are undeniably clear with impacts already affecting ecosystems, biodiversity and people. Associated with global warming, there are strong indications that rainfall and temperature changes are already taking place on both the global and regional scales. Furthermore, climate change is likely to bring changes in climate variability and extreme events, such as more frequent heat waves, less frequent cold spells and a great intensity of heavy rains events. Such changes are likely to be at least as important as changes in mean conditions in determining climate change impacts and vulnerability [4].

Agro-pastoralism is common particularly in the great East African Rift Valley region of the country. These varied eco-environmental settings in Ethiopia offer unique opportunities to study climate change in the tropics. As in other parts of Africa and the rest of the world, studies on Ethiopia's climate have shown changes in temperature and precipitation trends during recent decade. For instance, South Eastern, some lowlands of Ethiopia. Though the magnitude and trends of change reported vary with reports and locations, time series analysis of mean national maximum and minimum temperatures have shown positive trends [5].

The observed warming is accompanied by a steady decline in precipitation in many parts of the country. Although,the increases have been reported in some areas and no changes detected in others. Associated with these long term changes in mean temperature and precipitation patterns changes in climatic extremes have been observed Climatic extreme events such as drought, flood and hail often have more significant negative effects on the biophysical environment than the long-term mean changes in temperature and precipitation alone on the other hand, the occurrence of most climatic extremes is rare and change detection can be problematic [5].

1.2. Statement of the problem

Even though temperature and precipitation trends was studied in different part of the world in general and in some areas in Ethiopia, as far as our knowledge concerns there is no report about the temperature and precipitation tends in Adama City using station data to fill the gap. Hence, there is shortage of information about the temperature and precipitation trends over the given period 1979-2009E.C. Therefore, in this study, we are interested to study the trends of precipitation and temperature of Adama City for the period of 1979-2009E.C using data collected from Adama City Meteorological Station.

1.3. Objectives

1.3.1. General objectives:

To Analyzed The Precipitation And Temperature Trends of Adama City Over The Period of 1979-2009E.C Using Data Collected From Adama City Meteorological Station.

1.3.2. Specific objectives:

- To Analysis the Precipitation Trends of Adama City Over the Period of (1979-2009E.C) Using Station Data.
- To Analysis Maximum and Minimum Temperature Trends of Adama City Over The Period of (1979-2009E.C) Using Station Data.
- To Evaluate the Variability And Characteristics of Temperature And Precipitation of Adama City (1979-2009).
- Analysis the Time Series of the Temperature and Precipitation of Adama City (1979-2009).
- To describe the monthly , seasonal rainfall and Temperature of Adama City over the last 31 years

2. Review of literatures

Climate of the Earth varies throughout the planet. Large areas of the earth represent variability as a part of their normal climate condition over short and long time periods. Climatic variability can be described as the annual difference in values of specific climatic variables within averaging periods. These climatic variations will have unexpected consequences with respect to frequency and intensity of precipitation and temperature variability for many regions of the Earth [2].

Air temperature and precipitation are principle element of weather systems, so that examination of their behavior is important for understanding of climate variability. Both temperature and precipitation are highly varying quantities spatially and temporarily at different local, regional and global scales of the Earth [2] .For the prediction of future climate conditions, level of variability of these two weather elements must be examined and understood. Therefore, recently the focus on climate variability bases mostly on the detection of trends in instrumental records of precipitation and temperature. Several researches of climatic trends have recently been conducted on rainfall and temperature data at different period of records throughout the world [2].

Agricultural and related sectors, food security and energy sectors' of India are crucially dependent on the timely available of an adequate amount of water and conductive climate. Global climate changes may influences long –term rain fall patterns impacting the availability of water, along with the danger of increasing occurrence of drought and flood. The south west (sw) monsoon, which brings about 80% of the total precipitation over the country is critical for the availability of fresh water for drinking , and irrigation . The change of climate over the Indian region particularly the (sw) monsoon, would have a significant impacts on agricultural production and overall economy of the country [6].

Africa is one of the most vulnerable continents to climate change and climate variability, a situation aggravated by the interaction of 'multiple stresses' occurring at various levels, and low adaptive capacity. It is widely projected that as the planet warms, climate and weather variability will increase. Changes in the frequency and severity of extreme climate events and in the variability of weather patterns will have significant consequences for human and natural systems Increasing frequencies of heat stress, drought and flooding events are projected for the rest of this century, and these are expected to have many adverse effects over and above the impacts due to changes in mean variables alone [7].

Warming of the climate system can result in very large corresponding changes in the occurrence of climate extremes. Temperature extremes may occur due to a shift in the whole distribution, where there is an increase in the entire temperature probability distribution, or to changes in the shape of the distribution, such as an increase in variability causing a widening of the distribution. Understanding the precise characteristics of changes in temperature distributions in response to background warming is an important aspect of fully understanding changes in heat extremes and their associated impacts on human and ecosystem health [7].

The equatorial and southern parts of eastern Africa have experienced a significant increase in Temperature since the early 1980s. Seasonal average temperatures have also risen in many parts of eastern Africa in the last 50 years. Countries bordering the western Indian Ocean experienced warmer temperatures and more frequent heat waves between 1961 and 2008. Extreme precipitation changes over eastern Africa such as droughts and heavy rainfall have been experienced more frequently during the last 30–60 years. Continued warming in the Indian Ocean has been shown to contribute to more frequent East African spring and summer droughts over the past 30 years. Changes in climate variability and in the frequency of extreme events may have substantial impacts on the prevalence and distribution of pests, weeds, and crop and livestock diseases. For example, in the past, combinations of drought followed by high rainfall have led to wide-spread outbreaks of diseases such as Rift Valley fever and bluetongue in East Africa and of African horse sickness in South Africa [7].

Among the climatic elements, rainfall has the highest spatial and temporal variability in the tropical countries including east Africa due to this high rainfall variability, early or late on set and cessation of rainfall is not common. Large deviation of the onset and cessation of rainfall from the mean may sometimes lead to poor crop yields even when the rainfall amount is above normal. Prolonged dry spells within the season often impacts negatively on the crop yields and related water uses [8].

Also anomalous high intensity down pour resulting in flooding may affect the yields even though the total amount of rainfall within the season is close to normal. Other factors affected by on set and cessation of rain includes food security, Kenya, being an agricultural country on agriculture production for its economic growth. Close to 60% of Kenya’s economy is largely dependent on rain-fed agriculture products. The overall performance of rain fall season is largely dependent on the onset and cessation of rain fall [8].

The agricultural activity in western Kenya, is generally yields may suffer significantly with either a late onset or early cessation of the growing season, as well as with high frequency of damaging dry spells within the growing season. The yearly variation makes the planning of swing and selection of crop type and variety rather difficult. The ability to estimate effectively the actual start of the season therefore becomes vital. In order to plan rain fed agriculture, dependable probability level of on set dates of the rainy period and length of growing season are important [9].

This is particularly true for Zambia where more than 60% of the staple food crop maize is produced by small scale farmers under rain fed conditions. This has been acknowledged by the Zambia National Adaptation Programme of Action (NAPA) which highlights that Zambian communities are vulnerable to climatic hazards mainly droughts and flooding. Therefore knowledge of temporal changes in rainfall and associated extreme events is essential for successful crop production [10].

Droughts (dry spells) and floods are extreme climate events that percentage-wise are likely to change more rapidly than the mean climate .These extreme climate events to be among the world’s costliest natural disasters. With over 70 % of farmers relaying on rain fed agriculture in sub Sahara Africa, any changes in rainfall distribution is disastrous for crop production [10].

The success or failure of a crop depends more on the distribution of rainfall over the growing season rather than on the total rainfall in that period. Thus, many authors have attributed long dry spells within a season and shorter rain seasons as the major contributing factors to low yields. Although it is not possible to influence timing and amount of rain fall, knowledge of their frequency for a variety of durations is imperative, if they are to be well managed. Farmers’ preparation in the midst of such events is very pertinent. As a country, Zambia’s recurrent droughts and floods have caused widespread crop failure in the past, in high rainfall years due to water logging and erosion, and in dry years by delaying the onset and length of the growing season [10].

Significant rainfall deficits and/or flash floods during critical periods of crop growth have also frequently led to serious production shortfalls, with consequent impact on food security and nutrition. The rising temperatures may further increase the outbreak of plant and livestock diseases. Therefore from the socioeconomic stand point, knowing the frequency of dry spells and floods would help the farmer to prepare not only when to time various farming activities but to also adopt and/or adapt certain strategies that could reduce the risks associated with such eventualities. Such strategies might include early (or late) planting, adopting early maturing varieties among others [10]. Global climate has changed significantly in the last hundred years. Global mean surface air temperature has increased by 0.74^{o}c during the last century. Trend detection in temperature and precipitation time series is one of the interesting research areas in climatology of south west Iran. It is noted that precipitation and temperature changes were not globally uniform [11].

Climate change poses a huge challenge to Ethiopia and its people. The country is faced with increasingly, unpredictable rains, and sometimes the complete failure of seasonal rain problems which are linked to climate change. It is a country with large differences across regions which are reflected in the country's climate vulnerability. The lowlands are vulnerable to increased temperatures and prolonged droughts which may affect livestock rearing. The highlands may suffer from more intense and irregular rainfall, leading to erosion, which together with higher temperatures leads to lower total agricultural production. This, combined with an increasing population, may lead to greater food insecurity in some areas. Hotspots of increased food insecurity in the future, due to climate change, are likely to include areas in Afar, Tigray and southern Oromia, the central Rift Valley, and the eastern lowlands [7].

The implication of the changing rainfall trends is that it will become increasingly important to put adaptation measures in place to manage and reduce the risks of changing rainfall on productive systems such as agriculture and forestry and to build resilience. Decreasing the vulnerability of socio-economic sectors and ecological systems to natural climate variability through a more informed choice of policies, practices and technologies will, in many cases, reduce the long-term vulnerability of these systems to climate change [7].

Ethiopia is a country having a variability of climate change and located in a tropical region where temperature differences are strongly modulated by elevation [10].

It has unusual eco-environmental settings ranging from extreme heat at one of the lowest places in the world (Dallol) to one of the coolest summits in Africa (Mt. Ras Dashan).

The lowlands, below 1500 m above sea level, constitute about 61% of the total land mass of the country and are generally warmer and drier than the highlands and mountains. The warm and drier lowlands, particularly extensive in the south east, eastern and north eastern parts of the country, are inherently areas of low and erratic precipitation not suitable for reliable crop production and are used for extensive pastoral livestock production. The cool and moist highland plateau & mountains, on the other hand, are under extensive crop production. In between the two systems, there are transitional areas that share the properties of both. These are referred to as agro-pastoral systems and are characterized by a livestock-dominated crop production system [5].

The development of various indices – absolute and percentile – that can be described by computational statistics and software packages available since the late 1990s, has made the monthly, seasonal and annual temperature and precipitation extremes to be easily measurable from daily temperature and precipitation data records. As a result, during the last 10–15 years several extreme temperature and precipitation indices have been computed around the world from daily temperature and precipitation data. The existing reports on extreme temperature precipitation for Ethiopia indicate declining trends in frequency of heavy rains and an increase in frequency of dry extremes, number of warm days and nights [5].

Rainfall and temperature trend and variability analysis on different spatial and temporal scales has been a great concern during the past century because of the attention given to global climate change by the scientific community. According to some recent studies, Ethiopia has been suffering from an erratic nature of rainfall and increasing temperature, Dire Dawa, one of the cities of Ethiopia, has long been affected by extreme events associated with such regional climate parameters. Ethiopia is among those areas in the world most likely to be experience climatic variations for short and long time periods. Inter-annual variability of precipitation and temperature in Ethiopia is relatively large from the annual mean. As a result of climatic variations, natural resources of the country, such as vegetation, and the existing resources are easily damaged by changes [2, 15].

The Intergovernmental Panel on Climate Change (IPCC) in its fifth assessment synthesis report observed that warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented. Human influence on the climate system is clear and recent anthropogenic emissions of greenhouse gases are the highest in history and recent climate change have had widespread impacts on life and life support systems. In the (IPCC) fourth assessment report, it was also clearly stated that the warming of the climate system is explicit by the existing evidences from observations of widespread melting of snow and ice, increases in global average air and ocean temperature and rising global sea level [4].

Climate change negotiations and plans have so far been exclusively targeted on GHGs mitigation. Regardless of widespread and long-standing demand from developing countries for greater emphasis on adaptation strategies, the climate change conventions and negotiations have only recently started paying serious attention to adaptation aspects of climate change strategy actions [4, 15]. The United Nations Framework Convention on Climate Change (UNFCCC) refers to adaptation only in the context of the actual climate change situations. It implies that without greenhouse gas emissions, there is no climate change and hence no need for adaptation measures based on this, widely accepted interpretation, adaptation measures are urgently important since mitigation of greenhouse gases will not completely halt climate change related hazards. Adaptation measures are so essential to deal with the unavoidable adverse consequences of climate change to which the world is already committed [4, 15].

For vulnerable communities, adaptation measures should be based on their livelihood characteristics. By taking into consideration of the dynamics of the poor and their livelihoods, it is clear to understand how they will be affected by climate change hazards, how they might respond with the resources they have, and how these conditions can be replicated and built upon for successful adaptation strategies [4, 15].

In recent years, ENSO events and resulting severe damage or rainfall variability have become more frequent globally. The El Niño and La Niña (ENSO) events are the main causes of Ethiopian climate variability, including Gojjam region. Climate variability and its impact in different sector becomes a national problem that attracts the attention of nation leaders or scientists due to the frequent occurrences of damage particularly in agricultural sector [12]. Agriculture is the backbone of region's economy and 85% of the population lives in highlands depending on agriculture and favorable climatic conditions, which limits the productiveness of the area. However, nowadays climate variability becoming high and unseasoned rainfall is often observed. The basic climatic elements such as rainfall and temperature show seasonal or annual fluctuations somewhat different from normal expected climatic conditions in the region, which are very important to agriculture productivity in the area [12].

Understanding the impact of vegetation dynamics to climate variability and response of vegetation on climate variability at the inter-annual to decadal time scales are desirable. The climate variability impact that was somehow common to semi-arid region is also expanding to the highlands as high land environment is intervened by human intervention and global change. The vegetation coverage becomes sparse in many parts of the region and it is likely to become very sparse in places where the climate is highly variable [12].

Precipitation and air temperature are two of the most important variables in the fields of climate Sciences and hydrology. Precipitation is a critical component in rainfall-runoff relationships, and influences flood/drought assessment as well as mitigation measures. Temperature plays a prominent and well-known role in evaporation, transpiration, and water demand (both animal and human), and thus significantly affects both water requirements and strategies to assure its availability. The implications of changes in precipitation and temperature make it crucial for water resource planners to accurately assess their behavior and impacts on related hydrologic variables [13].

2.1. The Main Effects of Rainfall and Temperature Variability

Trends in rainfall extreme have enormous implications. Extreme rainfall events cause significant damage to agriculture, ecology, and infrastructure. They also cause disruption to human activities, injury, and loss of life. Socioeconomic activities including agriculture, power generating, water supply, human health, etc. are also very sensitive to climate variations [4].

Rainfall is the meteorological phenomenon that has the greatest impact on human activities and the most important environmental factor limiting the development of the Mediterranean semi-arid regions. Understanding rainfall variability is essential to optimally manage the scarce water resources that are under continuous stress due to the increasing water demands, increase in population and the economic development [4].

Ethiopia's economy is heavily dependent on rainfall for generating employment, income, and foreign currency. Thus, rainfall is considered as the most important climatic element that influences Ethiopian agriculture. The country has experienced frequent and extensive drought that caused food shortages and famine. The severity and frequency of occurrence of rainfall extremes events (meteorological, hydrological, and agricultural) vary for different parts of the country [4].

Many researchers now believe that the occurrence of various droughts in Africa, especially in southern Africa and the Horn, are caused by physical processes related to the occurrence of El Niño -Southern Oscillation (ENSO) events. ENSO is a coupled air and ocean phenomenon with global weather implications. When past ENSO events are compared with drought and famine periods in Ethiopia, they show a remarkable association. ENSO profoundly affects climatic variability in parts of sub-Saharan Africa, including the Sahel, Ethiopia, equatorial eastern Africa and southern Africa, where strong and persistent ENSO events create unique and persistent anomaly patterns in rainfall [4].

The Studies made at NMA have also shown that there is a link between El Nino and La Nina phenomenon and Ethiopian rainfall (NMA). During an El-Nino or La-Nina event, a complex and interconnected chain of climate variations occur across the tropical Pacific as the atmosphere-ocean system redistributes thermal energy. El Nino and La Nina events have a period of about two to seven years [1].

They tend to begin in May-June and last approximately a year, reaching their maximum intensity in the tropics during November-February and there is a claim that as El Nino and Southern Oscillation events are made more active by global warming, Belg rains are heavy and Kiremt rains are of a below average level. A negative sea surface temperature anomalies (SSTA) or La Niña is strong associated with rainfall deficiency in Belg and excess rainfall in Kiremt season; while, a positive SSTA or El-Nino is mostly associated with normal and above-normal rainfall amounts in Belg and deficiency of rainfall in Kiremt season. Furthermore, the National Meteorological Agency also realized that the sea surface temperatures (SSTs) in the Indian and Atlantic oceans also affect the region weather and climate variability. Most of the drought years are associated with El-Nino events; however, most of wet/flood years are associated with La-Nina episodes [1, 4]

2.2. Causes of Global and Regional Climate Change

Climate change is real and happening now. The average global surface temperature has warmed by 0.8°C in the past century and 0.6°C in the past three decades. The effects of climate change and variability such as rising temperature and changes in precipitation are undeniably clear with impacts already affecting ecosystems, biodiversity and people [4].

The Intergovernmental Panel on Climate Change (IPCC) in 2007 concluded that warming of the climate system was unequivocal and very likely (more than a 90% chance) caused by humans. The IPCC also concluded that global emissions would have to peak in 2015 and reduced by 25-40% in 2020 and by 50-85% in 2050 to have a 50% change of limiting global temperature increase to 2°C [4]. Water vapor and other “greenhouse gases” such as carbon dioxide, methane, and CFCs cause the greenhouse effect by trapping radiant heat emitted at infrared (long) wavelengths (as opposed to shorter, solar wavelengths which can pass through the atmospheric gases) from the earth’s surface and reradiating it back to the earth’s surface and trapped energy effectively, creates an enclosure around the earth’s atmosphere similar to a greenhouse, which not only traps heat, but also restricts air circulation that would otherwise cause cooling [1, 4].

It occurs because of internal variability within the climate system and external factors. The external causes may be natural or human induced human activity. Human activities cause climate change mainly fossil fuel burning and removal of forests. These contribute to climate change by causing changes in Earth’s atmosphere in the amounts of greenhouse gases, aerosols (small particles), and cloudiness (IPCC) [14]. At global scale, the main cause of greenhouse gas (GHG) emissions is from carbon dioxide (70%), primarily from burning of fossil fuel (petroleum) imported from industrialized countries, while the other sources for GHG are methane and nitrous oxide caused by deforestation and agricultural activities, particularly the use of pesticides. Climate change, driven by fossil fuel combustion and deforestation, is a becoming threat to lives and livelihoods in every part of the world at this time [14].

The latest assessment report by IPCC (2013) states with 95% confidence that human influence is the main cause of the observed warming in the atmosphere and oceans and other indicators of climate change and that continued emissions of greenhouse gases (GHGs) will cause further warming and changes in the components of the climate system. The emissions of greenhouse gases are predominantly from high-income countries while the negative effects of climate change are predominantly in low income countries. This means climate change is generally expected to hit developing countries harder than industrialized countries, as the developing countries are less capable of mitigating or adapting to the changes due to their poverty and high dependence on the environment for subsistence [14]. The strong warming trends in south west Iran were detected at the stations near large cities was due to high population growth, urbanization, industrialization were some of the reasons in the last 30 years for warming trends of temperature[11].

2.3. Climate Change Variability

Climate change is a change of climate which is attributed directly or indirectly to human activity. It alters the composition of the global and/or regional atmosphere and natural climate variability observed over comparable time periods. Climatic variability's are the types of changes (temperature, rainfall, occurrence of extremes); magnitude and rate of the climate change that causes the impacts on the area of public health, agriculture, food security, forest hydrology and water resources, coastal area, biodiversity, human settlement, energy, industry, and financial services. Changes in physical and socio-economic system have been identified in many regions. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), the global average surface temperature is likely to rise by 1.8 degrees to 4.0 degrees Celsius [14].

The sea level may rise by 30 to 60 centimeters. Climate variability will increase almost everywhere. Northern latitudes will experience more rainfall; many subtropical regions will see less. Detecting these changes and associating them with climate change poses huge problems since these systems are usually subject to many stress factors other than climate change too. Vulnerability is the degree to which a system (such as a social-ecological system) is likely to be wounded or experience harm or stress in the natural or social environment. Vulnerability results from a combination of processes that shape the degrees of exposure to a hazard, sensitivity to its stress and impacts, and resilience in the face of those effects. It is also considered a characteristic of all people, ecosystems, and regions confronting environmental or socioeconomic stresses and, although the level of vulnerability varies widely, it is generally higher among poorer people [14].

Baseline climate that was developed using historical data of temperature and precipitation from 1971-2000 for selected stations in Ethiopia showed the year-to-year variation of rainfall for the period between 1951 to 2005 over the country expressed in terms of normalized rainfall anomaly averaged for 42 stations [14]. The country during those periods (1951 to 2005) has experienced both dry and wet years over the last 54 years. These changes in the physical environment are expected to have an adverse effect on agricultural production, including staple crops such as wheat and maize. Trend analysis of annual rainfall in Ethiopia shows that rainfall remained more or less constant when averaged over the whole country while a declining trend has been observed over the Northern and Southwestern Ethiopia [14].

The rainfall is highly variable both in amount and distribution across regions and seasons. The seasonal and annual rainfall variations are results of the macro-scale pressure systems and monsoon flows which are related to the changes in the pressure systems. The spatial variation of the rainfall is influenced by the changes in the intensity, position, and direction of movement of these rain-producing systems over the country. Moreover, the spatial distribution of rainfall in Ethiopia is significantly influenced by topography which also has many unexpected changes in the Rift Valley. Being a closed basin, relatively small interventions in land and water resources can have far-reaching consequences for ecosystems goods and services, and potentially undermine the sustainable use of the area [14].

The National Metrological Agency revealed that in Ethiopia climate variability and change in the country is mainly manifested through the variability and decreasing trend in rainfall and increasing trend in temperature. Besides, rainfall and temperature patterns show large regional differences. For the IPCC mid-range emission scenario, the mean annual temperature will increase in the range of 0.9 -1.1 °C by 2030, in the range of 1.7 - 2.1 °C by 2050 and in the range of 2.7-3.4 °C by 2080 over Ethiopia compared to the 1961-1990 normal. A small increase in annual precipitation is expected over the country. Other sources of data have also substantiated the variability of climate and its trends in a somewhat similar ways. Historical climate analysis for Ethiopia indicates that mean annual temperature has increased by 1.3°C between 1960 and 2006, an average rate of 0.28°C per decade [14] The increase in temperature in Ethiopia has been most rapid in June, August, and September at a rate of 0.32°C per decade. Rainfall is historically highly variable and there is no clear trend in the amount of rainfall over time. Studies of localized meteorological data alongside community perceptions indicate that seasonal change may already be occurring as there are declining and increasing trends in certain months of the years. Mean annual temperature is projected to increase by 1.1 to 3.1°C in the 2060s, and 1.5 to 5.1°C in the 2090s. Under a single emissions scenario, the projected changes from different models span a range of up to 2.1°C [14].

The wide range between these different scenarios highlights the uncertainty in future projections for climate change in Ethiopia. Clearly Ethiopia is highly vulnerable to current variability and there are also indications that climate change will increase rainfall variability which will likely increase losses from rain-fed agriculture. The ecosystems of the country as well as its community are highly exposed to climatic variability. Ethiopia is vulnerable to climatic variability owing to its low adaptive capacity accountable to low level of socioeconomic development, high population growth, inadequate infrastructure, lack of institutional capacity and high dependence on climate sensitive natural resource-based activities (NMA) [14].

2.4. Early Ethiopia's Contribution to Climate Change

The emission of GHGs from various sources of energy usage has resulted in climate change by causing global warming. Climate change is a key concern to Ethiopia in our time and need to be tackled in a state of emergency. It has brought an escalating burden to already existing environmental concerns of the country including deforestation , agriculture sector land use and cover change and biomass consumption and thus to anthropogenic climate change. This phenomenon is occurring throughout the country and affecting every community although it may assume diverging degrees from place to place as the country has varied landscape featured by contrasting altitudinal ranges [14].

According to FIRST (2001) report, the GHG emissions accounted to 900 kg CO2 equivalent per capita and year in 1994. Compared to other countries, Ethiopia's emissions are very low (e.g. the U.S. emissions amount to 23.7 tones CO2 equivalent per capita and year in 1994, but it is affected by the adverse impacts of climate change brought by the carbon-intensive development paths of rich countries over the past century. The direct contribution of agriculture in the country is about 80% of the total GHG emissions. It is ranked as the most susceptible sector to climate change impacts and so do the livelihoods of subsistence farmers and pastoralists. This reflects the fact that livestock farming goes together with high methane emissions. The dominant position of livestock farming in Ethiopia's economy also influences the relative contribution of GHG to the total emissions. These are dominated by methane emissions, which account for 80% of the warming potential [14].

In addition to agriculture, the energy sector (heating, cooking) and transport contributes to 15% of GHG emissions. Biomass is the major source of household energy and estimates indicated that 95 percent of the total energy consumption in the county was made up of biomass fuels consisting of fuel wood, animal dung and crop residue. Fuel wood use makes up 81.8 percent of these traditional sources, while animal dung and crop residue make up 9.4 and 8.4 percent, respectively. Traditional fuels make up 99.9 percent of the rural energy consumption and the rural population consumes 86.7 percent of the total net energy. This higher fuel wood consumption is due to increase in populations. GHG emissions of the country have to do much With the basic needs of the livelihoods of these populations. Therefore, the future GHG emissions will likely increase with the projected increase in population [14]

2.5. Major Drivers to Climate Change:

Deforestation and Forest Degradation

Deforestation is the destruction of forested areas followed by a change in the land use (usually to agriculture or pasture) that prevents the forest from regenerating. Forest degradation refers to negative changes in the forest area that limit its production capacity. One good example that contributes to forest degradation in Ethiopia is the poorly regulated collection of firewood from natural forests. In many tropical countries, the majority of deforestation results from the actions of poor subsistence cultivators. According to IPCC, annual emissions from deforestation stand at 5.8 Gt CO_2, and around 17 per cent of global anthropogenic greenhouse gas emissions come from the forestry sector as a whole, including emissions from biomass decay, drained peat and peat fires. It is the third largest source of anthropogenic GHG emissions after energy supply and industrial activity [14].

Though forest sector is a major source of CO_2 emissions, reducing forest emissions can be achieved at relatively low cost compared with abatement in other sectors. Furthermore, as the large majority of deforestation occurs in developing countries, any international system that channels finance to reduce deforestation has the potential to help reduce poverty as well as preserve other ecosystem services such as biodiversity and regional rainfall patterns. Deforestation and forest degradation are driven by proximate/direct causes and underlying/indirect causes. However, deforestation and degradation occur through different processes. The main direct drivers of deforestation are generally agreed to be logging and the expansion of agriculture and infrastructure. Demand for wood fuels drives much of Africa's forest degradation. Though the role of firewood in forest degradation is somewhat contested, charcoal dominates cooking energy choices in urban areas and uncontrolled fires, livestock grazing in forests are widely recognized to contribute [14].

Proximate causes are human activities or immediate actions that directly impact forest cover and loss of carbon. These causes can be grouped into categories such as agriculture expansion (both commercial and subsistence), infrastructure extension and wood extraction. Underlying causes are complex interactions of fundamental social, economic, political, cultural and technological processes that are often distant from their area of impact. These underpin the proximate causes and either operates at the local level or have an indirect impact from the national or global level [14].

2.6. Minor Drivers to Climate Change

Minor sources of emissions today are transport, power, industry, and buildings, as described below. ***Transport:*** In transport, approximately 75% of the emissions come from road transport, particularly freight and construction vehicles, and to a lesser extent private passenger vehicles. Air transport also contributes a significant share (23% of transport related emissions). Emissions from inland water transport are minimal.. Ethiopia is endowed with vast energy resources particularly hydropower. Energy supply in the country is composed of three main sub-sectors, namely; biomass, petroleum and electricity. Currently the energy need of the country is satisfied by wood fuel (77%), dung (7.7%), crop residue (8.7%), Bagasse (0.06%), charcoal (1.15%), electricity (1%), liquid petroleum gas (LPG) (0.05%), and oil products (4.8%). Most of the energy is utilized for household purposes [14].

Electric power: The electric power sector only accounts for very low emissions as it is largely based on renewable energy, with hydro power accounting for more than 90% of total power generation capacity, supplemented by the use of on and off-grid diesel generators administered by the Ethiopian Electric Power Corporation (EEPCo). Current emissions in the energy sector a share of 3% of the country's total emissions. (The global average for electric power generation's share of a country's GHG emissions is more than 25%). [14].

Industry: Given the comparably small share of organized industrial economic activity overall, industry accounts for only 3% of GHG emissions. emissions from industry, cement is the single largest industrial source of emissions, followed by mining (32%), and the textile and leather (17%) industry. Emissions from steel, other types of engineering, the chemicals industry (incl. fertilizer), pulp and paper industry and food processing together account for only around 2% of industrial GHG emissions[14].

2.7. Climate Change Impacts

Climate change causes wide-ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity. Changes in rainfall pattern are also likely to lead to severe water shortages and/or flooding. Rising temperatures also will cause shifts in crop growing seasons which affects food security and changes in the distribution of disease vectors putting more people at risk from diseases such as malaria. Temperature increases will potentially severely increase rates of extinction for many habitats and species [14].

Climate change causes the frequency and severity of weather events. Some indirect effect of climate change includes, changes in soil moisture, land and water condition, change in frequency of fire and pest infect and the distribution of diseases. The potential for a system to sustain adverse impact on agriculture is determined by its capacity to adapt to the changes. Higher temperatures, reduced rainfall and increased rainfall variability reduce crop productivity that would be affected food security in low income and agriculture-based economies. Thus, the impact of climate change is detrimental to countries that depend on agriculture as the main livelihood [14].

Climate change has the potential to undermine sustainable development, increase poverty, and delay or prevent the realization of the Millennium Development Goals. Climate change can influence humans directly, through impacts on health and the risk of extreme events on lives, livelihoods and human settlements and indirectly, through impacts on food security and the viability of natural resource-based economic activity. The biophysical effects of climate change on agriculture induce changes in production and prices, which play out through the economic system as farmers and other market participants adjust autonomously, altering crop mix, input use, production, food demand, food consumption, and trade [14].

Climate change is generally expected to hit developing countries harder than industrialized countries, as the former are less capable of mitigating or adapting to the changes due to their poverty and high dependence on the environment for subsistence. Ethiopia's contribution to global greenhouse gas emissions is negligible, but it is affected by the adverse impacts of climate change brought by the carbon-intensive development paths of rich countries over the past century [14].

Ethiopia is hit harder than most countries by drought and its devastating consequences. Recurrent droughts have resulted in loss of life and property as well as the migration of people. Drought frequency is predicted to increase placing stress on already vulnerable production systems. The main stay of the Ethiopian economy is rain-fed agriculture, which is heavily sensitive to climate variability and change. Drought is also severely affecting hydropower generation, Ethiopia's main source of electricity. Flooding in turn causes significant damage to settlements and infrastructure, livestock and animal health, and the water logging of productive land undermines agriculture by delaying planting, reducing yields, and compromising the quality of crops, especially if the rains occur around harvest time [14].

In addition both droughts and flooding increase the stress on social institutions, and increase the vulnerability of households, particularly those living close to the poverty line, through loss of assets, impaired health, potential conflicts and animal disease with potential risk for humans. Climate change affects human and livestock health directly through morbidity and mortality impacts of temperature extremes, vectors of infectious diseases, proliferation of non-vector borne infectious diseases, air quality, floods and storms, and indirectly through impacts on food supply and water resources. Climate change creates a favorable environment for vector-borne diseases such as malaria and trypanosomiasis that are widespread in the country. Malaria and animal trypanosomiasis will expand their altitudinal range and it is anticipated that other new human animal and plant diseases will emerge and increase [14].

3. Material and methods

3.1. Area of description:

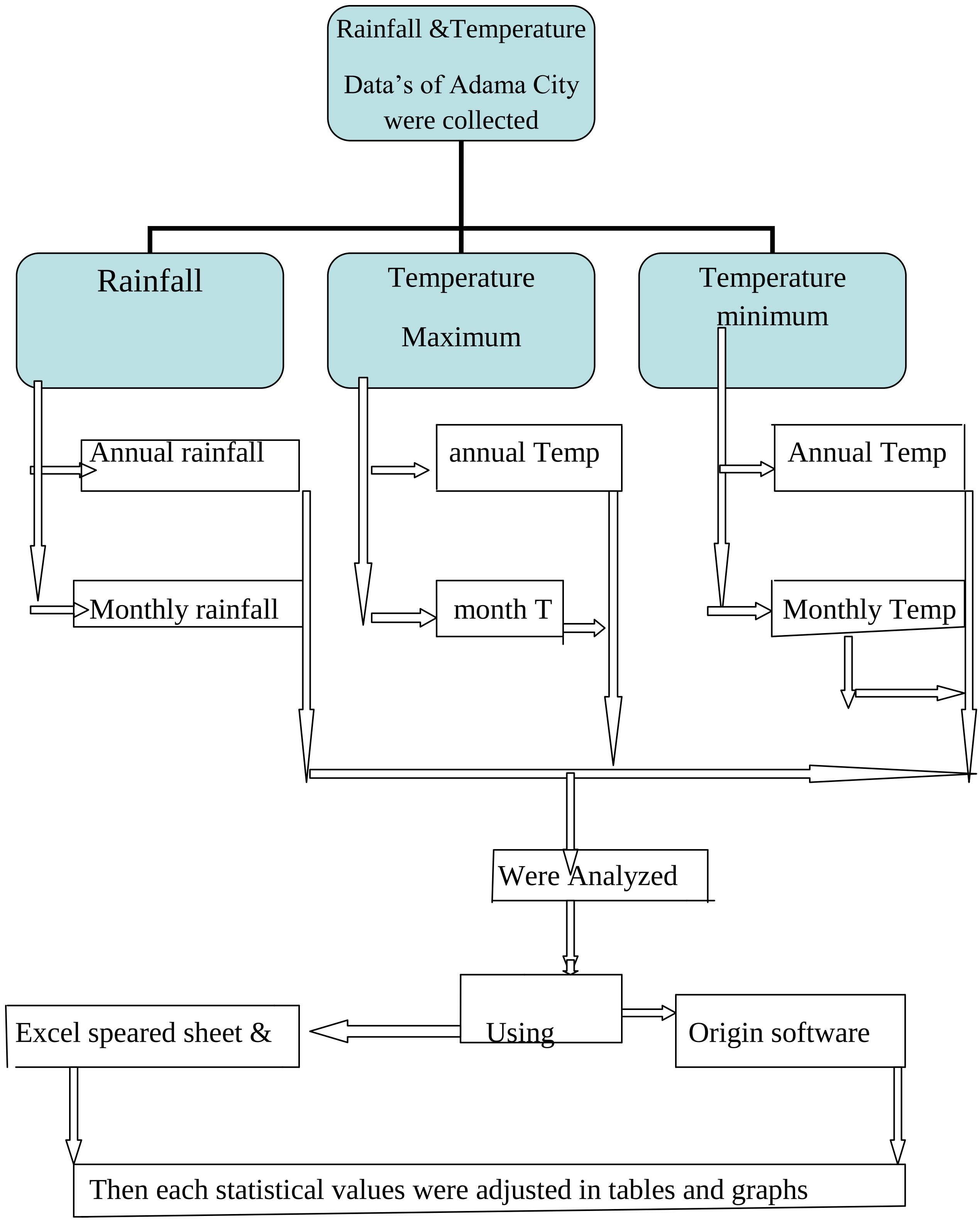
Adama city is a commercial center in east showa zone and located at 98 km away from the capital city Addis Abeba. The geographical location of Adama City is 39^{o} 17' E longitude and 8° 33' N latitude, situated in the Rift valley part of Ethiopia. The dominating climate of the city is hot (arid climate type). The average altitude of Adama is about 1648 m..

3.2. Data collection

The maximum and minimum temperature as well as for precipitation data were collected for the period of 1979 -2009 E.C from Adama City meteorological stations.

3.3. Data analysis

The data's were analyzed in descriptive statistics, such as mean, median, standard deviation, skewnes, kurtosis , coefficient of variation of temperature maximum, temperature minimum and precipitations. The data analyzed using, origin software and excel spreadsheet. In the first step the annual and monthly rainfalls of Adama City meteorological stations were calculated. Next then, the annually, monthly, minimum and maximum temperature values were calculated. After that, each statistical results of rainfall, maximum and minimum temperatures were putted in tables and the graphs were drawn using origin software to detect the trends of both climatic elements of the station over the time series.


Rainfall &Temperature
Data’s of Adama City
were collected
Rainfall
Temperature
Maximum
Temperature
minimum
Annual rainfall
Monthly rainfall
annual Temp
month T
Annual Temp
Monthly Temp
Were Analyzed
Using
Excel speared sheet &
Origin software
Then each statistical values were adjusted in tables and graphs

4. Results and discussion

4.1. Precipitation trends

Precipitation is the amount of water cycle in the Earth Surface [1]. Skewness is a measure of symmetry, or more precisely, the lack of symmetry. The data set is said to be symmetric if it looks the same to the left and right from the center point. The skewness for a normal distribution is zero, and any symmetric data should have skewness near zero. Negative values for the skewness indicate that data are skewed to the left and positive values for the skewness indicate that data are skewed to the right [15].

Kurtosis is a measure of data peakness or flatness relative to a normal distribution. That is, data sets with a high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have heavy tails. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak. The standard normal distribution has a kurtosis of zero. Positive kurtosis indicates a peaked distribution and negative kurtosis indicates a flat distribution [15].

The coefficient of variation (C.V) is the degree of rainfall variability that provides a measure of year to year variation in the data series. NMA (1996) documented that a series with (ratio of standard deviation to mean multiplied by 100) less than 20 % could be considered as less variable, (C.V) between 20 % - 30 % is moderately variable, and (C.V) greater than 30% is highly variable [9,15]

The descriptive statistics of annual rainfall and monthly rainfall of the given period such as, coefficient variation (C.V),coefficient of Skewness (C.S), coefficient of kurtosis(C.K), median,standard deviation, mean deviation, minimum and maximum were presented in Table1.

In the study area the annual totals rainfall as well as the months, the coefficient of variation (C.V) was greater than (C.V) =18.324% and with maximum coefficient of variation was occurred in December which is (C.V) = 205% , November =166.8% and October =137.97 % respectively. The results from the statistical value indicated us the data of rainfall were not normally distributed. According to the result almost all months have higher and homogenous character in rainfall coefficient of variation (C.V). Except September, July and August have low variation coefficient (C.V) relative to the other months. Since (C.V) is used to classified the degree of variability of rainfall events so the annual rainfall was less than 20% which is

18.324 %. The monthly rainfall have moderate values in August which is 28.79% and high values of variability in all months ranging between 39.99% to 205%. The higher degree of rainfall coefficient of variability indicated that, the data distribution were clustered or not closed to the mean values, in such case (C.V) can be >100% because the standard deviation is .greater than the mean values. In another ways (C.V) might be > 100% if the dates have zero values in our case the data's have zero values.

The mean annual rain fall of Adama City was 904.59 mm and. The monthly mean rainfall of Adama City were decreasing from September up to December, the January up to August were increasing trends. The precipitation of the study area was not evenly distributed throughout the time series. Therefore this indicated that there were higher variability of rainfall in the study area. Maximum mean seasonal rainfall was occurred in summer months like September 116.12mm, July 244 mm and August 212.4 mm and the minimum monthly precipitation was occurred in the months of November 11.2 mm, December 7.18mm and January 17.5mm.

The median of annual rainfall of Adama City was 879.8mm and the median of monthly rainfall were ranges between 0mm -220mm. The standard deviation of annual rainfall of Adama City was 165.76mm and the months have an interval values between 14.7mm which is the lowest to 95.6mm the highest.

The skewnnes coefficients (S.C) of the annual rainfall in Adama City was 0.5488mm and 0.01mm -2.57mm was the monthly skewnnes coefficient(S.C) of the City. The result indicated that, both annual and monthly rainfall of Adama City were positively skewed to the right from the central location which shows slowly increasing trends over the given period of time. The annual kurtosis coefficient (K.C) of the City was 0.6877mm which is positive and the kurtosis coefficients of all months were positive having a magnitude between 0.16mm to 8.10mm, except September and March have negative values -0.57mm and -1.2mm respectively.

Rainfall varies with latitude, elevation, topography, seasons, distance from the sea, and coastal sea-surface temperature. Long-term trends in rainfall are difficult to determine for Ethiopia due to strong inter-annual and inter-decadal variability in rainfall data. A lack of rainfall records impedes the proper analysis of historical trends in rainfall variability, which is particularly important since much of the rainfall in Ethiopia is brought about by localized, convective storms [15].

The analysis results indicates that most of the station's consecutive annual precipitation years are positively related [7]. The annual rainfall of Mekele City were decreasing trends and both the maximum and minimum Temperature were increasing trends [2].

	Annual	***Sep***	***Oct***	***Nov***	***Dec***	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***Jun***	***Jul***	***Aug***
N	31	31	31	31	31	31	31	31	31	31	31	31	31
Mean	904.59	116.12	36.4	11.2	7.18	17.5	26.0	57.4	62.2	53.33	61	244	212.4
Median	879.8	122.8	13.1	0.5	0	11.8	11.1	64.6	50.9	36	59	220	210
Ave.dev	128.66	39.158	38.6	13.8	9.94	16.7	26	40.2	36.8	39.25	20	73	48.46
Std dev	165.76	46.444	50.3	18.7	14.7	20.8	39.3	45.4	44.3	57.85	28	95.6	61.18
Skew	0.5488	0.1729	1.55	1.91	2.31	1.15	2.57	0.22	0.81	2.084	0.01	1.22	0.134
Kurt	0.6877	-0.57	1.27	2.85	4.18	0.54	8.10	-1.2	0.16	4.929	0.8	1.6	0.305
Minim	609	30.8	0	0	0	0	0	0	1.2	0	0	114	103.9
Maxim	1370.7	216.8	164.	69.5	51	72.5	183	151	180	259.6	122	533	344.4
C.V%	**18.324**	**39.99**	**137.97**	**166.8**	**205**	**118.6**	**151.1**	**79.1**	**71.2**	**108.5**	**46**	**39.3**	**28.79**

Table 1: Statistical summary of monthly precipitation for Adama City in (mm) from 1979-2009 E.C.

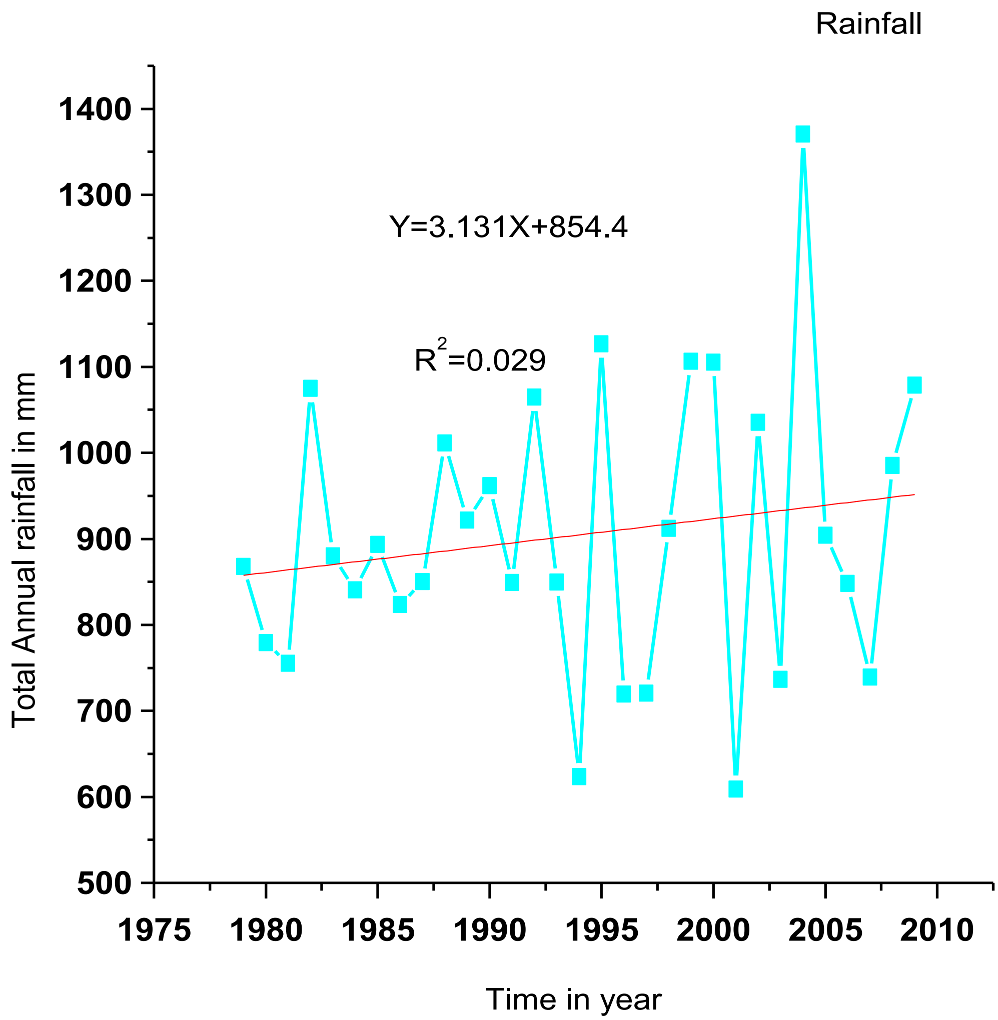


Figure 1: Annual precipitation trends of Adama City for the period of 1979-2009 E.C

As Figure:1 indicated that, the minimum annual precipitation was occurred in 1994 and 2001 with a magnitude of 623.4mm, 609 mm respectively. While the maximum precipitation was occurred in the following years 1982,1992,1995,1999 and 2009. The extremely peak maximum annual value's of precipitation was occurred in 2004 which is 1370.7mm. The rest years were gained a medium precipitation amount with a magnitude of 720 mm to 961.6 mm intervals. In general the amount of rain fall trends in the given time series oscillates in the range of between 609 mm to 1370.7mm. From the linear fitting graph, the trends of annual precipitation of the given time series indicated that slowly increasing trends.

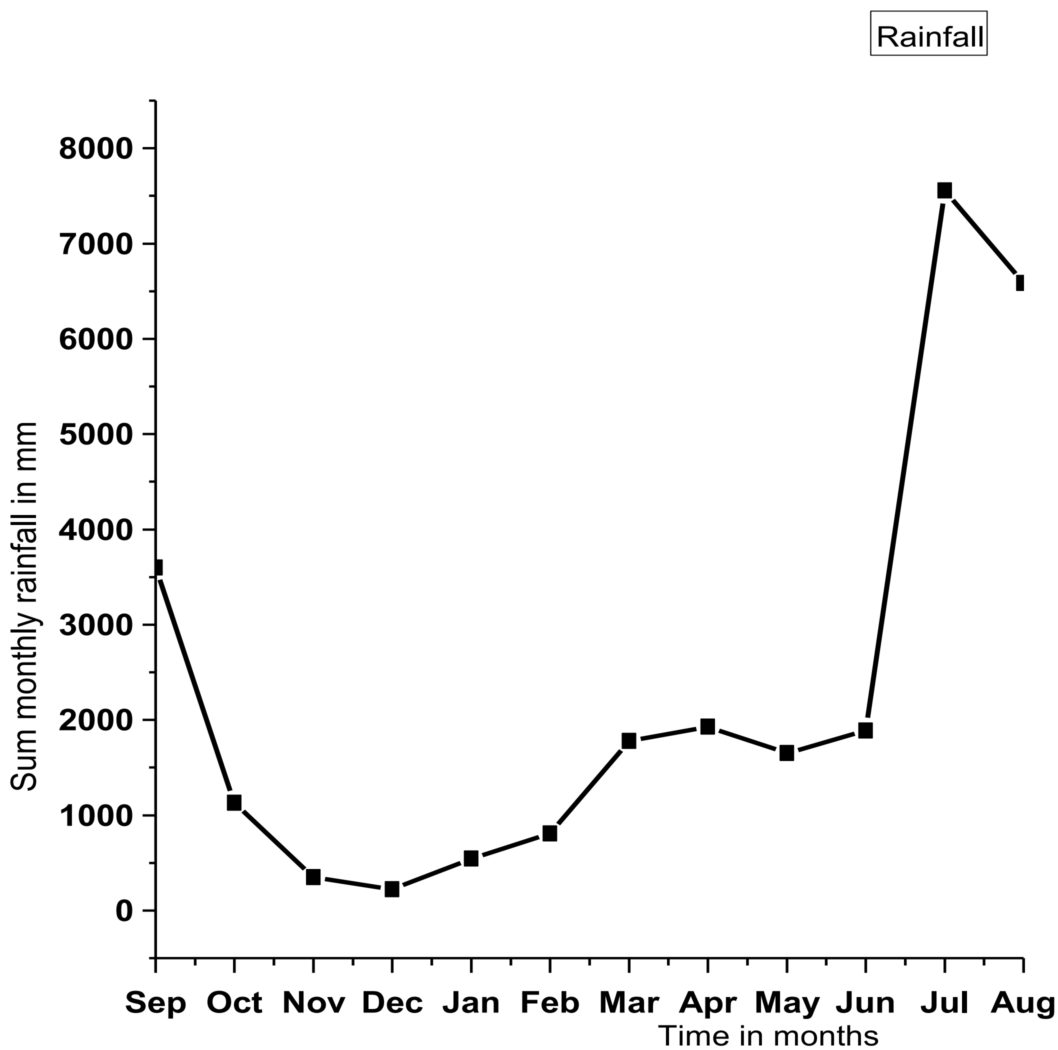


Figure 2: Graphs of monthly sum rainfall of the climatologically time series of Adama City 1979-2009 E.C

Figure 2: shows the graphs of monthly rainfall of the climatologically time series of Adama City. The graph indicated that, maximum rainfall was found in the months of, July, August and September and July have maximum peak values comparatively from the listed months. September to December the amount of rainfall shows decreasing trends and December have the minimum rainfall were observed. Starting from end of December up to March increasing trend were

observed. During March to May no trend of increasing or decreasing of rain fall were observed. In general in terms of seasons summer months have maximum rainfall. On the other hand the winter season have minimum amount of rainfall.

4.2. Maximum Temperature trends

Air temperature has crucial impact on the water cycle in the study area. So that analysis of trends in annual and monthly temperature data conducted for the periods of record 1979-2009. Figure 3 represents the mean annual maximum temperature and its trend in the period of under examination. The monthly mean values of maximum Temperature of the growing time series have almost the same magnitude ranging between 25.47^{o}c to 30.79^{o}c.

The median of each month also have almost similar values ranging between 25.91^{o}c to 30.8^{o}c with average deviation of the same magnitude in all months except in February 3^{o}c and March 2^{o}c and with large standard deviation in November, December, January, February and March have almost the same magnitude about 5^{o}c and all the rest months have the same magnitude approximately 1^{o}c and negatively skewed in all months except July, august, September and October have skewed positively.

In terms of kurtosis coefficient, November, December, January and March have maximum coefficient of kurtosis' which is about 27^{o}c. The rest months have low values with similar magnitude and positive but August have negative kurtosis which is -0.486 ^{o}c. The minimum magnitude of maximum temperature were occurred in November, December, January, February and March 0^{o}c magnitude but the rest have the same minimum temperature. The maximum Temperature have almost the same magnitude ranging between 27.94^{o}c to 34.5^{o}c with coefficient of variation in all months ranging between 3.31% to 27.24%. This indicated that the degree of maximum Temperature variability was $<$ 20% in all months except February has moderate variability which is 27.24%. This showed the distribution was almost nearest to the mean values.

	Sep	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*
N	31	31	31	31	31	31	31	31	31	31	31	31
Mean	27.254	27.79	26.206	25.47	26.187	26.98	28.78	29.81	30.79	30.02	26.5	25.94
median	26.97	27.87	27.243	26.05	26.968	28.96	29.77	29.84	30.8	30.09	25.92	25.91
Av. dev	0.8012	0.901	1.9898	1.738	1.9681	3.674	2.23	1.382	0.809	0.878	1.267	0.71
Std dev	1.0135	1.209	4.996	4.848	5.0004	7.354	5.522	1.874	1.082	1.222	1.904	0.866
Skew	0.6056	0.618	-5.101	5.109	-5.071	-3.47	-5.01	-0.16	-0.11	-0.65	2.406	0.382
Kurt	0.1679	0.907	27.535	27.76	27.346	11.47	26.77	1.353	0.485	1.03	7.255	-0.49
Minim	25.293	25.6	0	0	0	0	0	24.83	28.09	26.52	24.32	24.45
Maxim	29.797	31.1	30.67	30.64	30.923	32.92	32.79	34.5	33.07	32.22	33.97	27.95
C.V%	3.7	4.31	19.04	19	19.09	27.24	19.17	6.27	3.5	4.06	7.17	3.31

Table 2: Statistical summary of monthly maximum Temperature of Adama City from 1979-2009E.C

According to the National Meteorological Agency (NMA, 2007), the mean minimum temperatures has been increasing throughout the country particularly during the cool months by 0.37ºC per decade in the last sixty years [15].

The year to year variation of annual minimum and maximum temperatures is expressed in terms of temperature differences from the mean. Annual maximum temperatures over the last 30 years (between 1980 and 2008) showed upward trend at the analyzed meteorological stations located in Dire Dawa. On the contrary, the past 30 year trend of the minimum temperature has been gradually dropping by 0.01°C per decade. The Administration has experienced both warm and cool years over the last 30 years. However, the recent years are warmer than the early years. This analysis shows sustained warming as the annual maximum temperature has been rising faster than the minimum temperature [15]

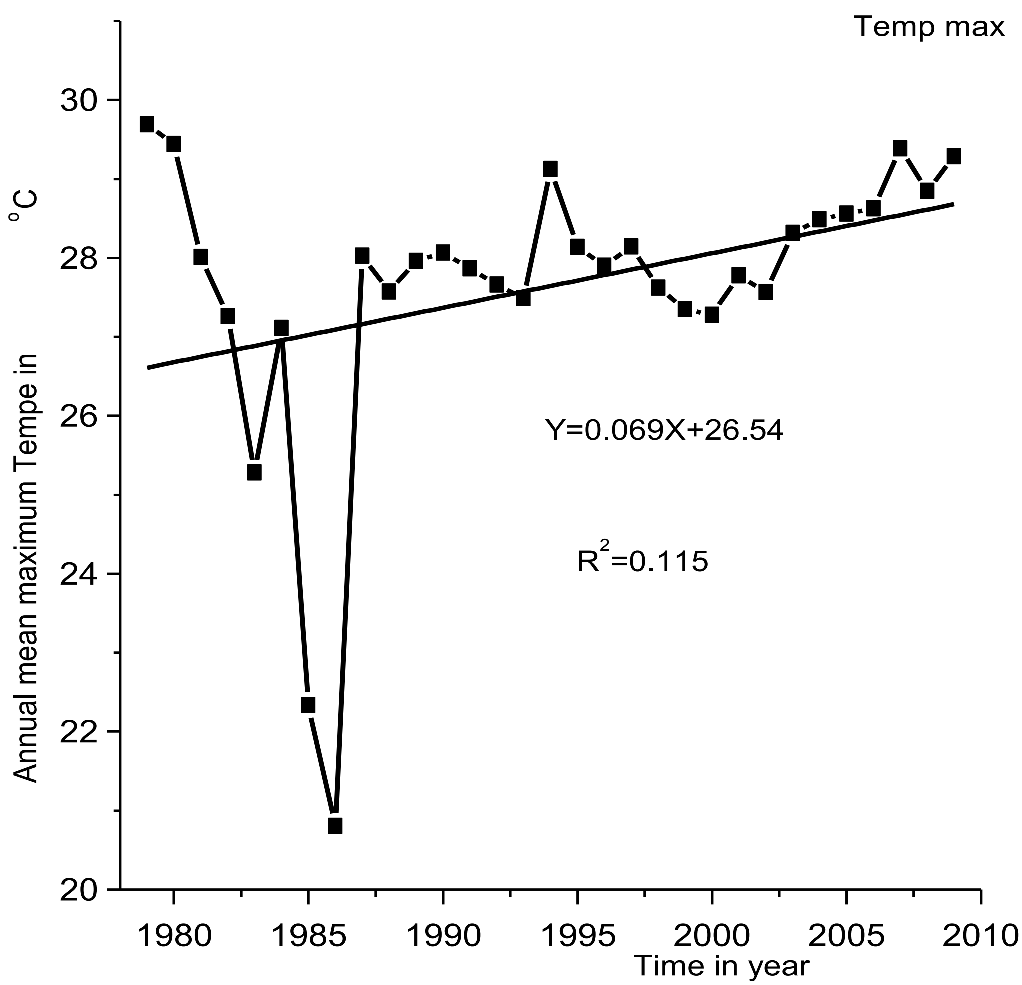


Figure 3: Maximum Mean Annual Temperature Trends of Adama City for the Period of 1979-2009 E.C

The maximum annual average temperature of the given time series occurred in the following five years 1979,1980,1994,2007,2009 which has a magnitude of about 29.32°c as shown in figure:3, The minimum annual maximum temperature exists in 1986 and 1985 with a magnitude of 20.80°c and 22.33°c respectively. The following nine years, 1981,1997,1990,1995, 2003,2004,2005,2006 and 2008 have the same magnitude near to the maximum temperature which is 28.35°c.The following thirteen years 1982, 1984, 1988, 1989, 1991, 1992, 1993,1996,1998,1999,2000,2001 and 2002 a medium annual maximum Temperature of magnitude 27.49°c. In general the annual time series indicated that, slowly increased Temperature trends the oscillation is lies between 20.8°c to 29.32°c. The slope of the function Y_{max}=mx+b=0.069X+26.54, with the degree of freedom 29, R-Square =0.115.

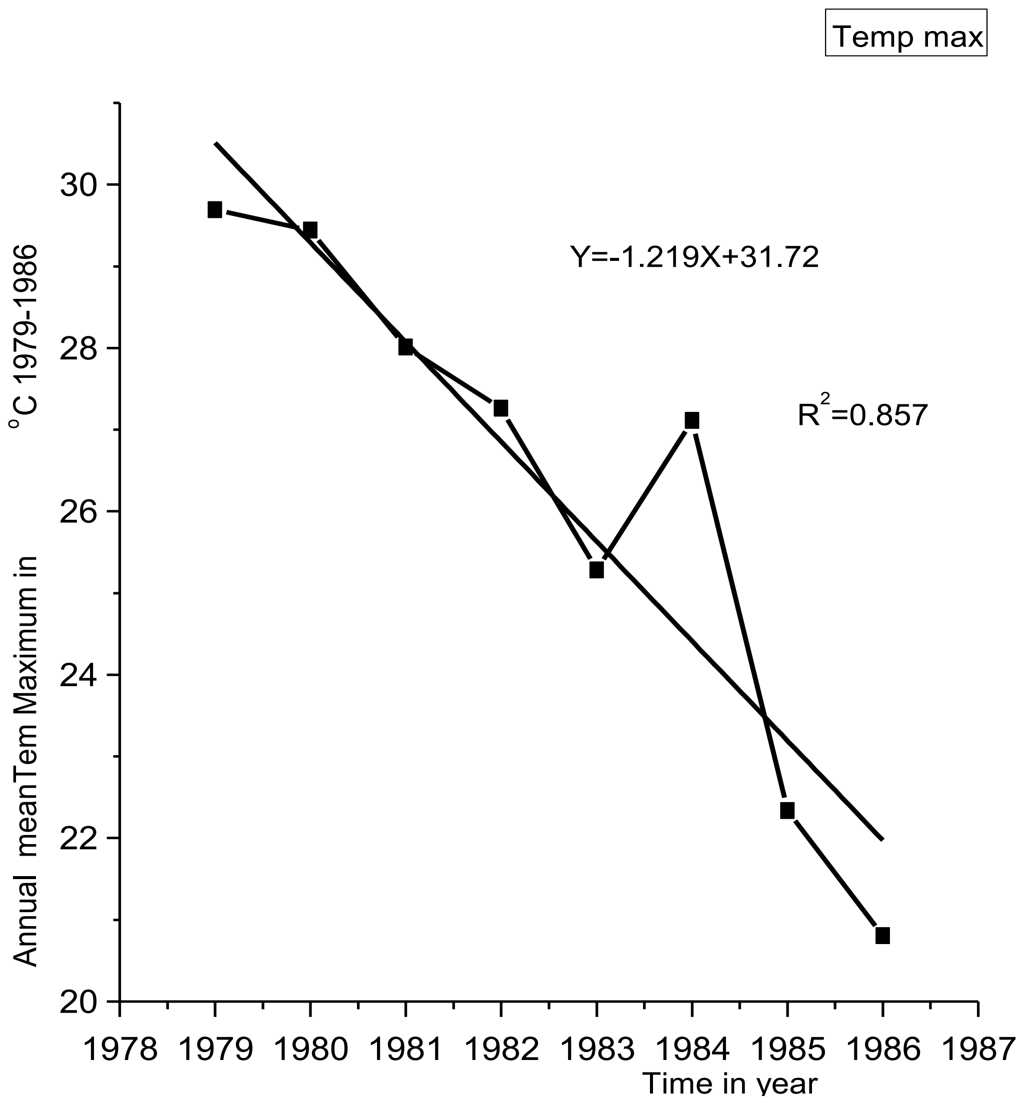


Figure 4: Maximum Mean Annual Temperature of Adama City for the Period of 1979-1986 E.C

The above figure indicated that the maximum Temperature was decreasing trends from the 1979-1986 except the year 1984 showed increasing upward. Therefore the graph was drown to indicate the trends clearly with a negative slope (-1.219).

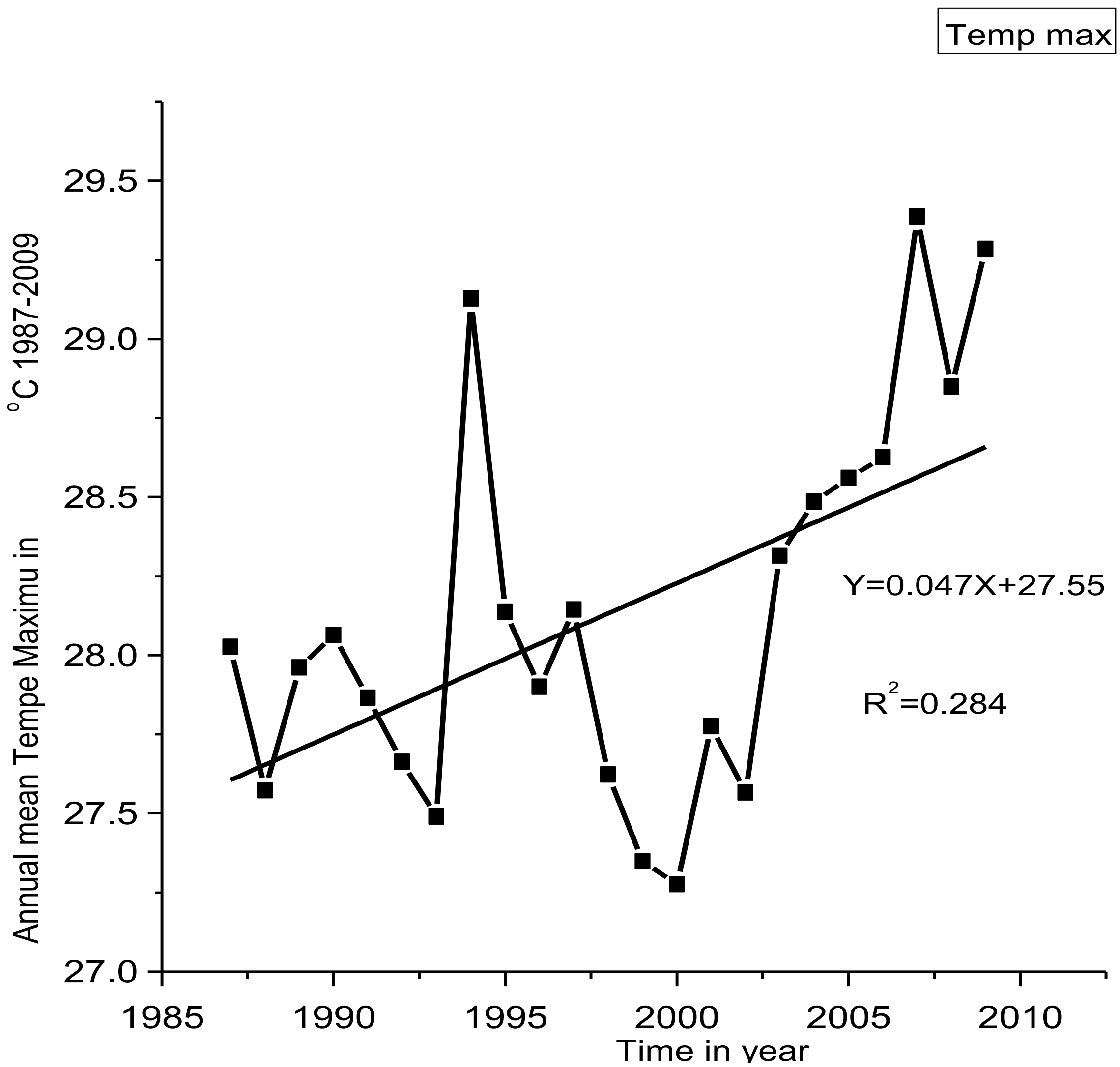


Figure 5: Maximum Mean Annual Temperature of Adama City for the Period of 1987-2009 E.C

The above figure 5 shows the actual trends which was increasing slowly upward in line with the trends of figure:3 having a positive slope which is 0.047. In 1994, 2007 and 2009 have maximum temperature values and 2001 and 1999, 2000 have the most minimum temperature of this graph. In general the trend is increasing slowly over the given time.

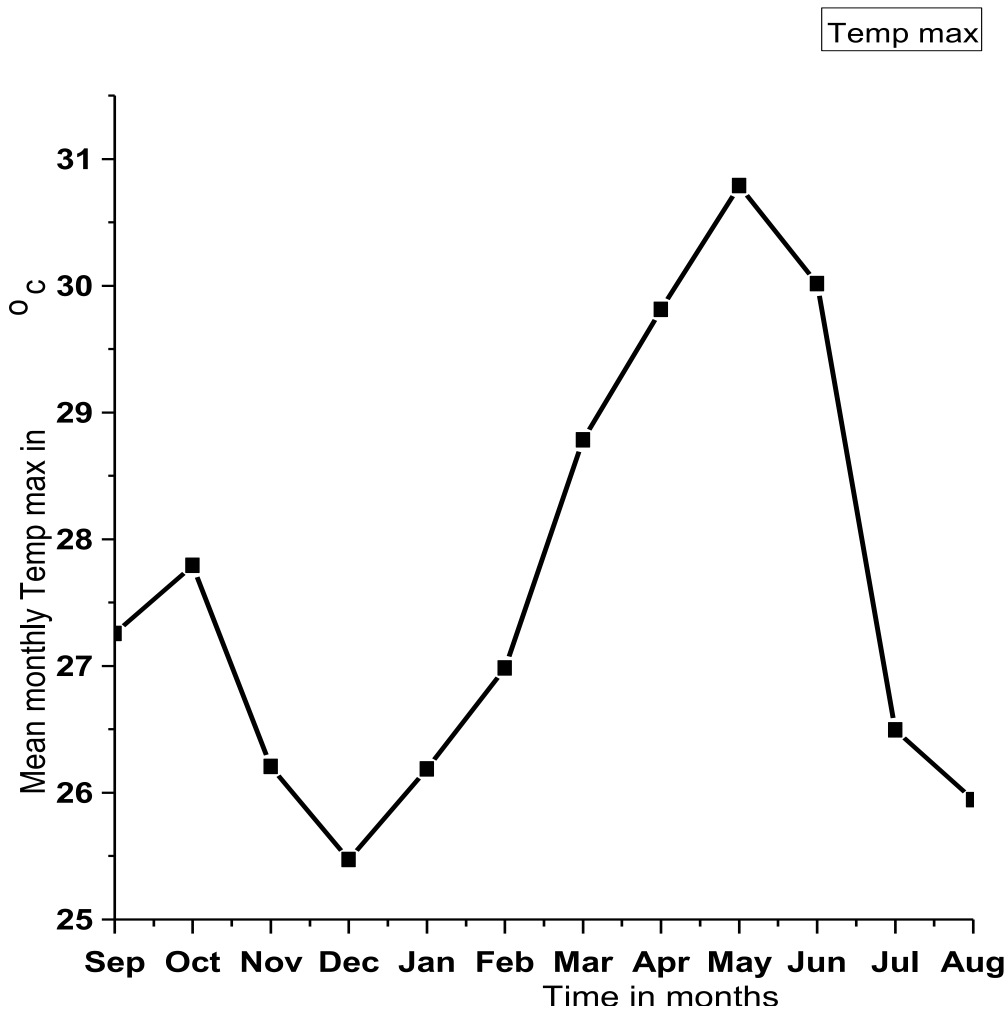


Figure 6: Graphs of monthly mean Tem max of the climatologically time series of Adama City1979-2009 E.C

The maximum mean value temperature was occurred in the months of April,May and June with a magnitude 29.81^{o}c, 30.79^{o}c, 30.02^{o}c respectively but May have peak values. On the other hand November, December and January have minimum Temperature values 26.206^{o}c, 25.47^{o}c and 26.187^{o}c respectively**.**

According to the Mann–Kendall monotonic trend analysis test, the maximum and minimum temperature analysis resulted in a general increasing trend. Whereas, rainfall amount resulted in a general decreasing trend based on the average recorded values of the different stations[4].

4.3. Minimum Temperature trends

The mean monthly values of the minimum Temperature of the study area were decreased from September up to December then, January to August were increased having a magnitude ranging between 11.94^{o}c to 16.83^{o}c and negatively skewed in all months. On the other hand the kurtosis were positive but negative kurtosis in September CK= -0.47 and August C.K=-0.122, with maximum variation coefficient (C.V) in all months ranging 3.94% to 27.52%

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
N	31	31	31	31	31	31	31	31	31	31	31	31
mean	15.247	13.572	12.652	11.94	12.63	13.85	14.97	15.385	15.87	16.83	15.82	15.99
median	15.193	13.613	13.25	12.15	13.55	15.07	15.33	16.01	16.71	17.617	15.92	16.06
Av. dv	0.7977	1.5418	2.9428	2.924	2.811	3.818	3.085	3.1097	3.185	3.2426	1.304	0.634
Std. dv	0.6483	1.1814	1.764	1.826	1.674	2.005	1.563	1.6088	1.646	1.3791	0.77	0.518
Skew	0.4297	-0.29	-2.95	-2.42	3.304	3.344	3.963	-4.265	-4.38	-4.96	-2.52	0.538
Kurt	0.4784	0.2003	11.185	8.633	13.68	10.81	19.47	21.162	21.84	26.237	7.654	0.122
Minim	13.523	9.971	0	0	0	0	0	0	0	0	11	14.42
Maxim	16.473	17.052	15.86	15.5	15.67	16.36	18.98	17.8	18.28	18.617	17.4	16.98
C.V%	5.18	11.34	23.24	24.47	22.24	27.52	20.57	20.15	20.03	19.26	8.21	3.94

Table 3: statistical summary of monthly Minimum Temperature of Adama City from 1979-2009 E.C

The minimum Temperature degree of variability was < 20% almost in all months but from November to May was 20 % < C.V< 30% which is moderate otherwise there was no high values of variability, this indicated that the data distribution was nearest to the mean values.

Regarding temperature, significant trends are found for maximum temperature data on annual and monthly basis while negative trends are detected for minimum temperature for the period of observation [4]

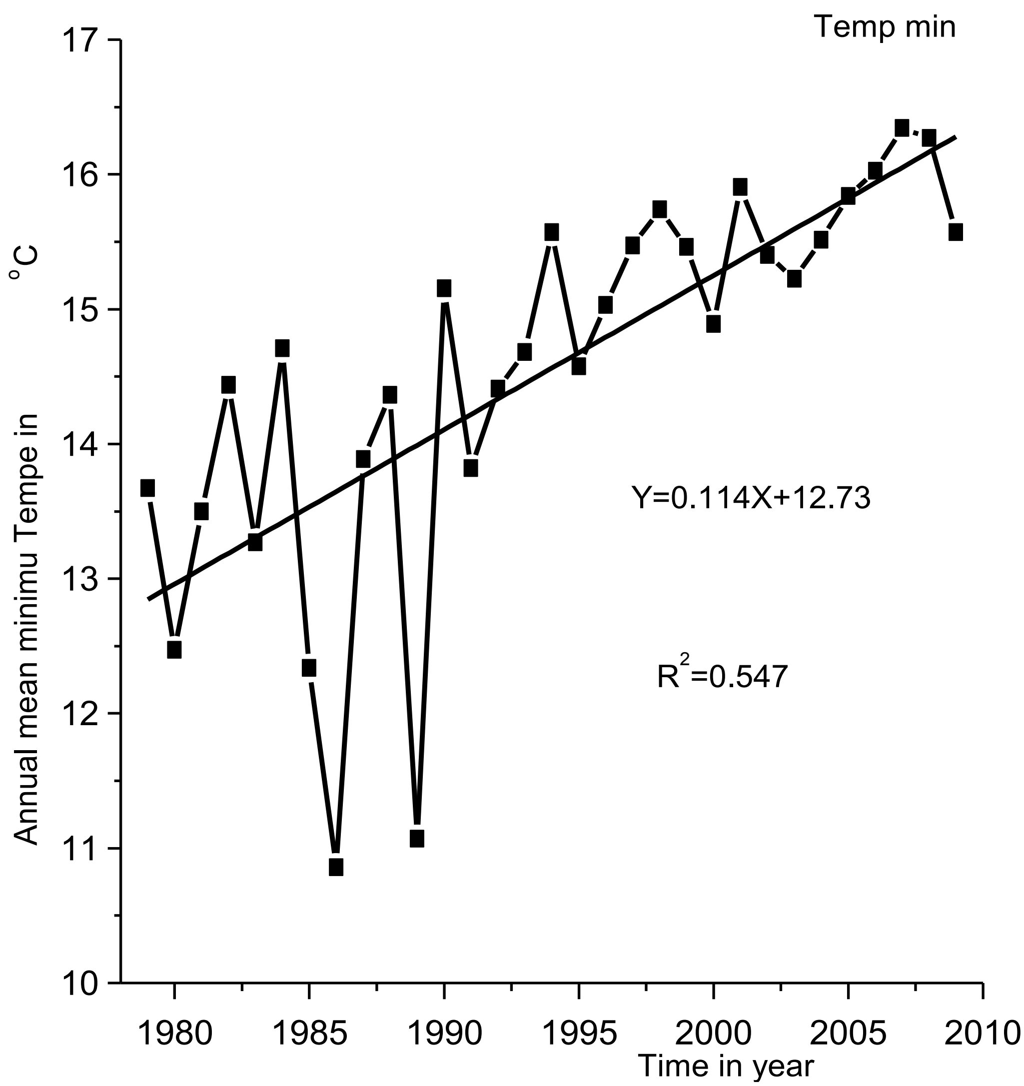


Figure 7: Minimum Mean Annual Temperature trends of Adama City for the period of 1979-2009 E.C.

From the given time series 1986,1989 has the most minimum annual average Temperature which is 10.85°c and 11.06°c respectively as we can see from the graph and the most maximum Temperature is appear in 2006, 2007,2008 which is 16.2°c this magnitude indicates the successive three years have constant annual minimum Temperature. In this five years, 1979, 1981,1883,1987,1991 have the same minimum average Temperature which is 13.70 ^{o}c.

In the following ten years 1996-2005 has constant minimum average Temperature which is 15.51^{o}c, then for the next three years 2006, 2007, 2008 the Temperature would be increased with about 1^{o}c And in 2009 return back by 1^{o}c. In general the annual minimum average Temperature of the time series is oscillates in the range of between 10.85^{o}c to 16.34^{o}c, even though it has a fractional increased in the time series. The slope of the function Y_{min}=mx+b=0.114X+12.73, with the degree of freedom 29, R^2=0.547. In general the trends of minimum Temperature is positive trends, which is slowly increased over the given time period.

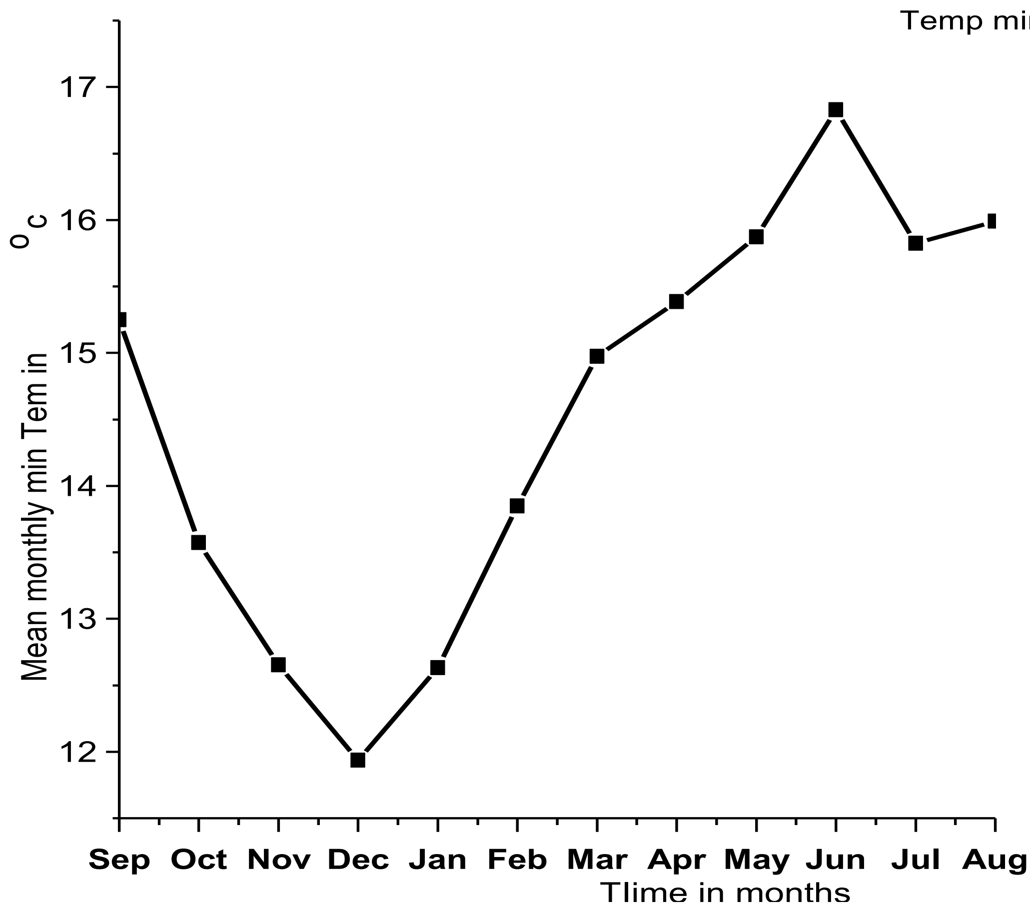


Figure 8: Graphs of monthly mean Tem min of the climatologically time series of Adama City 1979-2009E.C

From the above graph 8 December have the most minimum monthly mean temperature and June have the most extreme peak values of mean temperature minimum. In general the minimum and maximum mean monthly temperature indicated the same characteristics in the months December to January was minimum and May up to July was maximum.

5. Conclusions and Recommendation

5.1. Conclusions

This study investigated that rainfall and temperature trend analysis in Adama City meteorological station for the period of 1979 -2009 E.C.

The results of statistical data analysis were showed cyclic oscillations in every annual and monthly measured Temperature and Precipitations, however, in general even though there is a cyclic patterns of Temperature and rainfall in the study area, the trend were increasing trends throughout the growing time series for all rainfall and Temperature as we observed from the numerical statistical values and graphs of linear fitting and the relation of both parameters were a linear relationship. When we compare the increasing trends between the maximum and minimum Temperature, both were slowly increased. The variation coefficient (C.V) of rainfall was very high for the months ranging between 28.79% to 205% and for Maximum and minimum Temperature the coefficient of variation(C.V) lies between 3.31% to 27.24 and 3.94 % to 5.18% respectively.

The result indicated that the amount of precipitation in Adama City was extremely variable over the time series. It is similar to the Ethiopian climate variability in general but not similar with the specific area and particular time. Example korem is found in southern Tigray 2004 E.C was very dry year, in contrast Adama in that year have higher rainfall.

Climatologically the study area had gained mean maximum minimum Temperature from April up to August which is 16^{o}C and mean maximum Temperature April, May, June, July and August which is about 30 ^{o}C. This statistical result shows that there is a maximum evaporation and sun radiation in these months, therefore it was observed high amount of rainfall in the summer season and low rain in the winter seasons. Climatologically over the given period Adama City had gained mean values of rainfall amount annually 904.59mm and monthly September 116.12mm June, 61mm, July,244mm and Aug,212.45mm. As the different journals indicated, inversely related trends and now a day’s it is common due to Global warming both Temperature and precipitation have inversely related but here in

Adama City Metrological center, both Temperature and precipitation have Linear relationship which is increasing trends. Generally Ethiopia is vulnerable to climate variability, and climate change is likely to increase the frequency and magnitude of disasters. Adverse impacts of climate change may worsen existing social and economic challenges of the whole country, particularly where people are dependent on resources that are sensitive to climate change and summer rain-fed agriculture.

Past and current investments and disaster interventions in the country are more focused on recovery from a disaster than on the creation of adaptive capacity. Increased capacity to manage future climate change and weather extremes can reduce the magnitude of economic, social and human damage. Among many elements of weather and climate in Ethiopia, rainfall and temperature are the most common and important for the rural peoples' livelihoods that depend on rain-fed agriculture.

5.2. Recommendation

From the result, the Temperature and precipitation of Adama City for the growing period, they shows increasing trends. Here increasing of precipitation is interesting in a normal distribution for better productivity of agriculture and other uses but increasing of temperature above normal is not desire of our study area as well as in Ethiopia and Globally as whole. So to keep the normal condition of the Precipitation and Temperature trends, it is better to follow up the green economy policy by doing actively in reducing the Global warming by applying different mechanisms like a forestation, preventing over grazing, by recycle and reusing the industrial wastages, providing awareness for farmers to use wisely the farming activity for best products.

The other way of doing this is using renewable energy resource by avoiding the tradition energy use as much as possible. The agricultural and environmental sectors in all part of Ethiopia must pay a great attention in controlling deforestation and recovering the affected areas by performing water and soil conservation actions, together with the people by promoting awareness about the effects of climate change on the society as well as on natural resources. Indeed this study is not enough about the climate parameters of the Adama City, rather it needs further investigation.

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Table 4: Precipitation Data Table of Adama City for the Period of 1979-2009 E.C

year	month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1979	Total PRECIP	30.8	0	0	0	0	11.2	80.2	81.1	259.6	0	161.6	243.4
1980	Total PRECIP	186.9	52.9	0	0	34	31.3	6.8	50.9	9.4	50.3	185.4	171.4
1981	Total PRECIP	80.3	5.7	0	3.5	0	29.9	21.7	95.4	0	54.7	182.5	281.2
1982	Total PRECIP	153.7	7	0	0	0.7	183.9	83	114.7	13.3	12	337.8	168.7
1983	Total PRECIP	89	13.1	0	1.7	0	0	111	13.5	22.3	74.4	322	232.8
1984	Total PRECIP	160.3	43.9	0	3.5	41.2	27.8	0	46.3	8.6	65.9	232.8	210
1985	Total PRECIP	79.3	20	0	0	15.4	51.9	0	102.6	72.7	64.1	345.2	142.4
1986	Total PRECIP	173.8	13.8	35.6	51	0	0	2.6	49.1	26.5	70.1	229.6	171.5
1987	Total PRECIP	88.2	14.7	0	2.8	0	36.5	46.9	127.2	33	46.5	203.1	251.4
1988	Total PRECIP	93.9	0	7.9	0	27.2	0	111.5	65.1	115.2	120.2	220.2	250
1989	Total PRECIP	75.5	161.5	31.5	0	14.4	0	75.3	28.5	6.9	94	193.1	240.9
1990	Total PRECIP	144.7	132.8	0	0	11.8	25.6	105.2	19.8	49.3	55.3	196.5	220.6
1991	Total PRECIP	66.3	164.7	3.1	0	9.2	0	34.6	1.2	18.6	74	283.2	194.4
1992	Total	133.6	87.5	57.8	12.9	0	0	20.2	16.1	51.5	60.8	355.1	269

	PRECIP												
1993	Total PRECIP	107.8	1.7	0	6.6	0	6.2	108.2	28.7	177	51.2	216.8	145.3
1994	Total PRECIP	65.3	1.1	0	43.5	20.9	11.1	21.9	51.3	22.5	50.2	129.9	205.7
1995	Total PRECIP	122.8	0	5.3	48.8	46.5	69.1	151.2	88.9	3.6	75.2	235.6	279.7
1996	Total PRECIP	77.1	58.6	12.8	1.6	28.8	3.3	77.4	53.1	1.9	63.3	114.4	227.3
1997	Total PRECIP	68.4	6	5.3	0	72.5	6.3	90.1	41.3	71.1	50.2	144.3	165
1998	Total PRECIP	128.8	10.1	0.5	28.5	17.6	88.4	64.6	88.7	27.8	58.7	173.5	225
1999	Total PRECIP	138	25.4	6.7	0	23.1	31.6	82.1	101.7	64.7	62.8	225.7	344.4
2000	Total PRECIP	100.3	37.5	69.5	0	34.6	0	0	79.9	69.2	58.7	353.1	302.3
2001	Total PRECIP	34	132.7	0.4	12.5	62.6	0	0	25.3	22.1	50	156.1	113.3
2002	Total PRECIP	164.7	0	17.6	0.3	0	97.3	88.8	27.4	68.1	100.6	227.8	242.9
2003	Total PRECIP	192.1	0	0	0	22	0	10.4	17.6	68.7	54.8	215.1	155.8
2004	Total PRECIP	130.2	1.4	0.5	3.9	56	28.8	39.8	107.4	48.8	93.5	533.3	327.1
2005	Total PRECIP	132.8	34	5.2	0	4.4	0.2	69.2	35.1	36	38.9	443.2	105.2
2006	Total PRECIP	150.6	91.7	8.9	0	0	4.8	123	7.1	62.3	7.7	211.7	180
2007	Total PRECIP	78.6	2.7	47	1.5	0	0	11	180.4	3.6	74.9	131.3	207.9

2008	Total PRECIP	135	0.9	33.2	0	1.3	23	21.7	146	52.5	122.2	345.4	103.9
2009	Total PRECIP	216.8	9.1	0	0	0	38.9	121.8	36.4	166.4	31.9	250	207.5

Table 5: Maximum Temperature Data Table of Adama City For the Period of 1979-2009 E.C

year	Months	Sep	Oct	Nov	Dec	Jun	Feb	Mar	Apr	May	Jun	Jul	Aug
1979	TMP MAX	29.79667	31.09677	30.67	30.6419	2.04516	31.74287	31.23226	29.83	30.24516	30.07333	28.958	26.9516
1980	TMP MAX	27.47	27.2096	25.24	27.3258	30.9225	32.9206	32.3193	33	33.0706	31.5833	25.2661	27.0483
1981	TMP MAX	26.95667	28.0096	28.3	28.0322	28.887	28.9642	28.5612	27.0333	32.019	30.34	24.3161	24.7064
1982	TMP MAX	26.05	27.3129	27.27	25.9387	26.75	27.4714	26.1	26.7533	30.3322	30.0266	25.6419	27.4612
1983	TMP MAX	26.64	27.47	27.12667	26.5677	27.6516	0	28.9161	29.01	30.123	30.0893	24.958	24.8097
1984	TMP MAX	25.2931	25.8338	26.36	25.9322	25.8354	26.1068	29.7484	29.70667	30.6516	30.1066	25.3226	24.4451
1985	TMP MAX	26.48	27.4647	0	0	25.3	24.8785	29.4548	27.9	28.08667	28.6	24.7709	25.0741
1986	TMP MAX	25.87667	27.1354	25.5	25.0709	0	0	0	34.5	31.1451	28.62667	26.3967	25.387
1987	TMP MAX	26.52667	27.929	27.44	27.4806	26.9064	29.0142	28.7096	28.3433	30.9	31.6035	25.9194	25.5483
1988	TMP MAX	26.89667	27.9161	27.48	26.1741	26.8064	29.6379	29.5484	28.9633	29.2193	26.5233	26.2516	25.4612

1989	TMPMAX	28.333	27.2935	25.5967	25.9129	27.958	28.3107	30.3419	28.4933	31.2355	29.66	26.0967	26.3
1990	TMPMAX	26.31333	26.7548	26.5033	25.8	26.8965	29.2607	28.7709	31.6333	31.5935	32.22	26.074	24.9516
1991	TMPMAX	29.07667	25.6032	25.9167	25.4032	27.1096	29.8964	28.2677	31.0933	31.5193	30.5033	24.7483	25.2483
1992	TMPMAX	26.7133	25.8387	25.7533	25.3096	27.3419	28.3413	30.158	30.2933	30.8	29.8433	25.9322	25.6354
1993	TMPMAX	27.37	28.6806	27.3333	26.7838	24.6741	27.8178	28.5096	29.84	29.5903	28.19	25.8032	25.2838
1994	TMPMAX	28.2033	29.8322	28.6433	26.5193	26.2193	29.1821	29.9482	30.9533	32.8064	30.87667	29.6935	26.6483
1995	TMPMAX	26.97	28.458	27.54	25.4451	26.9677	29.4607	29.7677	29.0733	32.4161	30.09	25.5484	25.9129
1996	TMPMAX	27.3133	26.7096	26.78	26.2483	27.8322	28.1551	29.2903	28.6933	31.84	29.6033	26.3322	26
1997	TMPMAX	27.64667	28.9032	27.4833	26.2935	26.6357	29.6357	29.8677	30.2433	29.1	29.6033	25.6451	26.6645
1998	TMPMAX	26.4467	27.8741	26.9	25.1032	27.5032	28.7285	28.5774	28.76	30.6483	29.8667	25.8806	25.1833
1999	TMPMAX	26.4133	26.9806	26.0533	25.387	26.2258	28.4321	29.7838	28.7033	30.9129	28.17667	25.7225	25.3806
2000	TMPMAX	26.9167	27.3258	24.7433	25.1	26.8193	27.0931	30.4258	29.667	30.0774	28.5	25.4354	25.2
2001	TMPMAX	28.667	27.1129	27.24	25.9967	25.7612	27.9714	30.2483	24.8267	30.929	31.5333	26.8354	26.1774
2002	TMPMAX	26.6767	28.1709	27.2433	26.0548	26.6161	27.3178	26.9967	29.8967	30.2451	29.8333	25.7935	25.9516
2003	TMPMAX	26.7067	27.9419	26.9367	25.8387	27.2645	29.4285	29.3838	31.7233	30.7612	30.2	27.4161	26.1677
20	TMP	27.0	27.8	27.9	27.1	27.4	29	30.9	30.2	31.7	30.6	25.8	25.8

04	MAX	266	741	933	838	161		7	533	354	767	225	733
2005	TMP MAX	27.99	28.0806	27.4758	26.3483	27.3129	29.4142	31.0064	31.1967	31.1451	30.3533	26.0838	26.3193
2006	TMP MAX	27.2667	26.858	27.5033	26.2129	28.1193	29.5428	29.7774	30.698	31.1064	31.5667	28.2548	26.6006
2007	TMP MAX	28.8533	29.8838	27.99	26.8741	27.0225	30.5392	31.3129	31.5467	30.6645	30.4833	29.5193	27.9483
2008	TMP MAX	28.33	29.4161	27.9167	26.5645	28.0741	29.3724	32.7903	30.3267	29.7354	29.56	26.9516	27.1387
2009	TMP MAX	27.66	28.5645	27.4433	26.0387	27.9225	28.8357	31.5258	31.2533	29.8322	31.57	33.9709	26.787

Table 6: Minimum Temperature Data table of Adama City For the period of 1979-2009 E.C

year	1	2	3	4	5	6	7	8	9	10	11	12
1979	11.81613	14.73929	15.08065	14.12667	14.17742	18.02333	15.27419	16.15161	14.87	11.94194	9.673333	8.190323
1980	11.51935	15.06897	12.64516	12.55	14.76452	16.95667	11	14.41613	15.01333	9.970968	7.566667	8.196774
1981	8.516129	15.54643	16.24516	14.13333	16.70645	14.75	11.96774	14.85806	14.55667	10.73871	10.28	13.66774
1982	12.65484	15.12857	14.44839	14.39	16.49677	17.78667	15.70968	15.63871	15.06667	11.86774	12.43103	11.62581
1983	14.39355	15.13548	14.75333	14.476	18	15.7129	15.63871	14.75667	13.01	12.07667	11.27419	
1984	13.58387	15.37241	16.07097	16	15.77419	16.95333	15.4	15.54194	13.97241	11.78065	12.17667	13.87097
1985	13.73226	13.59286	13.79677	15.10333	15.57	16.41333	15.39032	14.9129	14.82333	12.71176		

1986	17.8	15.81613	16.82667	15.72258	15.46774	13.73333	11.23548	12.54333	11.12903			
1987	10.48387	14.25	14.4129	14.81333	13.24839	15.3	15.63871	15.22903	13.52333	12.94516	12.66333	14.1129
1988	13.99355	13.63103	15.40968	14.55172	14.71935	16.56667	15.81935	15.67419	14.64333	12.05806	13.17	12.10968
1989	12.7129	15.31071	15.6963	15.48182	15.87742	15.13	15.47097	14.67667	12.48065			
1990	13.96207	16.18214	16.05484	16.26	16.98387	17.98333	16.39032	16.05806	14.98	13.47419	12.97	10.56774
1991	11.94516	13.075	14.8871	14.61	16.33548	16.89	15.3871	15.7	14.79333	14.44516	9.833333	7.935484
1992	9.241935	13.03793	15.03548	16.01	16.7129	17.85667	15.91613	16.16774	15.19333	13.6129	12.59333	11.5129
1993	12.20645	13.34286	15.12	15.26333	17.13226	17.28667	16.1	16.48065	13.90667	13.46774	12.85	13.03226
1994	14.38065	13.93929	15.9	16.25667	17.94516	18.31333	17.2871	16.43226	14.95667	13.62903	13.34333	15.04194
1995	13.19032	14.73571	13.28387	15.99333	14.66452	16.56333	15.91613	15.79355	15.46	13.42903	13.74	12.14839
1996	14.83548	12.89655	13.30323	15.90333	16.53548	17.59667	16.32258	16.32258	15.44333	13.6129	13.55333	14.03548
1997	13.28387	14.90714	16.40968	16.36	16.76774	17.68	16.41613	16.42258	16.23	14.4871	14.54	12.15161
1998	13.97419	15.8	15.4129	15.63667	16.79032	17.84	16.59032	16.13226	16.11667	15.18387	14.75	14.65806
1999	13.99355	15.83929	16.12903	16.45	17.91613	17.61667	16.73226	15.62581	16.47333	13.06774	14.10667	11.56774
2000	13.91935	13.73448	13.97742	16.75667	17.34839	16.82667	15.47419	15.44516	15.88333	14.55161	12.77333	12.14839
20	13.54	15.21	16.75	17.12	17.51	18.37	16.82	16.67	16.27	14.3	13.25	15.03

01	516	429	161	333	29	667	258	742	333			871
20 02	14.06 129	15.38 929	15.33	16.18 333	17.36 774	17.78	16.46 452	16.91 613	15.24 333	14.52 903	13.92	11.64 516
20 03	13.06 774	14.18 214	14.91 935	16.62 667	16.28 065	16.84 667	16.62 903	16.66 774	15.63	14.23 548	14.86 333	12.75 161
20 04	14.05 161	14.12 414	16.42 903	16.87 333	16.95 161	18.01	15.85 517	16.00 323	15.89 667	13.67 419	13.87 333	14.42 903
20 05	14.25 484	15.12 593	17.28 065	17.36 667	18.28 065	18.22 667	15.6	16.68 065	15.87 667	14.82 581	14.68 621	11.85 806
20 06	13.93 226	16.35 714	16.73 871	17.35	17.26 129	18.14 333	17.08 387	16.46 452	16.01	14.71 29	14.96	13.27 419
20 07	12.60 968	15.83 571	17.11 613	16.44 333	17.23 548	18.14 667	17.4	16.56 774	16.34 333	17.05 161	15.86	15.50 323
20 08	15.67 419	15.41 034	18.97 742	17.74	17.30 645	17.48 667	16.59 355	16.98 387	16.11	15.46 774	14.77 667	12.69 677
20 09	12.03 548	15.55 714	16.94 516	17.49 667	16.96 452	18.61 667	16.40 323	16.72 258	15.76 667	15.24 839	13.7	11.37 097