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Research Article

Climate Change Indicators Trace for Identification of Climate Change Vulnerability in Salale Zone, Oromia Region, Ethiopia

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ABSTRACT

Droughts and floods have major environmental, social and economic repercussions. Climate change leads to recurrent droughts and floods in different parts of Ethiopia. Therefore, this study was aimed to characterize trends of climate change indicators (temperature, rainfall, drought, and flood). The study was conducted in the Salale zone, Oromia region Ethiopia. 30 years of climate data (maximum temperature, minimum temperature, and rainfall) from 1990-2019 was used to forecast climate variables. The precipitation/evaporation index was used to identify drought-prone areas. The flood-prone areas were identified using slope and rainfall distribution over main rivers. R statistical software, T-R, and Arc Map were used for data analysis. Accordingly, Sululta will receive higher annual rainfall, which is 1232.82 mm explicitly during the end term (2070-2099). The lowest annual rainfall will be scored at Sheno which is 594.04 mm during the near term (2020-2039). The projection of maximum temperature showed that there will be an increase of maximum temperature by 3.83°C and minimum temperature by 4.27°C in the future up to 2099. The highest maximum temperature will be scored at Ghatsion station, which will be 29.6°C in the end term and the lowest minimum temperature will be recorded at Sheno station which will be 8.1℃ in the near term. Areas with low rainfall and high temperature were identified as prone to drought, which indicates high evaporation after low precipitation/rainfall specifically low precipitation/evaporation (P/E) index. Areas found around flat land with main rivers and receive high rainfall are more prone to flooding occurrences.

Keywords: Climate change; Drought; Flood; Rainfall; Temperature; Ecosystems

INTRODUCTION

The Earth's climate is changing. Temperature is rising, snow and rainfall patterns are shifting, and more extreme climate events like heavy rainstorms are already taking place. Scientists are highly confident that many of these observed changes are linked to the levels of carbon dioxide and other Greenhouse Gases (GHG) in the atmosphere, which has increased because of human activities [1].

Climate change has increased the chances of co-occurring temperature and precipitation conditions that have historically led to a drought. A combination of record high temperatures and low (but not unprecedented) precipitation contributed to the severity of the drought [2]. Commonly, precipitation is the main driver of drought variability. Evidence suggests that anthropogenic warming has increased the likelihood of extreme droughts [3].

The resultant effects of drought are exacerbated by human activities such as deforestation, overgrazing, and poor cropping methods, which reduce water retention of the soil, and improper soil conservation techniques, which lead to soil degradation [4].

Droughts have major environmental, social and economic repercussions which affecting the availability of water for human use such as urban uses (including drinks), agriculture, and hydroelectricity generation. People most reliant on annual rainfall are generally the first to feel the impacts of drought. A single dry year can impair activities like dryland farming or livestock grazing that depend on unmanaged water supplies [5].

Flash floods can also occur after a period of drought when heavy rain falls onto very dry, hard ground that the water cannot penetrate. All flood plains are vulnerable and heavy storms can cause flash flooding in many parts of the world (World Meteorological Organization, Natural hazards floods, and flash floods) [6].

Hence, climate change adversely affects hundreds of millions of people and poses serious threats to the global food system and rural livelihoods. The influence of climate change on agricultural

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production, natural resource, and subsequent response mechanisms varies greatly from one area to another [7].

Thus, adaptation reduces the costs of climate change impacts and thus reduces the need for mitigation. Adaptation and mitigation can be complementary, substitutable, or independent of each other [8]. Adaptation and mitigation are substitutable up to a point, but mitigation is required to avoid irreversible changes to the climate system and adaptation is still necessary due to the irreversible climate change resulting from current and historic rises in GHG and the inertia in the climate system.

Ethiopian highlands receive between 600 mm-2700 mm of rainfall annually [9]. Besides high rainfall variability, also water shortages are prevalent in the Ethiopian highlands that ultimately indicates drought occurrence.

It is predicted that climate changes will lead to recurrent droughts and heavy rainfall in different parts of Ethiopia. The recurrent droughts and heavy rainfall reduce land used for agriculture and crop productivity in Ethiopia. Ethiopia loses more than 1.5 billion tons of fertile soil each year through heavy rain and flooding [10].

Ethiopia is the most vulnerable to climate change impacts due to fewer resources to adapt: Socially, technologically, and financially. Climate change is anticipated to have far-reaching effects on the sustainable development of the country, including the ability to attain the Millennium Development Goals.

Ethiopia has faced an El Niño induced drought in 2015/2016 and has led to a new drought in pocket areas across the country including the Salale zone. As a result, 5.6 million people in Ethiopia were facing emergency food assistance in 2017. Millions of children, pregnant and lactating mothers have required supplementary feeding [11].

Therefore, the reduction of drought, flooding, and its impacts can be achieved through sustainable management and proactive measures against disasters. Accurate and timely provision of drought and flood information is essential in Ethiopia. Hence, drought and flood-prone area identification and assessment are significant, particularly for farmers to prepare and establish a good plan to tackle the disastrous effect of drought and flood.

Salale zone, Oromia region was chosen for reasons of the zone is prone to drought and floods, but the specific places prone to drought and flooding were not yet identified. Therefore, this study aimed to characterize the trend of climate change indicators as tools for climate change vulnerability. Specifically, this study intended to characterize trends of temperature and rainfall, and then detect drought and flood-prone areas to identify the vulnerability of areas to climate change.

MATERIALS AND METHODS

Description of the study area

Salale zone comprises sixteen (16) districts. Fiche town is the administrative centre of the zone, which is 115 km North of Finfinne/Addis Ababa. Accordingly, the Salale zone is approximately located between 9008′52" to 10035′17" North latitude and 37056'13" to 39034'47" East longitudes (Figure 1).

Topography: Salale zone, Oromia region is characterized by dissecting high plateaus and mountains associated with hills, valleys, and gorges. Its altitude extends from about 1000 located in the Abay gorge in the Wara Jarso district to over 3500 m.a.s.l. located in Degem district. The larger portion of the zone lies between altitudes ranging from 2500 m-3000 m ASL, followed by 1500 m-2000 m ASL. Cheleleka (3571 m), Gara Guda

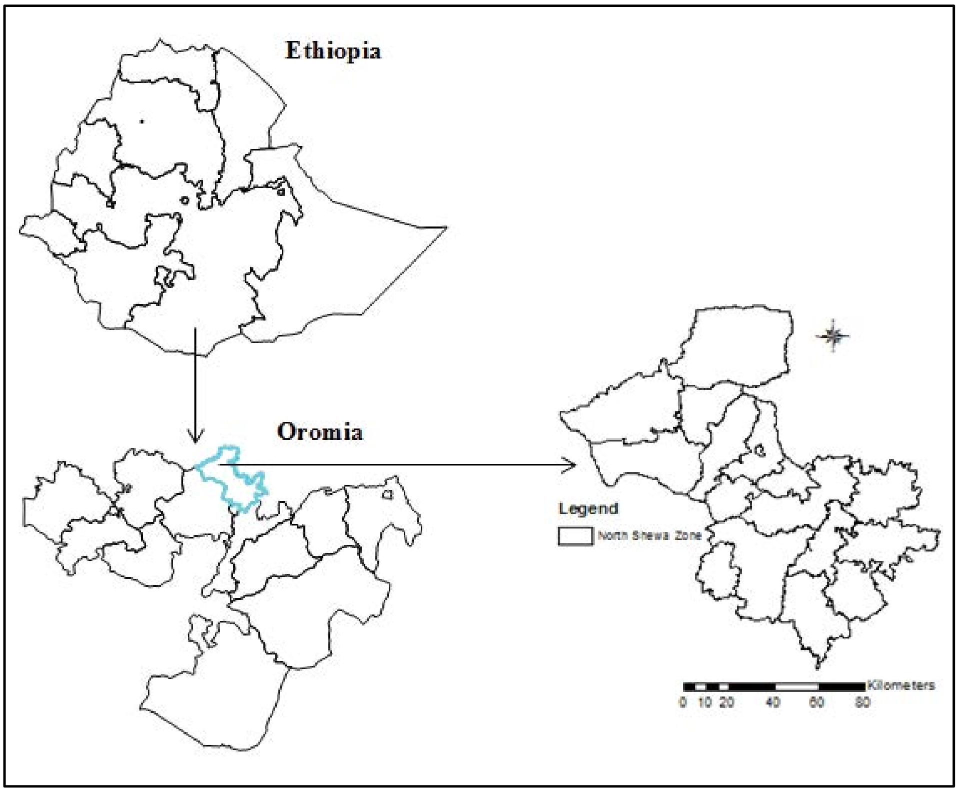

Figure 1: Map of study area Salale zone.

(3544 m), Intoto (3211 m), and Elen are some of the major mountains found in the zone. In general, the study region is characterized by varying topographical features that resulted in the existence of microclimatic variation and endowment of different natural vegetation resources that contribute to good agricultural development [12].

Agro-ecology of the study area: The traditional ecology of the Salale zone, Oromia region ranges from upper Gammoojjii to Baddaa. About 23% of the total area of the district is characterized by tropical/Gammoojjii climatic conditions, while about 35% and 42% of the total area of the Zone are characterized by subtropical/Badda Daree and Baddaa agro-climatic/traditional ecological conditions respectively. Salale zone, Oromia region is characterized by two rainy seasons, namely summer and spring locally known as Ganna and Arfaasaa rains respectively. Most of the areas of the zone experience mean annual rainfall ranging between 800 mm and 1600 mm. Likewise, the Salale zone experiences mean annual temperature ranging between 10°C-25°C [13].

Climate data source

Temperature, rainfall trends and forecast approach: Climate data are the major requirement for the analysis of current and future climate change. Therefore, 30-years climate data of the study area which is a daily weather dataset (maximum temperature, minimum temperature, and rainfall) from 1990-2019 was obtained from the Ethiopian National Metrology Agency (ENMA). The climate data were calibrated and used as a baseline for future climate, forecasts of the study area. The Agricultural Modeling Intercomparison and Improvement Project (AgMIP) climate scenario generation was used to generate future scenarios using climate models of Coupled Model Intercomparison Project Phase 5 (CMIP5).

The Latitude, Longitude, and average elevation of each district were used to generate future climate scenarios. The script was created 120 deltas adjusted data files (3-time scales (near term, midterm and ends term) × RCPs (4.5 and 8.5) × 20 GCMs). The climate modelling RCPs (RCP 4.5 and RCP 8.5) mainly recommended by AgMIP (Agricultural Modeling Intercomparison and Improvement Project) was used.

Three-time slices 2019-2039 (for the near term), 2040-2069 (for the midterm), and 2070-2099 (for end-term) were chosen. General Circulation Models (GCM) were used for forecasting the future climate variables [14]. The general circulation models used were; CCSM4 (Community Climate System Model) of the USA, HadGEM2-ES Met Office Hadley Centre (Hadley Centre Global Environment Model) of UK, and MIROC5 (Model for Interdisciplinary Research on Climate) [15]. These GCMs were selected based on their consistency among regions, their wide use in recent assessments, resolution, and performance in regions.

The set of delta was adjusted. AgMIP files were created for maximum temperature (Tmax), minimum temperature (Tmin), and rainfall. Four-digit codes were used to identify the location of the dataset (ETSACEXA. AgMIP)

The first 2 digits (ET) are an abbreviation for the country, Ethiopia; the second 2 digits (SA) refer to the specific site location, which was assigned for Salale. The fifth digit is the period and emissions scenario C=RCP4.5 (2010-2039 for the near term), E=RCP8.5 (2010-2039 for the near term), G=CP4.5 (2040-2069 for midterm), I=RCP8.5 (2040-2069 for midterm), K=RCP4.5 (2070-2099 end-term), M=RCP8.5 (2070-2099 for end-term) they were selected for each GCM. The sixth digit is the GCM of CMIP5 scenario for (E=CCSM4), (K=HadGEM2-ES) and (O=MIROC5) was used. Finally, based on the output of forecasted climate variables, line graphs showing maximum temperature (Tmax), minimum temperature (Tmin), and a bar graph showing rainfall of the study area was designed.

Drought prone area: Precipitation datasets were acquired from the Ethio-precipitation and down-scaled to the study area. This data was used to compute Precipitation evaporation Index. The precipitation, evaporation Index was used to analyze the condition of meteorological drought based on the moisture of the areas (from high moisture to dry).

For each district, drought occurrences/drought-prone areas were identified. The drought-prone areas of the annual P/E index were then interpolated from the Ethiopian precipitation map to obtain a meteorological drought distribution map. The raster values were then classified into five classes (high moisture, moderate moisture, low moisture, dry, and very dry) representing areas of different drought-prone areas.

Flooding prone areas: For this study, the rainfall data were obtained from the Ethiopian National meteorology agency and down-scaled in the form of a map. The flood occurrence frequency of heavy rain was forecast from the baseline rainfall data. Longitude and latitude GPS records were collected from different districts specifically from flood plains around main rivers. The slopes of areas were classified into flat to steep slope areas. Finally, the slope, main rivers, and GPS records were overlaid and areas prone to flood were identified using an Arc map.

Data analysis

R statistical software and T-R were used to forecast temperature, rainfall and to identify the analogs site of the study area. Arc Map was used for identifying meteorological drought and flooding and prone areas.

RESULT AND DISCUSSION

Characterize trends of climate variables

Rainfall: The future rainfall will be scored at different Districts in the Salale zone, Oromia region varies according to GCMs used (Figure 2). The higher rainfall will be expected in the end term (2070-2099) RCP8. 5 using MIROC5 GCM which is 1058.97 mm, in end term RCP 8.5 using HadGEM2-ES GCM which is 976.13 mm, and in end term RCP 4.5 using CCSM4 which is 953.92 mm at Fiche. The lower rainfall will be received in the near term (2020-2039) RCP 4.5 according to the prediction of rainfall using HadGEM2-ES GCM which is 824.71 mm.

Correspondingly, at Sheno, the higher rainfall will be expected in the end term (2070-2099) RCP 8.5 using MIROC5 GCM which is 828.3 mm, in end term RCP 8.5 using HadGEM2-ES GCM which is 745.46 mm, and in end term RCP 4.5 using CCSM4 which is 676.26 mm. The lower rainfall will be expected in the near term

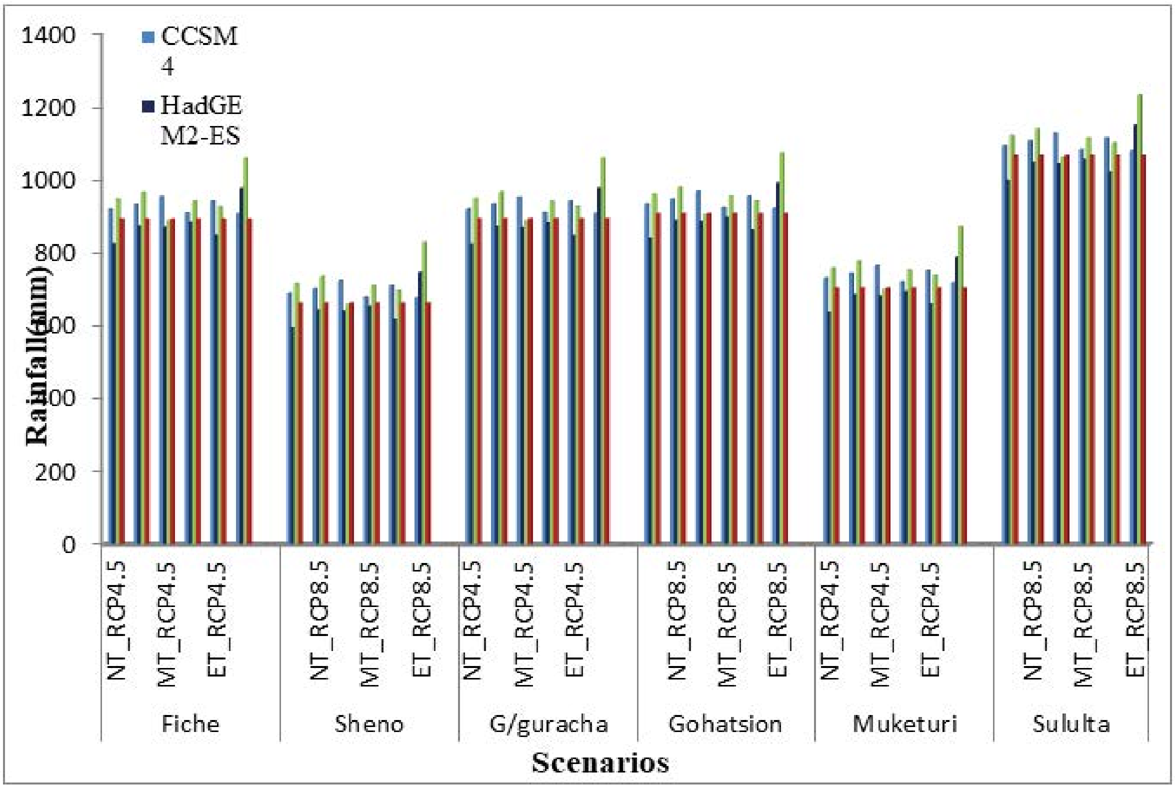

Figure 2: Future rainfall distribution of different districts in Salale zone, Oromia region.

(2020-2039) RCP 4.5 according to the prediction of rainfall using HadGEM2-ES GCM which is 594.04 mm.

Exclusively, Gergeguracha will receive higher rainfall in the end term (2070-2099) RCP 8.5 using MIROC5 GCM which is 1056.97 mm, in end term RCP 8.5 using HadGEM2-ES GCM which is 974.13 mm, and in the midterm (2040-2069) RCP 4.5 using CCSM4 which is 951.92 mm. The lower rainfall will be received in the near term (2020-2039) RCP 4.5 according to forecasts of rainfall using HadGEM2-ES GCM which is 822.71 mm.

The higher rainfall will be expected in the end term (2070-2099) RCP 8.5 using MIROC5 GCM which is 1073.59 mm, in end term RCP 8.5 using HadGEM2-ES GCM which is 990.75 mm, and in the midterm (2040-2069) RCP 4.5 using CCSM4 which is 968.54 mm at Gohastion. The lower rainfall will be received in the near term (2020-2039) RCP 4.5 according to forecasts of rainfall using HadGEM2-ES GCM which is 839.33 mm.

The higher rainfall will be scored in end term (2070-2099) RCP 8.5 using MIROC5 GCM which is 870.07 mm, in end term RCP 8.5 using HadGEM2-ES GCM which is 787.23 mm and in the midterm (2040-2069) RCP 4.5 using CCSM4 which is 765.02 mm Wuchale. The lower rainfall will be received in the near term (2020-2039) RCP 4.5 according to forecasts of rainfall by HadGEM2-ES GCM which is 635.81 mm.

The higher rainfall will be expected in the end term (2070-2099) RCP 8.5 using MIROC5 GCM which is 1232.82 mm, in end term RCP 8.5 using HadGEM2-ES GCM which is 1149.98 mm, and in the midterm (2040-2069) RCP 4.5 using CCSM4 which is 1127.76 mm at Sululta. The lower rainfall will be received in the near term (2020-2039) RCP 4.5 according to forecasts of rainfall using HadGEM2-ES GCM which is 998.56 mm.

Generally, Sululta will receive higher annual rainfall, which is 1232.82 mm explicitly during the end term (2070-2099). The lower rainfall will be scored at Sheno which is 594.04 mm during the near term (2020-2039). If afforestation/plantation, forest conservation, and water resource conservation have an effect on the whole zone in different districts successfully, the rainfall amount expected will be exceeding the forecasted values. But, if conservation of the natural resource and climate change mitigation activities will not come into place, the rainfall expected will be less than the future forecasted amount. Besides, some specific places in districts may receive more than average annual rainfall. E.g. areas around Tulu salale, in the Girar Jarso district receive higher rainfall in the zone.

Maximum Temperature (Tmax): Some meteorology stations in Salale, Oromia region, were not scoring the temperature of districts. Only five stations (Sululta, Fiche, Ghatsion, Gebreguracha, and Shano) applicably score the temperature measurements in the zone. The future Maximum Temperature (Tmax) of the study area varied according to GCMs used. The maximum temperature will be increased from 23.6°C to 27°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 25.6°C using CCSM4 GCM for RCP8.5 and RCP4.5 in the midterm, and 25.2°C using MIROC5 GCM for RCP8.5 in end term at Sululta (Figure 3). Generally, the projection of Tmax showed that there will be an increase of Tmax by 2.4°C in the future up to 2099.

The maximum temperature will be increased from 20.4°C to 23.8°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 22.4°C using CCSM4 GCM for RCP8.5 in the midterm, and 21.7°C using MIROC5 GCM for RCP8.5 and RCP4.5 in the end term at Fiche. Generally, the projection of Tmax showed that there will be an increase of Tmax by 2.3°C in the future up to 2099.

The maximum temperature will be increased from 23.0°C to 28.6°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 26.6°C using CCSM4 GCM for RCP8.5 in the end term and 25.3°C using

MIROC5 GCM for RCP 8.5 in the end term at Gebre Guracha. Generally, the projection of Tmax showed that there will be an increase of Tmax by 3.83°C in the future up to 2099.

The maximum temperature will be increased from 24.0°C to 29.6°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 27.6°C using CCSM4 GCM for RCP8.5 in the end term and 26.3°C using MIROC5 GCM for RCP8.5 in the end term at Gohastion. Generally, the projection of Tmax showed that there will be an increase of Tmax by 3.83°C in the future up to 2099.

The maximum temperature will be increased from 19.4°C to 25°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 23°C using CCSM4 GCM for RCP8.5 in the end term and 21.7°C using MIROC5 GCM for RCP8.5 in the end term.

Generally, the projection of Tmax showed that there will be an increase of Tmax by 3.83°C in the future up to 2099. The highest maximum temperature will be scored at Ghatsion station, which will be 29.6°C. But, implementation of climate change mitigation and adaptation strategies can determine the increases and decrease of maximum temperature.

If climate change strategies are commendably implemented in all districts in the Salale zone, Oromia region to retort climate change, the amount maximum temperature will be scored may be less than the forecasted values. In other ways, recommended climate change adaptation strategies will not apply in the entire zone, the maximum temperature will be recorded in different districts may be more than the forecasted amount.

Minimum Temperature (Tmin): The future minimum temperature (Tmin) of the study area varied according to GCMs used. The minimum temperature will be increased from 10.8°C to 16.9°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 14.6°C using CCSM4 GCM for RCP8.5 in the end term and 13.7°C using MIROC5 GCM for RCP8.5 in end term at Sululta (Figure 4). Generally, the projection of Tmin showed that there will be an increase of Tmin by 4.27 in the future up to 2099.

The future minimum temperature (Tmin) of the study area varied according to GCMs used. The minimum temperature will be increased from 8.4°C-14.5°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 12.2°C using CCSM4 GCM for RCP8.5 in the end term and 11.3°C using MIROC5 GCM for RCP8.5 in the end term at Fiche.

The future Minimum Temperature (Tmin) of the study area varied according to GCMs used. The minimum temperature will be increased from 8°C to 14.1°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 11.8°C using CCSM4 GCM for RCP8.5 in the end term and 10.9°C using MIROC5 GCM for RCP8.5 in the end term at Gebre Guracha.

The future Minimum Temperature (Tmin) of the study area varied according to GCMs used. The minimum temperature will be increased from 14.8°C to 20.9°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 18.6°C using CCSM4 GCM for RCP8.5 in the end term and 17.7°C using MIROC5 GCM for RCP8.5 in the end term at Gohatsion.

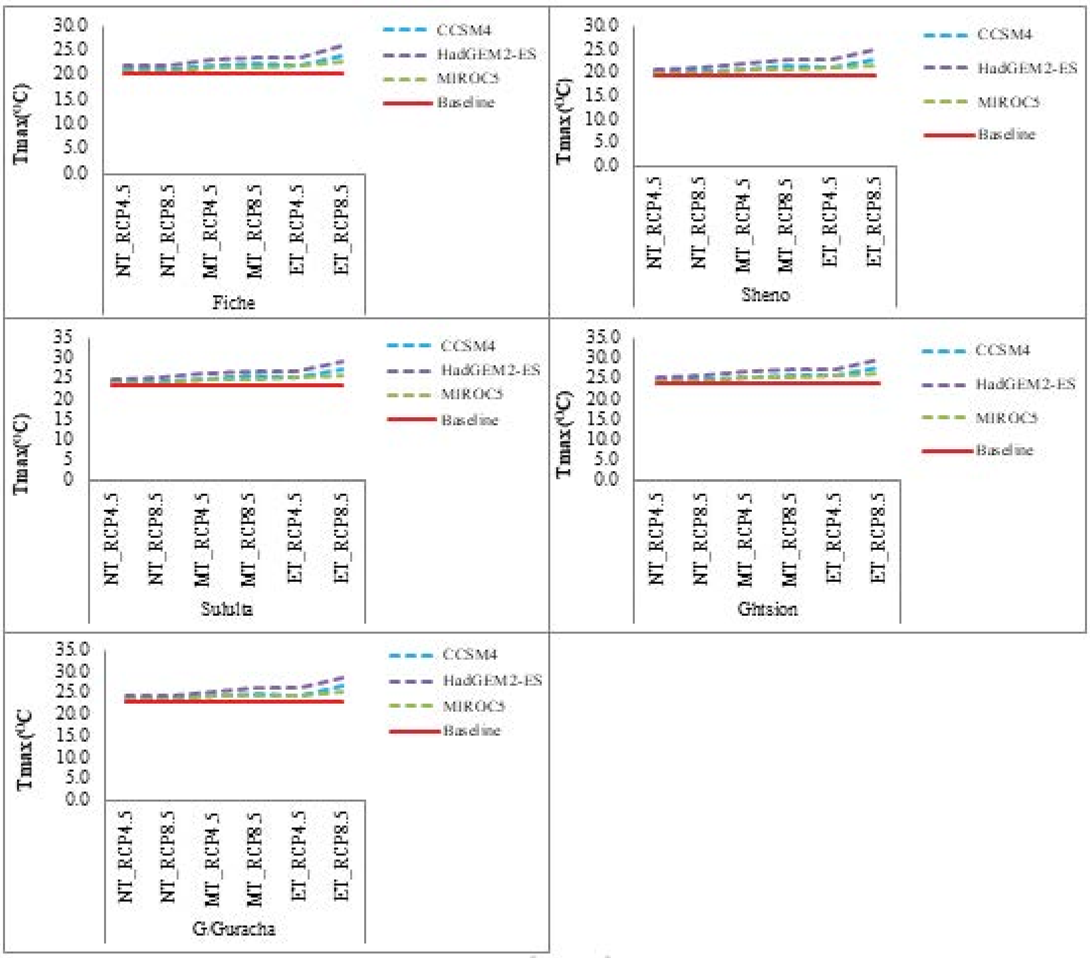

Figure 3: Future Maximum temperature of meteorology stations in Salale zone, Oromia region.

The future Minimum Temperature (Tmin) of the study area varied according to GCMs used. The minimum temperature will be increased from 7.4°C-13.5°C using HadGEM2-ES GCM for RCP 8.5 in the end term, 11.2°C using CCSM4 GCM for RCP8.5 in the end term and 10.3°C using MIROC5 GCM for RCP8.5 in the end term at Sheno.

Generally, the projection of Tmin showed that there will be an increase of Tmin uses 4.27°C in the future up to 2099. The lowest minimum temperature will be recorded in Sheno from the stations of the Salale zone, Oromia region.

Drought prone areas

For this study, precipitation/rainfall and temperature distribution over the main rivers were used to compute drought-prone areas Salale zone, Oromia. The precipitation/rainfall distribution over the main rivers in the study area classified into five classes as indicated using (Figure 5A). In similar ways, the temperature distribution over the main rivers in the study area was classified into five classes as indicated using (Figure 5B) below.

Based on the rainfall and temperature distribution precipitation, evaporation was considered and raster values were classified into five classes representing an area of high moisture (85.2-112.8), moderate moisture (69.5-85.2), low moisture (54.8-69.5), dry (38.7-54.8) and very dry (36.9-38.7) areas as indicated to in (Figure 5C) below.

Accordingly, areas with low rainfall and high temperature were identified as dry areas which indicate high evaporation after low precipitation/rainfall specifically low precipitation/evaporation (P/E) index. Besides areas with high rainfall and low temperature were identified as high moisture (humid) areas which indicate low evaporation after high precipitation/rainfall specifically high precipitation/evaporation (P/E) index. Hence, areas depicted with red colour indicate very dry sites which have very low moisture (very dry) and prone to meteorological drought in the zone as mapped below (Figure 5C).

Accordingly, in the Dera district, some parts of upper kola for instance were Meneyu, Jiru Dada, Babu Dire, Hamuma Gindo, Homa Boneya, Bahit, Wegile Michael, Dembi Birje and Mamo Bukini are prone to meteorological drought. In Kuyu District some parts of Daye Wilincho, Dawicha Kerenesa, Daro Berbersa, Daro Tatessa, Daro Wilencho, Jila Kerenesa, Amuma Bubisa, and Temosasa Roge are prone to meteorological drought. In Were Jarso District some parts of Faji Ajersa, Korgego Lutu, Bisetino Dera, Jem Jemela, Lantu Wele argi, Kolaje Mogedera, Lantu Wele Argi, and Shenkora Shesheng are prone to meteorological drought. In similar ways, in Girar Jarso District some parts of kolenga Eyesus,

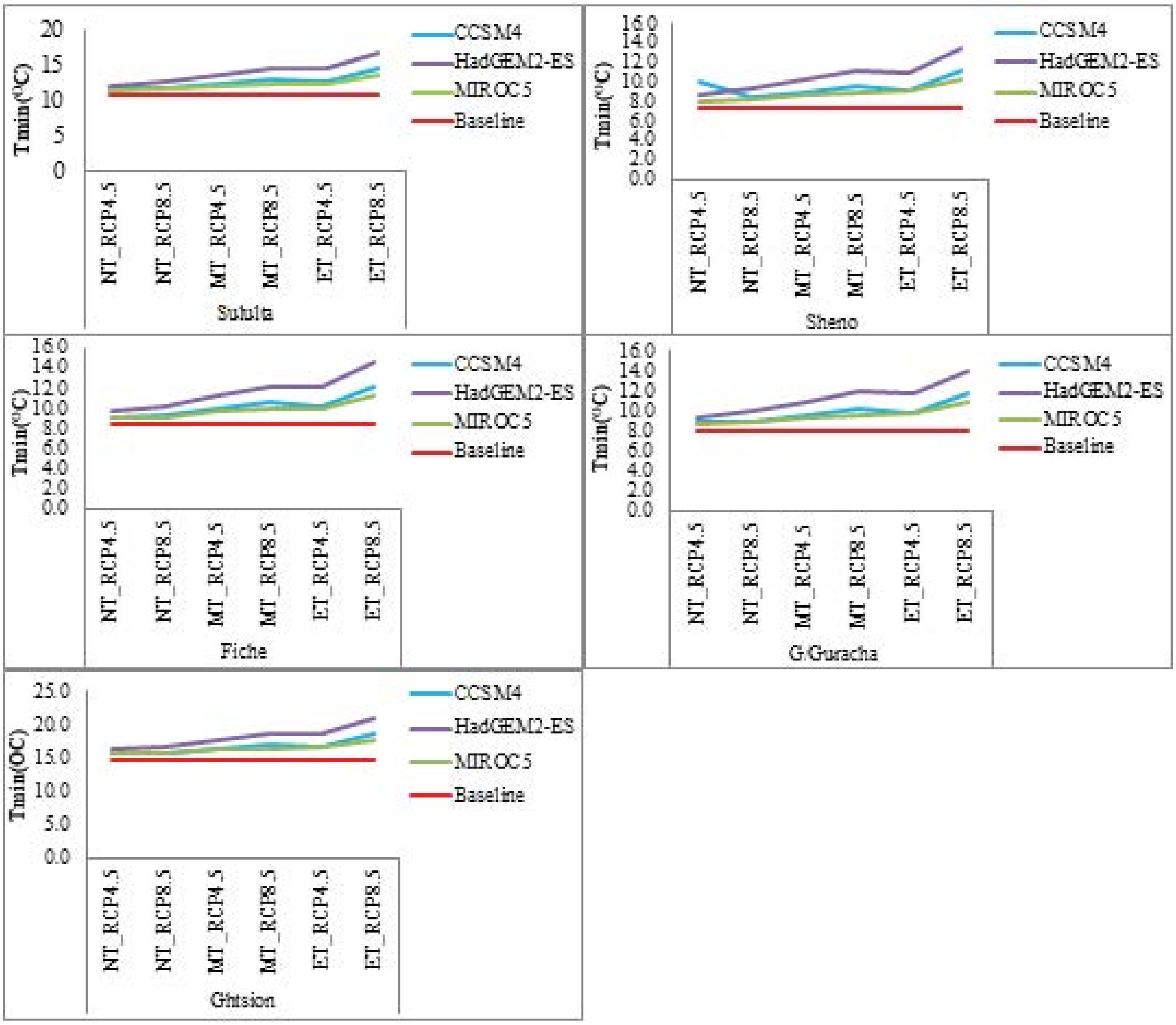

Figure 4: Future minimum temperature of meteorology stations in Salale zone, Oromia region.

Enegwal, Shebel, Adisige, Wedeso Amiba, and Sherer Genet are prone to meteorological drought. In Hidabu Abote District some parts of Gedebo Jema, Adea Necho, Gedabo Geyorgis, Amuma mechara, and Amda Arero are prone to meteorological drought.

Therefore, Dera, Kuyu, Were Jarso, Girar Jarso and Hidabu Abote districts are the more vulnerable to meteorological drought. Unlike, Mulo, Jida, Bereh, and Abichugna Districts are free from meteorological drought. Likely, a tiny proportion of Debre Libanos and Wuchale districts are affected by meteorological drought as indicated in (Figure 5C) below.

Flooding prone areas

Flood occurrence, mainly affects different areas that differ in terms of magnitude and frequency in the Salale zone, Oromia region. For this study, current analysis in occurrences of floods as a hazard was used. The data were extracted from Ethiopia-slope, rainfall distribution, and Ethiopia's main rivers distribution. Slope (Figure 6B) and annual rainfall distribution over the main rivers (Figure 6A) essentially considered as factors that boost the vulnerability of areas to flood. The annual amount of rainfall received in a milliliter over the main rivers indicated a different colour. Main rivers, areas depicted with a blue and blue light colour (Figure 6A) received a high amount of annual rainfall up to 1,032 mm-1,203 mm.

The slope raster was classified into five classes ranked from flat land to steep slope (Figure 6B). As indicated below in (Figure 6C), flat land areas (classified from 0.01 to 3.69 and depicted with white colour) found around main rivers with high rainfall are predisposed to flooding with heavy rain and they are flood plain. The movement of surface water after heavy rainfall is very low and it intends to cover the flood plain then after cause flooding. Hence, the flood occurrence points identified and indicated with red colour on the map from GPS longitude and latitude records as indicated in (Figure 6C) below. As a result, areas found around the flat with main rivers and receive high rainfall are more prone to flooding occurrences in the Salale zone, Oromia region.

Accordingly, flatland found around main rivers with high rainfall in Abichugna (Durima, Ayida Tegilu, Gadula, Adere Derisa, Baso chinibile, Muti, Abidela and Neseri Menehoro), Wuchale (Abu Yifech, Usmani, Harkiso, Engoye Gordoma, Adare Gordoma, Mechala Sele and Gomorona Sabo), Jidda (Debele Genjo, Arebsa Chifara, Golelcha, Haro Abu, Wanya Kore, and Ayida Dawo), Debre Libanos (Gorona Wertu, Tere Giyorgis, Eegotamina Anki, Babu Edero and Tumano) and Bereh (Lenicho Choba Sulula, Habru Kuna Kura Jida, Lege Beri Lege Belo, Repa Denibel and Dabe Muda Gudo) and were Jarso (Lencho Borso, Wele Chilelo, Hose, Jarso, Jemo Berdada, and Bito Milki) districts are the most vulnerable to flooding in Salale zone, Oromia region as indicated on (Figure 6C). In addition to the flood plain of these areas, main

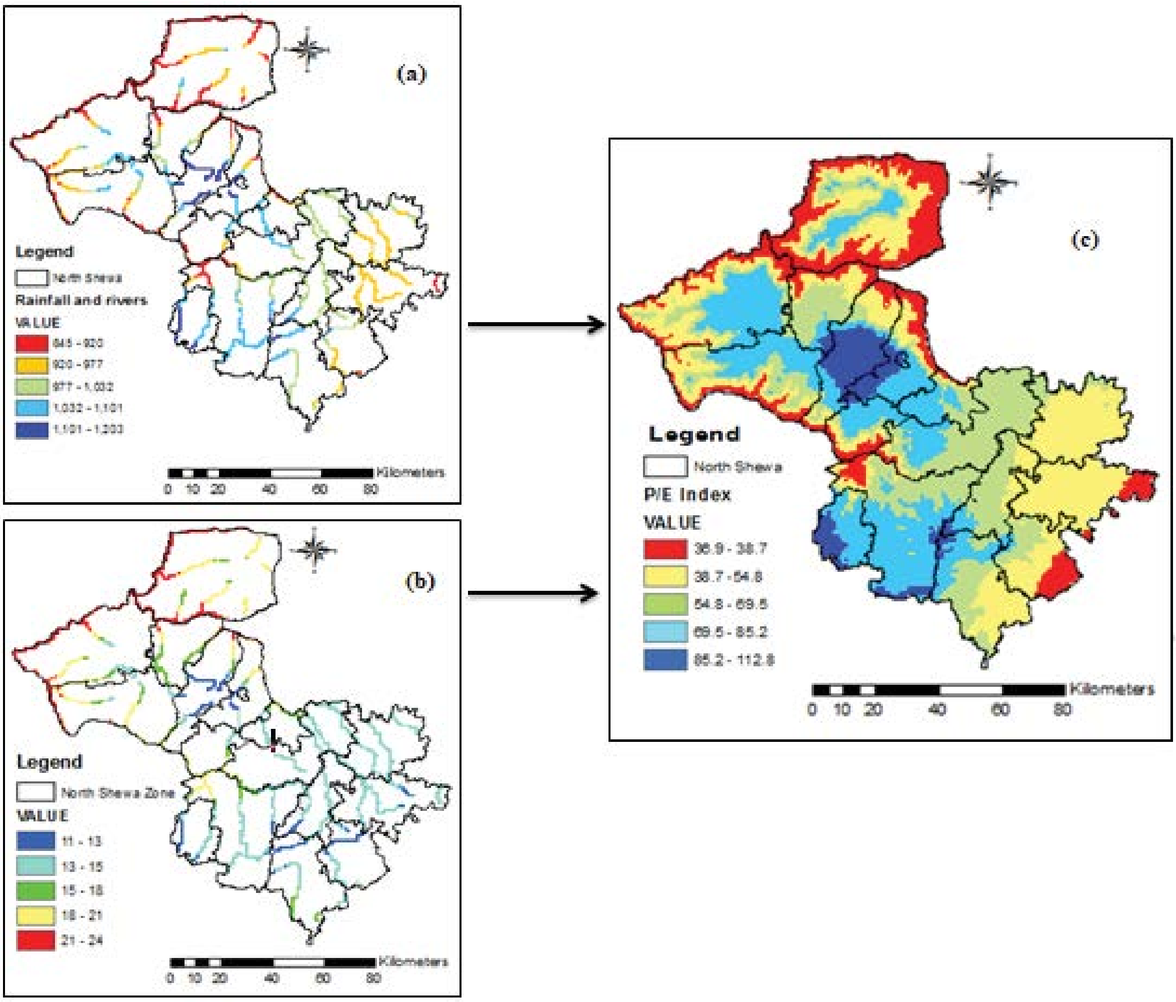

Figure 5: **(a)**: Precipitation/rainfall and temperature **(b)**: Distribution over main rivers in Salale zone, Oromia region **(c)**: Drought prone areas (depicted with red colour).

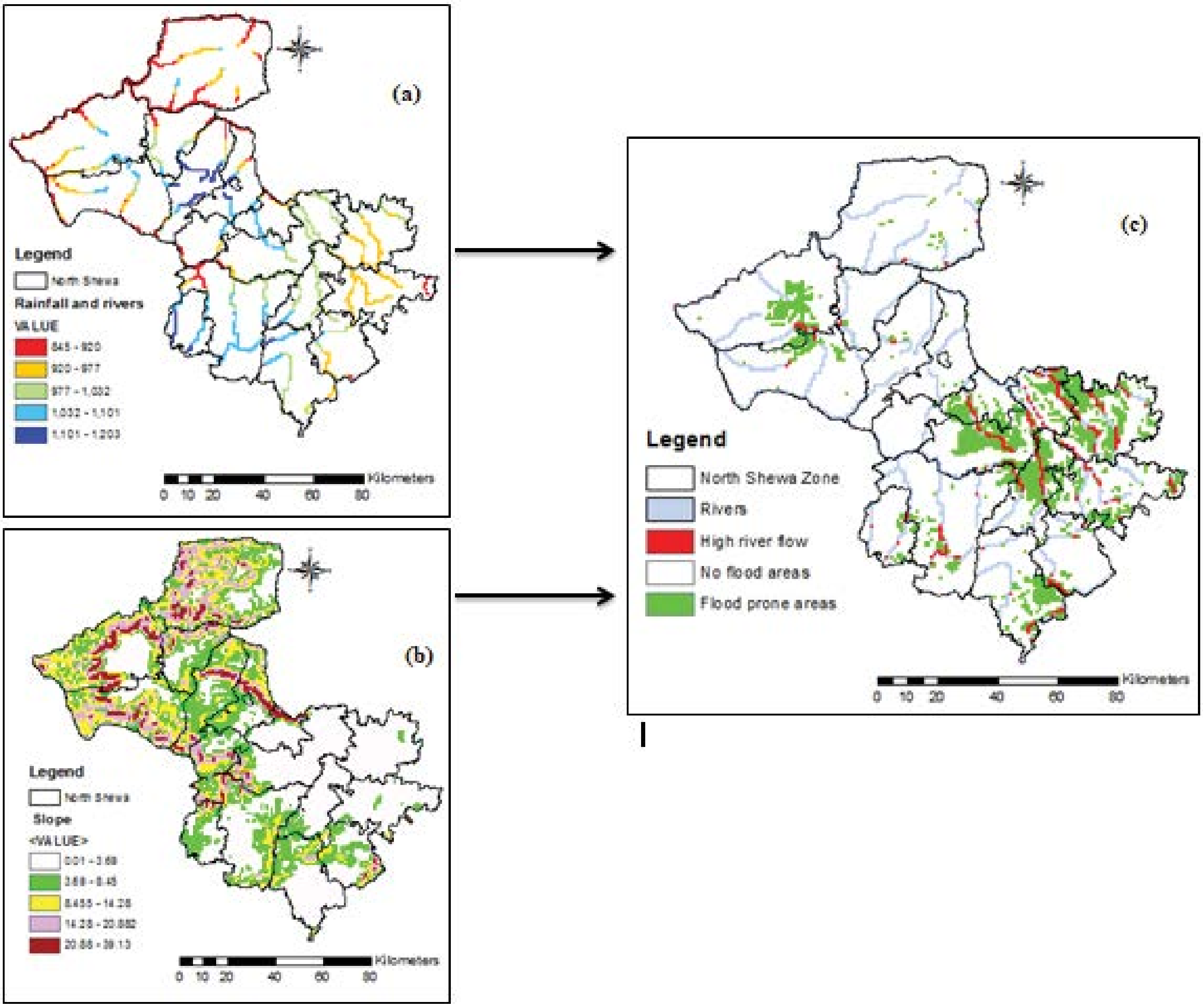

Figure 6(a): Main rivers in Salale zone, Oromia region; **(b)**: Slope in Salale zone, Oromia region, **(c):** Flood prone areas (indicated by green areas).

rivers which cause flooding are cross the areas, and several plane areas are possibly correspondingly the source of main rivers.

Likely, a very tiny proportion of Sululta (Gulele Gebreal, Chancho Buba, Ako Afo Babo, Waju Dalota, Wererso Nono Menabechu, and Dire silo Gehito), Kimbibit (Tabotana Mehamede, Segele Dinki, Zengo, Data Borana Godeti, Adadimoto, Menushana laykombolcha, Tuka Abdola, and Bosona Serabi), Kuyu (Bonde Gidabo, Sambo chica, and Liben Kura), Mulo (Amuma Bubisa Dembure, Boro Tiro Derba, and Kura Kemele) and Aleiltu (Tiku, Awja lafto Belo and Chle Senkele) districts are slightly affected by flooding. Unlike, Yaya Gulale, Dera, Degam, Hidabu Abote, and Girar Jarso districts are comparatively free from flooding occurrence.

DISCUSSION

Projecting into the future, most global climate models indicate some increase in rainfall in both dry and wet seasons in Ethiopia [16]. In similar ways, the rainfall over the study area will be increased during midterm and end-term. But, as showed in the above result, in the near term especially using RCP4.5, there was a recurrent drought and El Nino events at the study area particularly as seen in 2015/2016.

The National Meteorology Agency (NMAE) has also shown that the trend of annual rainfall shows more or less constant when averaged over the whole country [17]. According to this study, the rainfall in the study area will be increased. Studies with more detailed Regional Climate Models (RCM), however, indicate that the sign of expected rainfall change is uncertain over Ethiopia and East African highlands including the Salale zone, and the consensus is that rainfall variability is likely to increase.

According to this study, there will be an increase in temperature in the study area which is also supported by [18]. The global temperature is forecast to rise by 1.4°C-5.8°C over the period 1990-2100 due to increases in greenhouse gas concentrations in the atmosphere. Studies made by the National Meteorology Agency (NMA) under the climate change national adaptation program of action of Ethiopia (NAPA, 2007) [17] have also shown, the mean annual temperature will increase in the range of 2.7-3.4°C by 2080 over Ethiopia including Salale zone, Oromia region. According to this study, there will be an increase of Tmax by 3.83°C in the future up to 2099, which is supported by NAPA, which arises in average temperature, and Median annual temperature will continue to increase through the 2090s.

Major floods have been a common occurrence leading to loss of life and property in numerous parts of the country. Variations in rainfall amounts have led to droughts or floods as extreme weather events. Climate variability has already begun to affect highland areas, with rainfall irregularities and associated flooding and droughts of greatest concern in Ethiopia including the Salale, Oromia region. For instance, localized flooding below hillsides is a widespread hazard in the foothills of the mountainous areas which can damage agriculture and ecosystems [19]. This supports the result of this study which is areas found around flat land with main rivers and receive high rainfall are more prone to flood occurrences.

Most models predict a larger percentage of precipitation falling during heavy events, which can increase the risk of disasters such as floods and landslides. Ethiopia's National Meteorological Agency (NMA) identifies drought and flood as the major hazards in the future as well, with potential negative impacts on agriculture and food security [20].

CONCLUSION

According to this study, Sululta will receive higher annual rainfall which is 1232.82 mm explicitly during the end term (2070-2099). The lower rainfall will be scored in Abichuna Gne'a, Aleiltu, and Kimbibit which is 594.04 mm during the near term (2020-2039).

The projection of Tmax showed that there will be an increase of Tmax by 3.83°C and Tmin by 4.27°C in the future up to 2099. The higher maximum temperature will be scored at Ghatsion station which will be 29.6°C and the lower minimum temperature will be recorded at Sheno station which will be 8.1°C in the Salale zone, Oromia region. But, if climate change strategies are commendably implemented in all districts in the Salale zone, Oromia region to retort climate change, the amount maximum and minimum temperature will be scored may vary accordingly.

Areas with low rainfall and high temperature were identified as prone to drought in the zone which indicates high evaporation after low precipitation/rainfall specifically low precipitation/evaporation (P/E) index. Areas found around flat land with main rivers and receive high rainfall are more prone to flood occurrences.

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CONFLICTS OF INTEREST/COMPETING INTERESTS

We confirm that all authors listed on the title page have contributed significantly to the work, have read the manuscript, attest to the validity and legitimacy of the data and its interpretation, and agree to its submission. The manuscript is the authors' original work and has not received prior publication and is not under consideration for publication elsewhere. Therefore, we confirm that all authors of the manuscript have no conflict of interests to declare.

AVAILABILITY OF DATA AND MATERIAL/

DATA AVAILABILITY

Not applicable

CODE AVAILABILITY

Not applicable

AUTHOR'S CONTRIBUTIONS

All authors listed on the title page have contributed significantly to the work, have read the manuscript, attest to the validity and legitimacy of the data and its interpretation, and agree to its submission.

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