Analyzing Temporal Variation of Temperature and Rainfall in Rajshahi District

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ABSTRACT

Globally, the climate change brought on by global warming is causing a profound metamorphosis. Nestled in the heart of Bangladesh, Rajshahi experiences its own unique weather patterns and environmental dynamics. For the purpose of conducting trend analysis on the climate patterns of Rajshahi, extensive data spanning from 1970 to 2018 has been acquired from the Bangladesh Meteorological Department (BMD). This comprehensive dataset encompasses monthly averages of both temperature and rainfall. Tools like MS Word, MS Excel, SPSS, and Geographic Information System (GIS) are used to explore statistical analysis and identify trends at the study location. The findings indicate a discernible increase in temperatures alongside a consistent decline in precipitation levels. The escalation in minimum temperatures is surpassing that of maximum temperatures. Over the span of 1970 to 2018, the annual mean temperature in Rajshahi demonstrates a pronounced upward trajectory, characterized by a swift escalation of 0.013 °C per annum. The annual temperature fluctuations exhibit rates of 0.017 °C and 0.009 °C for maximum and minimum ranges, respectively. Throughout 1970-2018, the maximum temperature in pre-monsoon, monsoon, and post-monsoon seasons saw respective increments of 0.019 °C, 0.036 °C, and 0.006 °C/year. From 1990 to 2018, the seasonal maximum temperature also showed a marginally positive trend throughout the winter season. With rates of 0.008 °C, 0.018 °C, and 0.016 °C/year for the winter, pre-monsoon, and monsoon seasons, respectively, and a minor falling tendency of -0.015 °C/year for the post-monsoon season, the seasonal minimum temperature shows an increasing trend across these seasons. In Rajshahi, the annual average rainfall has been falling from 1970 to 2018 at a rate of -1.0593 mm/year. Winter, pre-monsoon, monsoon, and post-monsoon seasons show declining tendencies in the seasonal average rainfall, with the monsoon season showing the largest annual decreases (-2.509 mm). There is climate fluctuation in Rajshahi on both an annual and decadal scale. The average temperature climbed by 0.0422 °C over the past ten years (2000-2009), whereas the average rainfall decreased by 26.01 mm per decade.

Key Words: Climate change, Temperature, Rainfall.

1. Introduction

Climate change characterized by global warming has emerged as one of the most significant and essential environmental challenges (EPA, 2016). Climate change looms as a paramount global threat, impacting weather systems, hydrology, ecology, and the environment across multiple domains. (Rahman & Lateh, 2015A) growing number of 'on the ground' research from cold and wet to warm and dry ecosystems reveal that global warming is altering the timing of life-cycle events in plants and animals (Crick et al., 1997; Schwartz, 1998; Walkovszky, 1998; Bradley et al., 1999; Beaubien & Freeland, 2000). In the last decade, the heightened greenhouse effect's potential to induce global warming has captured escalating public interest and garnered extensive media focus. (Gore, 2007).

A key component of the current conversation about climate change is the accurate evaluation of temperature and precipitation patterns. (Begert, 2004). On a global scale, People have witnessed a sequence of exceptionally warm years over the last two decades. Among them, 1998 stands as the warmest recorded year worldwide based on instrumental data, further accentuated by the peculiar dynamics of the El Niño Southern Oscillation (ENSO) over the decades (Trenberth and Hoar, 1996). As per the findings of the Intergovernmental Panel on Climate Change (IPCC), the Earth's surface temperature has exhibited a consistent rise since the post-industrial period of the 19th century (Watson and Albritton, 2001). On a local or regional level, changes in rainfall patterns are probably a result of the observed global warming (Aldrian, 2008). Research on climate change frequently focuses on examining global average temperature trends and predicting the future trends that are most likely to occur (Esteban-Parra, 1998). Forecasts based on global climate models propose that the escalation of greenhouse gases could lead to a global-scale augmentation in precipitation, a consequence of climate change (Houghton, 1996). At both the worldwide level (Hulme et al., 1998; Lambert et al., 2003; Dore, 2005) and within specific regions (Puebla et al., 1998; Gemmer et al., 2004; Kayano and Sansigolo, 2008), evidence indicates alterations in rainfall patterns due to the effects of global warming. However, a number of scientific investigations and media accounts indicate that climate change is already

well underway (Dore, 2005). Various studies have been conducted on trend analysis of temperature and precipitation in Bangladesh. According to predictions made by Parry et al. (2007), Bangladesh's temperature and rainfall will continue to rise steadily as a result of climate change. One of the most important aspects of Bangladesh's climate is the variability of rainfall over time and space (Shahid et al., 2009).

Agro-climatic conditions in Rajshahi and Rangpur Division were studied (Ferdous, 2011). Research indicated a decrease in yearly average temperature in Rajshahi, Rangpur, and Dinajpur regions by 0.0134, 0.0262, and 0.01180 ℃/year. Chowdhury et al. (2012) conducted a study on long-term changes and trends in certain climatic variables such as rainfall and temperature at Sylhet. The results showed that comparing the two halves of the time span, there is an upward trend observed in summer, critical period, and monsoon rainfall, with increases of 24.5%, 33.8%, and 1.13% respectively. Changes in the diurnal temperature range in Bangladesh during the period 1961–2008 were analyzed by Shahid et al. (2012). They found the mean minimum and mean maximum temperatures in Bangladesh have both exhibited substantial increases, with rates of 0.15°C/decade and 0.11°C/decade, respectively. Begum and Alam (2013) have studied the rainfall of Bangladesh for annual, seasonal, and divisional and found a decreasing trend in recent times (1981-2010) with an increasing trend during the period (1951-2011). The analysis showed the linear trend lines for all divisions except Dhaka and Rajshahi. A study was conducted by Afzal and Bhuiyan (2014) on the countrywide annual rainfall as well as divisional rainfall trend analysis. Results showed that Rajshahi stands as the warmest division among the others, characterized by lower rainfall observations. Analyzing the rainfall trends across various divisions of Bangladesh over the past decade, it becomes evident that Rajshahi experiences the least amount of rainfall, while Dhaka witnesses' moderate levels and Sylhet encounters higher rainfall intensities compared to the remaining divisions.

Mullik et al. (2019) have studied the observed trend in temperature and rainfall in Bangladesh using a pre-whitening approach. They found that trends for all three indices. The monsoon season registers the highest increase at 0.015 °C/yr for mean monthly temperature, while winter demonstrates a decrease of −0.002 °C/yr. Annually, a significant rise of 0.008 °C/yr or 0.4 °C in 50 years is observed ($p < .05$). Mean rainfall exhibits upward trends in three seasons, except for winter.

To the of our best knowledge, there have been few studies conducted on Bangladesh, especially on Rajshahi districts about its temperature and rainfall trends But for broader understanding further study is needed. This study aims to unveil the influence of climate change on the variations in temperature and rainfall patterns across the Rajshahi Region.

2. Study Area and Datasets

2.1 Study Area

Rajshahi District, positioned in the northwestern expanse of Bangladesh, stands as a prominent administrative division within the nation. Geographically, it can be pinpointed at approximately latitude 24.3745° N and longitude 88.6042° E. This district boasts considerable historical and cultural eminence, serving as a pivotal urban center in its region. The district finds its borders defined by the Padma River to the south, the Naogaon District to the east, the Chapai Nawabganj District to the west, and the Bogura District to the north.

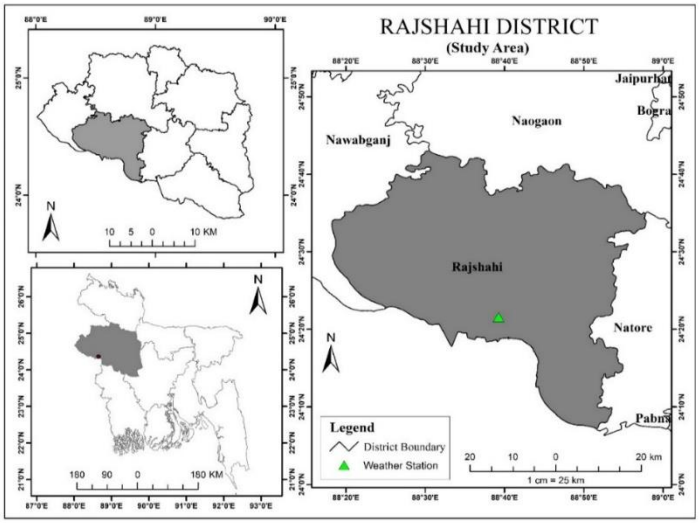

Fig 1. Study area map

2.2 Data

The temperature and rainfall data from 1970 to 2018 has collected from the Bangladesh Meteorological Department (BMD) to examine the trend analysis of climate.

3. Methodology

3.1 Trend Calculation

The temperature and rainfall data from 1970 to 2018 were collected from the Bangladesh Meteorological Department (BMD) to examine the trend analysis of climate.

From the monthly data, seasonal mean and annual mean values have been computed for the four seasons e.g. (a) The winter season (b) The pre-monsoon season (c) The monsoon season (d) The post-monsoon.

Simple Linear Regression methods have been applied for trend analysis. The linear regression between the dependent variable y and the independent variable x can be written as the equation of a straight line.

y=bx+a+e ……(i)

Where a is the intercept, b is the regression coefficient or shape and e are random error components. The positive (negative) value of b indicated an upward (downward) trend. b is the slope of the trend line. a shows the point where the trend line intersects the y-axis.

4. Results and Discussion

4.1 Seasonal Variability of Temperature in Rajshahi

The present study concentrates on the seasonal temperature patterns in Rajshahi between 1970 and 2018. The line graph (Figure 2) illustrates the highest temperatures observed during the winter season. Notably, a substantial increase in temperature variability has become evident in more recent years, particularly from 1992 to 2010. A similar trend recurred from 2003 to 2006, with temperature deviations exceeding 2.5°C. The overall trend displays a downward trajectory at a rate of +0.0056°C annually.

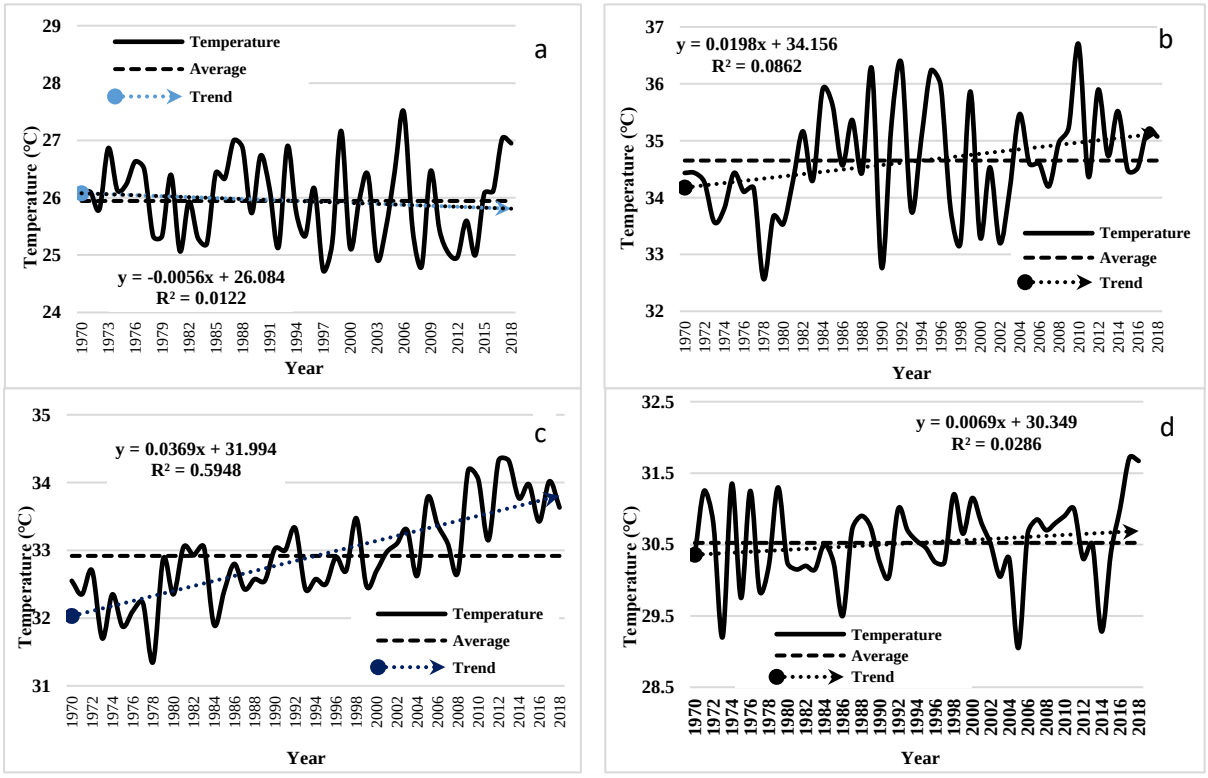

Fig 2. Trend of Maximum temperature at different seasons (a) Max. Temperature of Winter Season (1970-2018), (b) Max. Temperature of Pre Monsoon Season (1970-2018), (c) Max. Temperature of Monsoon Season (1970-2018) and (d) Max. Temp. of Post Monsoon Season (1970-2018)

Figure 2(a) showcases the maximum temperatures before the monsoon season, revealing an upward trend of 0.0198°C per year. This temperature profile exhibits sporadic fluctuations, with instances of sudden spikes to nearly 36°C followed by abrupt drops to around 33°C. Despite data collection occurring during the monsoon season, significant temperature variance is notably absent. Instead, a consistent ascending trend is observed, punctuated by intermittent fluctuations, primarily concentrated in recent years (2009, 2010, and 2012). The annual temperature escalation registers at 0.0369°C.

The post-monsoon graph shows a wider range of maximum temperatures, which indicates that temperatures have been rising at a variable rate over the years at a rate of 0.0069 °C/year. The local temperatures in 1973 and 2005 are essentially identical. This occurrence spread out over 30 years.

From 1988 to 1990, the minimum temperature decreased noticeably by about 3°C (Figure 3). The temperature rose from 1970 to 1981 and from 1998 to 2000, however during 15 years, from 1982 to 1997, the rate of temperature decline was less rapid than usual. As a result, if the temperature rises for 11 years, it will fall for the following 15 years according to a tendency. The increase in the winter minimum temperature is 0.0087°C/year.

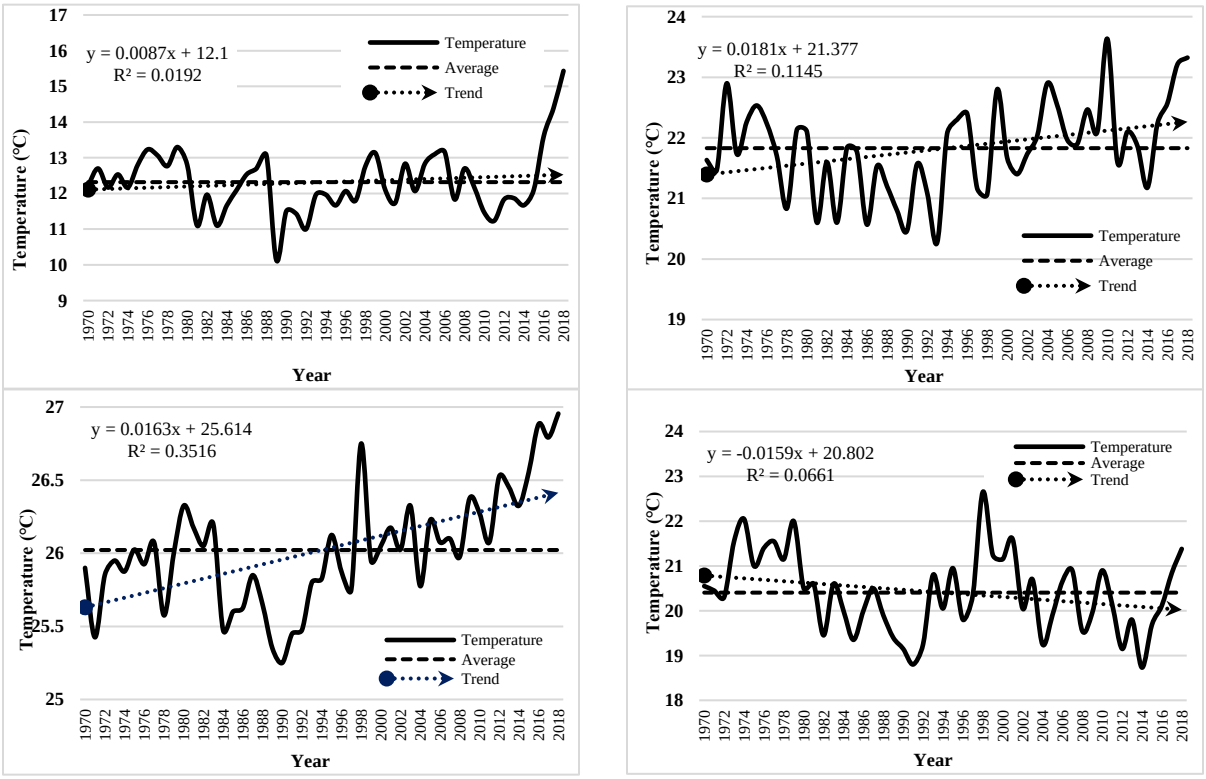

Fig 3. Trend of Minimum temperature at different seasons (a) Min. Temp. of Winter Season (1970 - 2018), (b) Min. Temp. of Pre Monsoon Season (1970 - 2018), (c) Monsoon Minimum Temperature (1970 - 2018) and (d) Min. Temp. of Post Monsoon Season (1970 - 2018)

The graph (Figure 3(b)) represents the minimum temperature observed in the pre-monsoon season, revealing a gradual increase at a rate of 0.0181°C per year. Notably, during the years encompassing 2004, 2008, and 2010, as well as the period leading up to and following these years, minimum temperatures consistently exceeded 22°C. In 1971, temperatures came close to 23°C, and in 2010, they exceeded 23°C. Figure 3(c) underscores a comparable trend, illustrating an increase in temperature at a rate of 0.0163°C per year. Furthermore, a unique instance occurred in 2012, when the minimum temperature spiked to 26.5°C, a phenomenon otherwise uncommon.

In the minimum temperature graph of the post-monsoon season (Figure 3), a more diverse fluctuation of temperature is noticed. In the early years (1973, 1974, 1979) of the graph, the minimum temperature was as much as 22°C but at the beginning of the eighties (1982, 1985) the temperature dropped as low as 19.5 °C and more so in the 1991 when it dropped lower than 19°C. However, the temperature again started to rise in the late nineties (1993, 1995, 1998, 1999) and went over 22.5°C in 1998. The trend line shows downward movement in recent times at – 0.0159 °C/year.

4.2 Seasonal Variability of Rainfall in Rajshahi

Depicted in Figure 4 is the representation of winter season rainfall. The rainfall during the winter months has exhibited a consistent pattern over the years, with the majority of years experiencing less than 20mm of rainfall. Notable exceptions to this trend are three distinct instances (1979, 1981, 1991) where the recorded rainfall exceeded 20mm. An annual decrease of -0.2451 mm in winter season rainfall has been observed. The graph (Figure 4) displays this declining trend more prominently at -0.3197 mm/year. Notably, in various years (1973, 1980, 1988, 1989, 2005, 2006), rainfall remains consistently under 80mm. A notable exception is the year 1979, characterized by remarkably low rainfall, just shy of 20mm.

Conversely, during the monsoon season, a substantial amount of rainfall is vividly evident (as illustrated in Figure 4). With an average annual rainfall surpassing 250mm and a peak of 450mm in 1998, the trend line, however, reveals a gradual decrease in rainfall at a rate of -2.5095 mm/year. Notably, as the third millennium commenced, there has been a discernible reduction in rainfall.

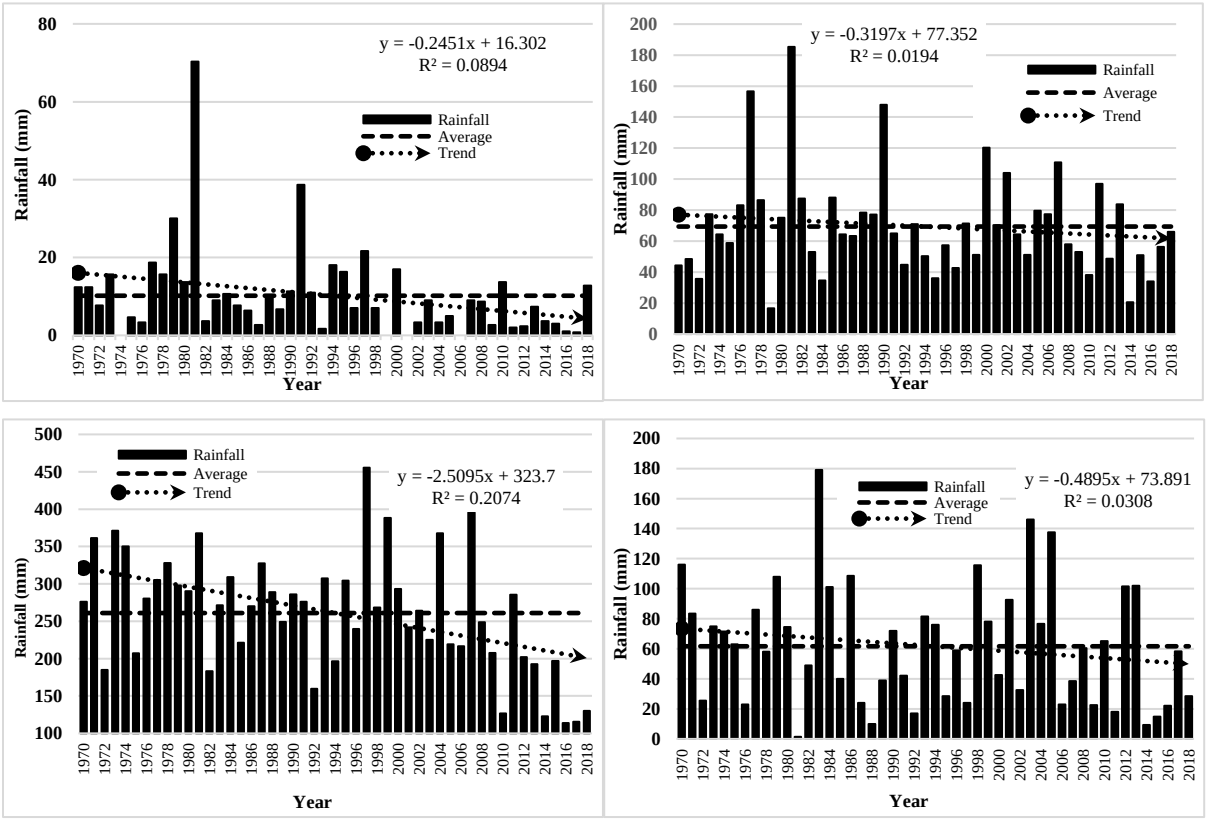

Fig 4. Trend of Rainfall at different seasons (a) Rainfall of Winter Season (1970 - 2018), (b) Rainfall of Pre Monsoon Season (1970 - 2018), (c) Rainfall of Monsoon Season (1970 - 2018) and (d) Rainfall of Post Monsoon Season (1970 - 2018)

In the post-monsoon season, the frequency of rainfall events appears to be diminished, as evident from the declining trend line depicting a decrease in rainfall at a rate of -0.4895 mm/year (Fig. 4(d)). Despite this consistent pattern, subtle variations in the range of rainfall are noticeable.

Especially, the lowest recorded rainfall hovers slightly above 0mm in the year 1981, juxtaposed with the highest recorded rainfall of approximately 180mm occurring just a few years later in 1983.

4.3 Analysis of Annual Temperature and Rainfall

The lowest average annual minimum temperature is shown in Figure 5, with 1989's reading of 19.5°C standing out as a remarkable exception. Additional observations show that temperatures have risen during 2015, reaching a record-high lowest temperature of more than 22°C. The annual minimum temperature development is on the rise, with an average annual increase of 0.0095°C.

The plot of annual maximum temperatures in Figure 5 shows an upward trend at a rate of 0.017°C per year. Despite variations, a clear pattern can be seen as the maximum temperature steadily climbs in the direction of greater values. The culmination of this trajectory was the maximum temperature, which peaked in 2017 at 32.4°C.

The graph in Figure 5 demonstrates a decrease in total yearly precipitation of -12.711 mm/year. Even though there is a lot of variety, the annual rainfall has decreased recently. The wettest year on record was 1981, when there was little over 180mm of rain, while the driest was 2014 when there was only 45mm.

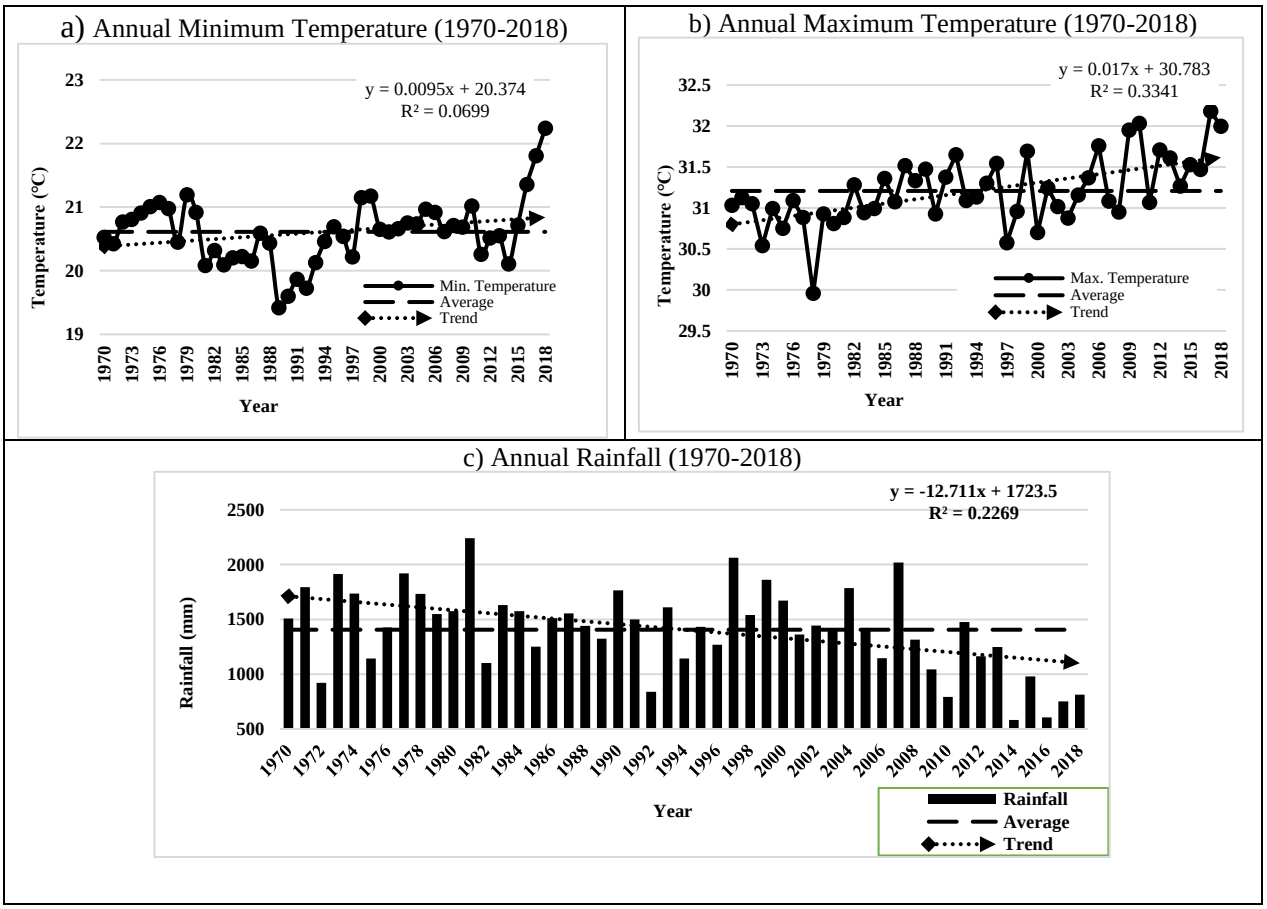

Fig 5. Trend of annual Temperature and Rainfall

5. Conclusion

This study assessed the temperature and rainfall trend over Rajshahi District. The findings revealed a decreasing tendency for the post-monsoon minimum temperature and the winter maximum temperature, respectively, at a rate of -0.0056°C and -0.015°C each year. Rajshahi's annual maximum and minimum temperatures have an abrupt upward trend of 0.017°C and 0.009°C, respectively. Pre-monsoon and monsoon seasons saw an increase in the seasonal maximum and minimum temperatures of 0.019°C, 0.036°C, and 0.018°C, 0.016°C every year, respectively. Post-monsoon maximum temperatures are falling by 0.006°C per year and by 0.008°C per year, respectively. The annual average rainfall is falling at a rate of -1.0593 mm. The average rainfall in the four seasons of winter, pre-monsoon, monsoon, and post-monsoon is decreasing at -0.2451, -0.319mm, -2.509mm, and -0.489mm, respectively. Most rainfall decreases are occurring during the monsoon. In the most recent period (2006-2017), the maximum and minimum temperatures have increased by 0.0437°C and 0.036°C per era, respectively. The average annual rainfall in Rajshahi has been falling dramatically throughout the past era, from 2006 to 2017, with a worrying trend of -5.59 mm/year.

Due to time constraints, this first study has some limitations, but it also offers potential data for future studies. I will be useful for creating better strategic plans for decision-makers and other government and non-government organizations.

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