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Analysis of Climate indices in Daykundi province, Afghanistan

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Abstract

Climate events can have many impacts on various sectors. The studies show notable change in trait of natural disastrous. This study examined maximum, minimum temperatures and precipitation trend of climate indices in Daykundi province of Afghanistan during the 1986 to 2019. This analyzed eight sites and each stations calculate minimum, maximum and DTR temperatures variability and precipitations trend with positive and negative trends were gotten. The linear regression trend was utilized to find out notable trends. The finding of study showed maximum and minimum temperature were observed upward trend significantly in nationwide of Daykundi. Minimum temperature has been raised greater compared to maximum temperature resulting diurnal temperature range (DTR) has remarkably decreased. Precipitation indices of climate change were detected by high fluctuation during 1986-2019. Positive precipitation trend were happened in all study sites except of Kajarn district. The mean annual precipitation had upward trends with extensive range of scattering. Kajran district were experienced on precipitation reduction -0.48 mm per annum during study period.

Keywords: Climate indices, Temperature, Precipitation, DTR, Trends

1. Introduction

Climate parameters which are used to distinguish the condition of climate system and perception of different climate mechanism have been developed based on climate variability. The spatial-temporal of diverse climate parameters is also defined by climate condition of study site (Baltas, 2007; Deniz *et al.*, 2011) ^[4, 6]. Climate trend analysis find out which mean surface temperature has raised by 0.3°C to 0.6°C globally since last decades of 19th century, and 0.2°C to 0.3°C over last four decades (Easterling *et al.*, 2001) ^[8]. The recent study have indicated that minimum temperature have rarely raised at a higher rate than maximum temperatures, resulting in a decline in diurnal temperature in some parts of the globe. The small positive of precipitation trend have been recorded globally, almost 1% over land during 20th century, with a greater raised, especially in cold season in the high latitude of Northern Hemisphere. The spatial-temporal trend have considerably happened over the last century, and trend of warming, enhanced precipitation, decreased diurnal temperature range (DTR) have not been alike, globally. For instance, in the mid-latitude of Northern Hemisphere continents have been showed warming in winter and spring, whole year cooling in the northwest North Atlantic and mid-latitude over the North Pacific in the last 40 years (Nicholls *et al.*, 2001) ^[17]. The result of studies show that the incidence and severity minimum temperature events have declined dramatically. The maximum temperature trends has increased normally and excessive precipitation trend have happened vast areas especially in the mid and high latitude (IPCC, 2007). There is notable compromise among the finding of regional temperature studies, e.g. North America (Vincent & Mekis, 2006), Africa (Mokssit, 2003), Europe (Tank & Können, 2003) and Asia (Klein Tank *et al.*, 2006) ^[24, 16, 23, 13]. The annual trends lowest and highest daily minimum and maximum temperature have raised in a year in the last five decades of twentieth century in the most part the world. Substantial reduction in the number of frost days and remarkable raise in the minimum temperature have been occurred (Frich *et al.*, 2002) ^[9]. The intense precipitation trends have been showed in positive about 15 percent of sampled global land areas (Alexander *et al.*, 2006) ^[3]. Climate change trend may be critical for arid and semi-arid regions i.e. Afghanistan, and it effect on the flood, drought and heat waves. Afghanistan is landlocked country with semi-arid climate and most vulnerable due to intense of precipitation and natural hazard consisting droughts and floods (Rehana *et al.*, 2021) ^[19]. Overall, the annual precipitation has occurred an increasing in the South, South-west, East and Central zones of Afghanistan. Rainfall has shown in decreasing in and raised temperature in all agro-climate zone of Afghanistan (Saboory & Tomer, 2019) ^[20].

Climate indices is poorly documented due to insufficient meteorological data during four war decades. Aich *et al.*, (2017) [2] stated based on regional climate model (RCM) of Coordinated Regional Climate Downscaling Experiment (CORDEX)-South Asia that mean temperature raise over global level 1.8°C during 1950-2010. There is uncertainty regarding analyzed data rainfall on the past change. The precipitation trend from eight different stations in Kabul river basin showed increasing 4.88-30.42 mm/year, also minimum temperature have remarkably raised during 2000 to 2018 (Aawar *et al.*, 2019) [1]. In this study will be assessed the precipitation variation, maximum and minimum temperatures trend in Central of Afghanistan, especially Daykundi province based on National Weather Service of Climate Prediction Center (CPC) of global data.

2. Materials and methods

2.1 Study area

Daykundi province is located in central of Afghanistan and the second largest province in the Hazarajat region. The province lies at latitude 33.995 N and longitude 66.321 E and it bordered by Ghor province in the North; Bamyan province in the northwest; Helmand in the West; Urozgan in the South; Ghazni in the East. Daykundi covers about 17,501 km square, and 2.7 percent of total area of Afghanistan which is shown in Fig 1. The land area is covered by 80 percent by mountain. The province is divided in nine administrative government, namely: Nili is capital of Daykundi with elevation 1152 m above sea level, Shahrstan, Gizab, Ashtarlay, Khadir, Kiti, Miramor, Sang-e-Takht and Kajran. Climatically, during long winter season the temperatures may drop to 16 degree Celsius, the mean annual precipitation range is 200-250 mm and mostly occurred about 28-35 mm normally during the March and April.

It has a population about 723980 and they rely in agriculture as the main source of income. Around 6 percent is used for agriculture purpose and the main crops grow i.e. wheat, barley, potatoes, almond and beans. This province is the one of least productive province due to barren and inaccessible land with shortage of water, small landholders, poor soil quality and severity of food insecurity.

2.2 Data

The climate indices such as daily temperature and precipitation was extracted from CPC-NOAA (Climate Prediction Center-National Oceanic Atmosphere Administration) website: https://psl.noaa.gov/data/gridded/data.cpc.global_temp.html and temporal resolution coverage is a period of 1986 to 2019. The spatial resolution of climate indices is 0.5°×0.5 degree. The data was obtained from eight sites of throughout Daykundi province with specified latitudes and longitudes that is shown in Table 1. The center of each districts were selected as study sites.

2.3 Analysis Approach

This study estimated the changes in each of the minimum and maximum temperature trends and precipitation extreme statistics by using linear regression.

2.3.1 Linear Regression

One of the simplest methods to calculate the trend of the

data is linear regression. The equation of linear regression line is defined by:

$$Y = a + bX$$

Where, X is explanatory variable and Y is the dependent variable, b is the slope of the line and a is the intercept. The slope of regression describes the trend, with positive as increasing and negative decreasing trend. The observed trend is conducted by considering the precipitation and temperatures as dependent variable and time as explanatory variable.

4. Result & Discussion

4.1 Temperature Trend

Climate change analysis was explored by driving force of prediction and detection long-time change in temperature indices. This study analyzed three indices of temperature i.e. maximum temperature, minimum temperature and diurnal temperature in entire of Daykundi province. The maximum temperature trend have significantly increased all study sites (Fig 2). Khadir, Miramor, Sang-e-Takht and Shahrstan with higher raised maximum temperature with 2.1 °C, 2.02 °C, 2 °C and 2.1°C, respectively during thirty-four years and temperature variations is shown in Fig 2. The mean annual minimum temperature variation has increased significantly, compared to maximum temperatures. The analysis of minimum temperature represent cold season became warmer and these areas are more vulnerable due to climate change impacts. Data in Table 2 were observed Meramor with highly positive trend (5.8 °C) and Khadir and Sang-Takht with (3.1°C) increased minimum temperature. A study of minimum and maximum temperatures was conducted in Thailand that show the temperature extremes raised notably in summer days and decrease cool night (Masud *et al.*, 2016) [15]. The mean annual temperature has raised 0.5-1.5 °C in the south of Canada, and minimum temperature is greater compared to maximum temperature in first five decades of 20th century (Zhang *et al.*, 2000) [26]. The finding of study in Arab region during middle of twenty century were on agreement with warming trends that indicate warm days and nights, greater extreme temperature, lower cold days and nights (Donat *et al.*, 2014) [7]. The finding a study in Hindu Kush Himalaya over the period of 1961 to 2015 was accord that indicate reduction in number of cold days, cold night and frost days, and trend of minimum temperature water higher than maximum temperature significantly (Sun *et al.*, 2017) [22].

Diurnal temperature range (DTR) is a parameter independent of interior of climate change. Data shows the mean minimum temperature is not higher than mean maximum temperature and the study is showed the DTR negative trend in all stations of in Daykundi Province. The finding of study in Bangladesh during 1961 to 2008 is agreement that is showed downward trend diurnal temperature trend (DTR) (Shahid *et al.*, 2012) [21]. The result of study show the negative trends of DTR are dependent on positive trend of cloud cover (Zhou *et al.*, 2009) [27]. The result of study Jaswal (2010) [12] confirmed cloud cover cause reduction of DTR in Bangladesh during pre-monsoon and winter seasons. Reduction in DTR during 50 years is attributed in raised of cloud cover (Braganza *et al.*, 2004) [5]. Cloud cover influence on reduction of DTR in northern and southern hemisphere in summer during 1921-2010 (Yong *et al.*, 2017) [25]. Also, reduction DTR were occurred in entire of Canada over period of twenty century (Zhang *et al.*,

2000) [26]. The minimum precipitation was with range 15mm in Kejrán and 48mm in Meramoor in 2018.

4.2 Precipitation Tend

Mean annual precipitation in center of Daykundi province (Nili) is nearly 214.5 m. Table 3 show the maximum precipitation were occurred in 783 mm in 2019 and minimum precipitation was 20.8mm in 2018. Precipitation trend indicate upward with 5.1mm per year resulting show high fluctuations of precipitation indices during study period (Fig 3). Precipitation oscillation were extremely befallen in Ashtarlay, Shahristan, Sang-Takhat and Khadir districts among Daykundi province. Kejrán district with downward trend of precipitation (-0.48 mm per year) were recognized in the study sites. A study was conducted by Longobardi *et al.* (2010) [14] corroborated that decrease precipitation in Italy during last five decades. Finding of study in Pakistan shows notably declining precipitation trends in western parts of Indus River Basin and remarkably raise in precipitation variation in high mountain ranges (Hartmann & Buchanan, 2014). The downward trend of precipitation have been happened in most region of Mediterranean between 1901 to 2009 and scant raised of precipitation in northern Africa, Italy and Peninsula (Philandras *et al.*, 2011) [18].

5. Conclusion

The fluctuation of climate indices were occurred significantly during five decades and it affected the nature and living things. Ecosystem and humans can respond alteration in climate parameters rather than they do conversion in average parameters. Although, the analyzed variation of climate parameters is momentous for future prediction, especially agriculture and water sectors. Study examined trendies of climate indices in eight selected sites throughout Daykundi province. The variability of climate indices were observed by linear regression. The mean

annual maximum, minimum and diurnal temperatures and mean annual precipitation were analyzed for all stations in the nationwide of Daykundi province the over period of 1986 to 2019.

Results of this study mentioned which climate indices variation numerate momentous climate profile of Afghanistan especially Daykundi province that temperatures trends and precipitation variation have been happened during the past decades. The metereolgocial department have not enough data for analysis of climate parameters due to climate change. Spatial-temporal data from CPC-NOAA (Climate Prediction Center-National Oceanic Atmosphere Administration) is way to analyze the climate indices and shows impact of climate change. According to finding of study, maximum temperature has been increased significantly. T_{max} in Khedir, Meramoor, Sang-e-Takht and Shahristan districts show raised more than 2°C and these areas is more vulnerable due to climate change. Minimum temperature show positive trend compared maximum temperature whole of Daykundi. Cool days, cool night and frost days were fewer experienced compared to previous centuries. Diurnal temperature range (DTR) has been decreased substantially. Reduction of DTR depend on fewer raised of T_{max} than T_{min} entire of study period and it highlighted ongoing warming is a global phenomenon. Overall, precipitation shows positive trend with high fluctuation during study period except of Kejrán districts. The positive trend of precipitation shows high range of dispersion. Conversely, the western area of Daykundi province were observed negative precipitation trend with record of -0.48mm per year during 1986 to 2019.

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Table 1: Geographical coordination of research studies through-ought Daykundi Province

| No. | Districts | Study Sites | Latitudes (°) | Longitudes(°) | Elevations (m) |
|-----|--------------|--------------|---------------|---------------|----------------|
| 1 | Ashtarlay | Band-e-Mazar | 34.067 | 66.293 | 2686 |
| 2 | Kejrán | Markaz | 33.194 | 65.625 | 1244 |
| 3 | Keti | Bazar | 33.513 | 65.676 | 1459 |
| 4 | Khedir | Khadir | 33.923 | 65.933 | 2461 |
| 5 | Merammor | Tagab | 33.814 | 66.783 | 2285 |
| 6 | Nili | Center | 33.722 | 66.144 | 2009 |
| 7 | Sang-e-Takht | Paish-Mazar | 34.192 | 66.041 | 2730 |
| 8 | Shahristan | Ulqan | 33.702 | 66.563 | 2183 |

Table 2. The variation of maximum, minimum and diurnal temperatures during 1986 to 2019 in Daykundi province

| No. | Sites | Change in Tmax | Change in Tmin | Change in DTR |
|-----|--------------|----------------|----------------|---------------|
| 1 | Ashtarlay | 1.972 | 2.6826 | -0.7106 |
| 2 | Kejrán | 1.3906 | 2.2712 | -0.8806 |
| 3 | Keti | 1.3498 | 2.635 | -1.2852 |
| 4 | Khedir | 2.0128 | 3.1076 | -1.0948 |
| 5 | Merammor | 2.0298 | 5.8718 | -3.842 |
| 6 | Nili | 1.8428 | 2.6758 | -0.833 |
| 7 | Sang-e-Takht | 2.0128 | 3.1076 | -1.0948 |
| 8 | Shahristan | 2.159 | 2.1692 | -0.0102 |

Table 3: Precipitation trend during 1986-2019 entire of Daykundi province

| No. | Sites | Mean annual precipitation (mm) | Maximum Precipitation (mm) | Year | Minimum precipitation (mm) | Year | Change in precipitations in year (mm) |
|-----|-----------|--------------------------------|----------------------------|------|----------------------------|------|---------------------------------------|
| 1 | Ashtarlay | 250.9 | 663 | 2013 | 28 | 2018 | 8.4807 |
| 2 | Kejrán | 146.2 | 283 | 1992 | 15 | 2018 | -0.4864 |

| | | | | | | | |
|---|--------------|-------|-------|------|------|------|--------|
| 3 | Keti | 181 | 350 | 2019 | 20 | 2018 | 0.4713 |
| 4 | Khedir | 223.8 | 449 | 2019 | 22 | 2018 | 4.3481 |
| 5 | Merammor | 262 | 644 | 2016 | 48 | 2018 | 10.226 |
| 6 | Nili | 214.5 | 783 | 2019 | 20.8 | 2018 | 5.1468 |
| 7 | Sang-e-Takht | 223.8 | 449 | 2019 | 22.2 | 2018 | 4.3481 |
| 8 | Shahristan | 214.6 | 516.7 | 2019 | 25.1 | 2018 | 5.5052 |

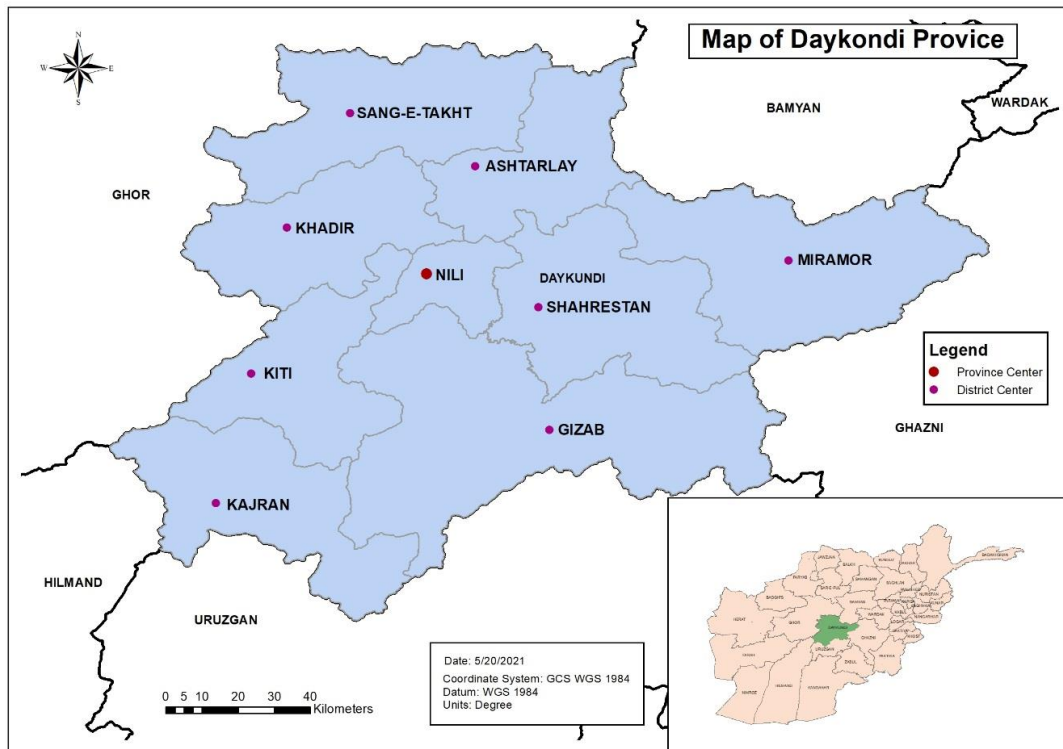


Fig 1: Map the study areas of Daykundi province, Afghanistan

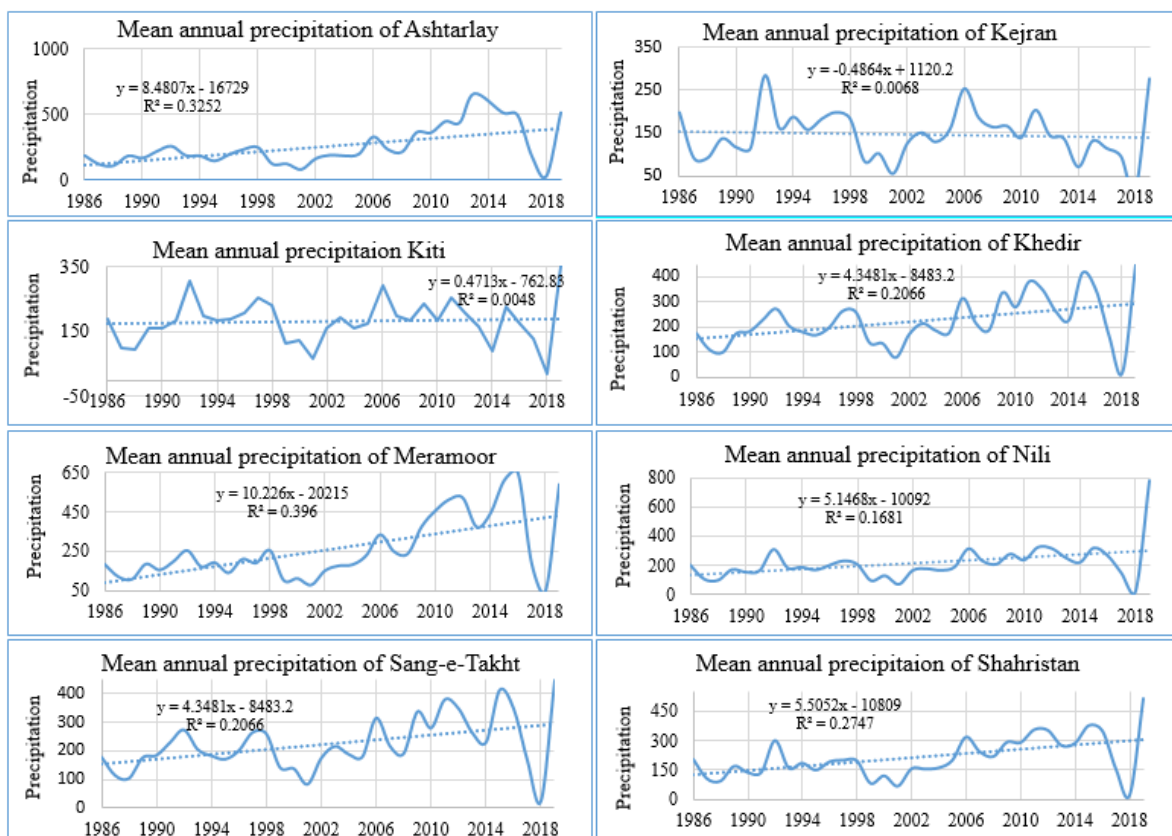


Fig 2: Precipitation trends in Daykundi province over the period of 1986 to 2019

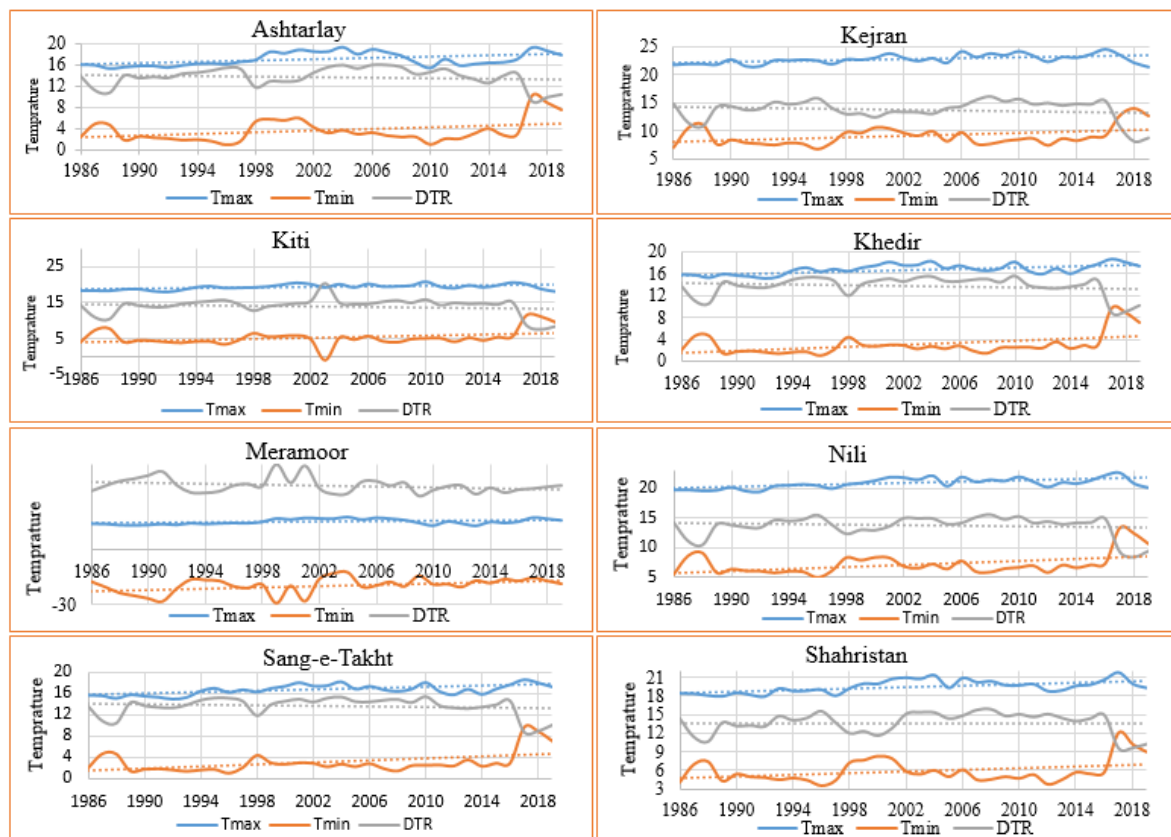


Fig 3. The mean annual of maximum, minimum temperatures and DTR trends in Daykundi province during 1986-2019

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