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# Impacts of Climate Change on Public Health: Bangladesh Perspective

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**Abstract:** A study was conducted in Rangamati, Sylhet and Faridpur districts over the period 1972-2002 to observe the impacts of climate change on public health especially on Malaria. The climate related variables included were temperature, rainfall and relative humidity. It was observed that with the rise of yearly average maximum temperature, yearly total rainfall and yearly average humidity, malaria prevalence in Rangamati was increased and with the rise of yearly average maximum and minimum temperature in Sylhet and Faridpur, malaria prevalence were also increased. Yearly average minimum temperature in Rangamati, yearly total rainfall in Sylhet and Faridpur and yearly average humidity in Faridpur were found to be negatively correlated with malaria prevalence.

**Key words:** Climate change · Public health · Malaria prevalence · Environmental variation

## INTRODUCTION

The global climate change is one of the most significant environmental issues of the present world [1]. Rosenberg and Maheswary [2] mentioned that the effects of global climate change are evident now, as we are experiencing through irregular weather conditions, these effects are multidimensional and the effects are not the same across the globe, because of geographic locations and different levels of development. In recent years, climate change related health impacts have also taken precedence. According to IPCC [3], global warming would cause increase of vector borne and water borne disease in the tropics [4]. It has been estimated that climate change causes 2 percent of all cases of malaria worldwide [5]. Estimation shows that at least 3000 millions of people of all tropical countries are exposed to the risk of dengue while 2400 millions tropics and subtropics are at risk of malaria [4, 6]. There is a close link between local climate and the occurrence or severity of some diseases and other threats to human health [7].

Githeko *et al.* [8] has reported that vector borne diseases are common in Bangladesh. Heavy rains may have linked to increase the Malaria, Dengue, Kala-azar i.e., vector-borne disease probably sensitive to long-term climate change [3]. Malarial occurrence in Pakistan in regions experiencing higher minimum temperatures in late 1980s [9]. Due to climate change, humidity, rainfall and temperature is changed, these three climatic mechanisms, in changing conditions, cause an increase in insects, pests, diseases and microorganisms [10].

Climate changes have important effects on the prevalence of infectious diseases in Bangladesh [11]. Malaria is one of the major public health problems in Bangladesh, out of 64 districts in the country malaria is highly endemic in 13 districts and 10.90 million people are at risk of the disease, more than 98% of the total malaria cases in the country are reported from these 13 high endemic districts (Bandarban, Khagrachari and Rangamati) and Cox's Bazar district report more than 80% of the malaria cases every year [12]. The Anopheles mosquitoes tend to prefer a temperature range from 24 to 27 degrees Celsius, *Anopheles dirus* is the most widespread mosquito in Bangladesh [13]. The malaria parasite (*Plasmodium*) is transmitted by adult infected female mosquitoes that bite humans to obtain blood necessary for egg development, the time from laying of eggs to development of an adult mosquito is 20-25 days, over the next 20-30 days, female *A. dirus* can bite and spread malaria [14]. Three weather parameters (temperature, humidity and rainfall) are important for mosquito activity and malaria epidemiology; temperature, humidity and annual rainfall in Bangladesh fluctuate from year to year, if the overall temperature is risen as predicted, their habitat may be changed, leading to a possible change in malaria with climate change [5].

Bangladesh Centre for Advanced Studies(BCAS) and National Institute of Preventive and Social Medicine (NIPSOM) have carried out a study in three different climatic zones representing drought prone Rajshahi district, flood prone Manikgonj district and salinity

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affected Satkhira district in order to have a better understanding of the possible link between climate change and human health.

This study have been carried out in three different malaria zones representing high endemic Rangamati district, epidemic prone Sylhet district and non endemic-non epidemic prone Faridpur district with an aim to explore and find correlation between climate change factors and malaria prevalence in Bangladesh.

## MATERIALS AND METHODS

The study included in three different malaria zones-high endemic, epidemic prone and non endemic-non epidemic prone areas representing randomly selected Rangamati, Sylhet and Faridpur districts. Month wise data of climate variables i e, temperature, rainfall and relative humidity over the period 1972-2002 for these three districts were collected from Bangladesh Meteorological Department and converted into yearly maximum and minimum average temperature, yearly total rainfall and yearly average relative humidity. District wise data of BSE (Blood Slide Examined) and MCD (Malaria Cases Detected) for these districts during the period were also collected from MIS, DGHS, Mohakhali, Dhaka. Climate factors such as yearly maximum and minimum average temperature, yearly total rainfall, yearly average relative humidity and MCD were compared and analyzed. To find the association between MCD and climate change factors the Pearson's correlation was applied.

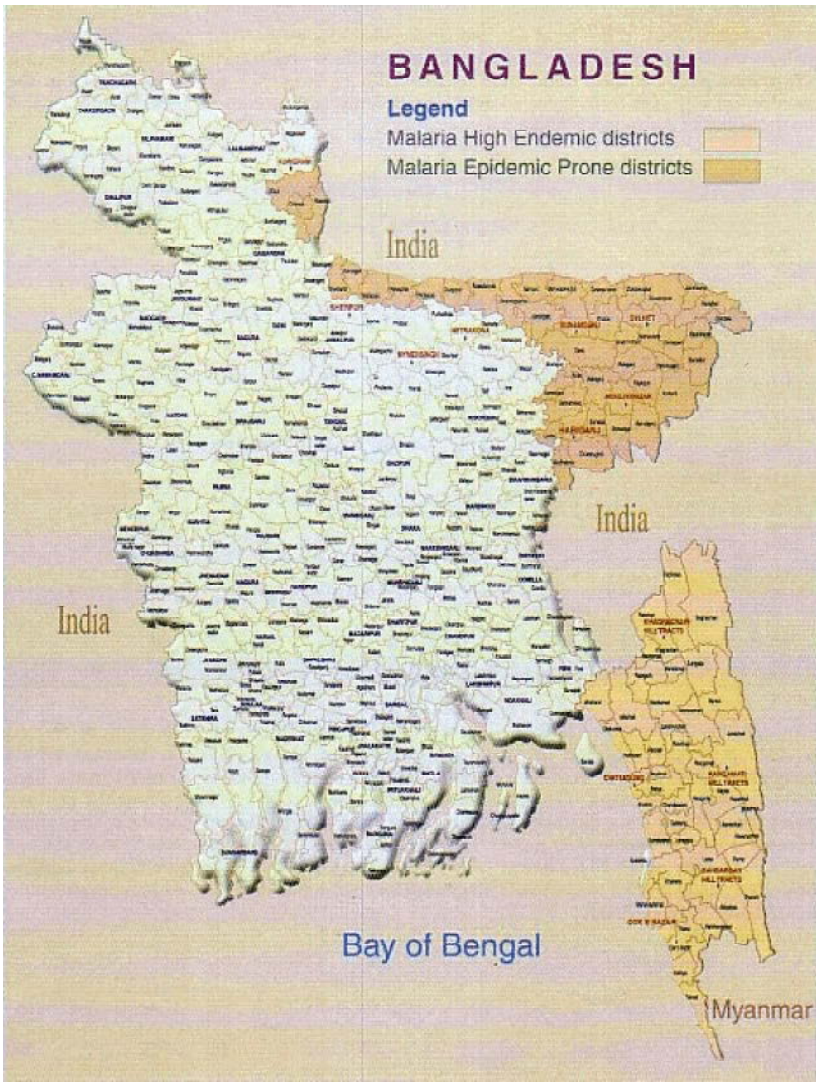


Fig. 1: Map showing the malaria high endemic and epidemic prone districts in Bangladesh

## RESULT AND DISCUSSION

**Climate Change and Climate Variability Issues in Malaria High Endemic Area: Impacts on MCD (Rangamati)**

**Infectious Disease (Malaria Case) Statistics:** In Rangamati district, Malaria Case Detected (MCD) is marked by an increasing trend over the period 1972-2002 and highest MCD (95,0173 per 10,00,000 Blood Slide Examined-BSE) were observed in 1998.Three weather parameters are important for mosquito activity and malaria epidemiology: temperature, rainfall and humidity. MCD due to weather parameters change and their correlation were analyzed under this study.

**Climate Statistics:** Estimated regression of annual maximum temperature over the period from 1972-2002 reflects an average rise of 0.03°C per annum (Fig. 3). The annual minimum temperature is marked by decreasing trend of 0.06 °C over the years. The decrease in annual minimum temperature is observed to be twice as large as that of annual maximum temperature.

Annual total rainfall increases by 12.28 mm. The highest annual total rainfall (3895 mm) was observed in 1993 and the lowest average rainfall (1374 mm) was in 1972 (Fig. 4). The Fig. 4 shows that the highest annual average relative humidity (81%) was in 1977, 1998, 2000 and 2002 and on the other hand, the lowest was in 1994 and 1995. The yearly average relative humidity is marked by an increasing trend of 0.07% during the study period.

**Correlation Between Climate Related Variables and Malaria Case Detected:** The study intended to find the correlations between climate factors and prevalence of malaria included data of temperature, rainfall and humidity of Rangamati district from 1972-2002. The findings derived from data analysis are presented below.

Correlation coefficients have been calculated between malaria detection through blood slide examination and each of the four climate factors i.e. annual average maximum temperature, annual average minimum temperature, annual average rainfall and annual average humidity.

In Rangamati study area, Malaria Case Detected (MCD) were found to have positive correlation with annual average maximum temperature (+0.25), annual average rainfall (+0.14) and annual average humidity (+0.46) and to have negative correlation with annual average minimum temperature (-0.30).

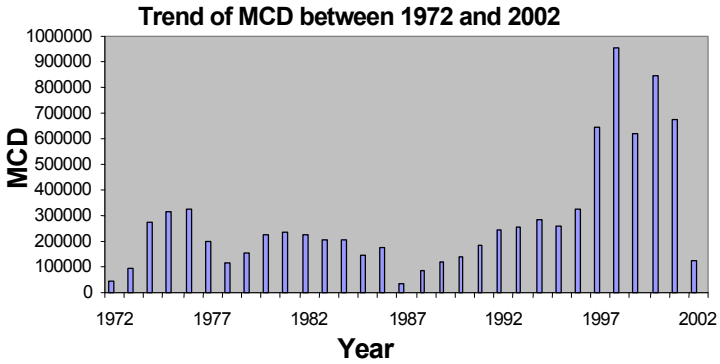


Fig. 2: Trend of Malaria Case Detected in Rangamati

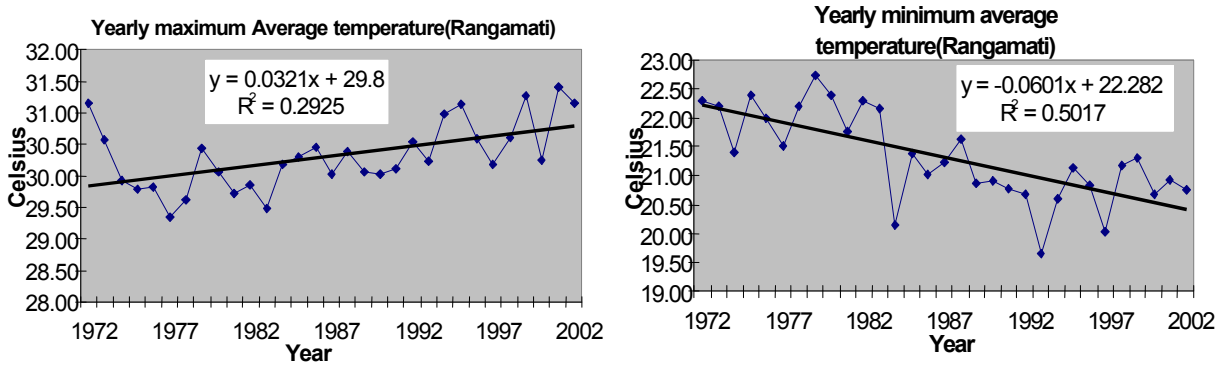


Fig. 3: Trends of annual maximum and minimum temperature

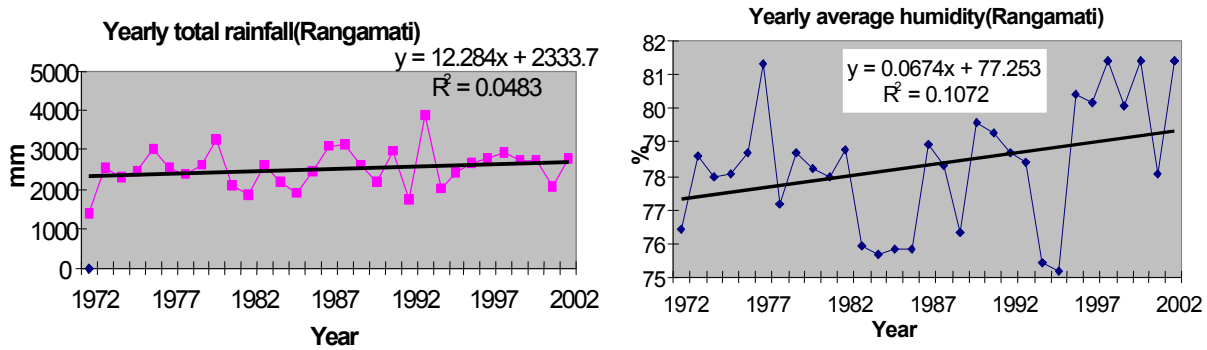


Fig. 4: Regression of yearly total rainfall and yearly average humidity

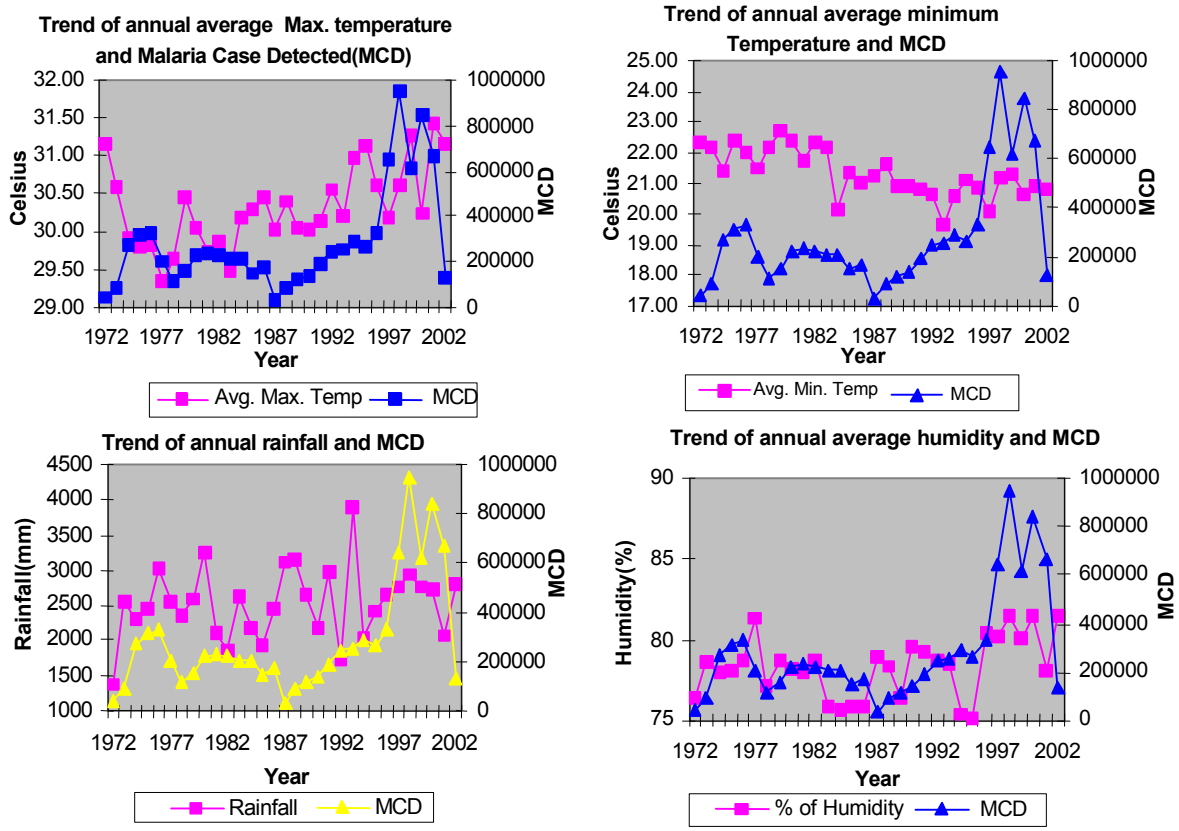


Fig. 5: Trend of climate variables and MCD in Rangamati for the period of 1972-2002

Table 1: Results of correlation analysis on MCD and climate factors of Rangamati area are shown below

| | Climate variables | Value of Correlation Coefficient |
|---|---|---|
| n=31 | Annual average maximum temperature | + 0.25 |
| | Annual average minimum temperature | -0.30 |
| | Annual total rainfall | + 0.14 |
| | Annual average humidity | + 0.46 |

The trends of MCD and climate variables for the period of 1972-2002 are also shown in graphical presentation. The following graphs represent positive correlation between MCD and annual average maximum temperature, annual total rainfall, annual average humidity.

**Climate Change and Climate Variability Issues in Malaria Epidemic Prone Area: Impacts on MCD (Sylhet) Infectious Disease (Malaria Case) Statistics:** Out of 9 malaria epidemic prone districts, we randomly selected Sylhet district as study area. In the district, MCD shows increasing trend during 1972-2002. The highest MCDs (639673 per 1.00 million) were observed in 2002 and the lowest MCDs (8266 /million BSE) were in 1987.

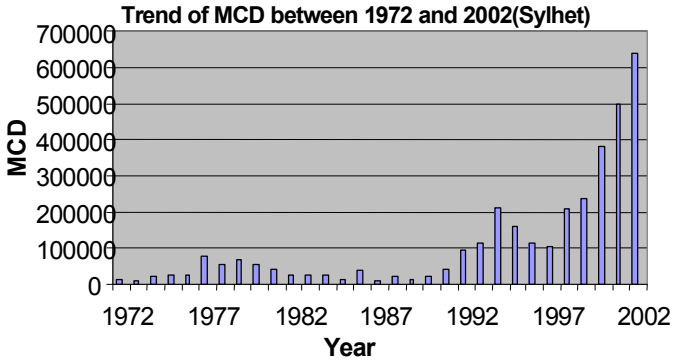


Fig. 6: Changes in Malaria Case Detected frequency in Sylhet from 1972-2002

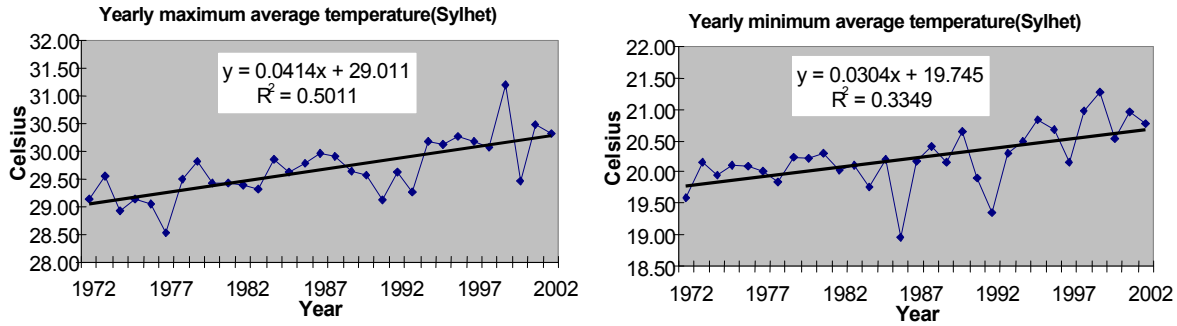


Fig. 7: Regression of annual maximum and minimum temperature

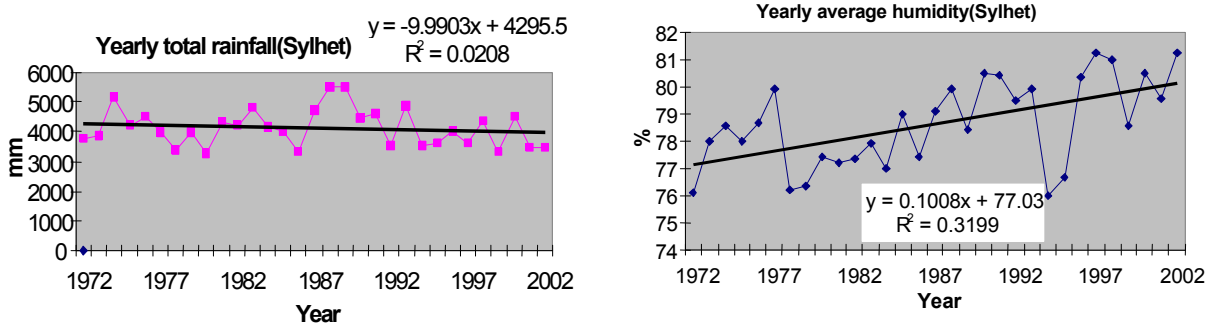


Fig. 8: Trend of yearly total rainfall and yearly average humidity

**Climate Statistics:** Data for weather parameters for malaria epidemic prone district Sylhet over the period 1972-2002 was provided by Bangladesh Meteorological Department (BMD).The data were analyzed to find annual and decadal changes. Regression of annual maximum temperature for the period 1972-2002 shows an average rise of 0.04°C (Fig.7) and the highest temperature(31.18 °C) was in 1999 and the lowest annual maximum temperature(28.53°C) was observed in 1977.The annual minimum temperature is also found by an increasing trend of 0.03°C during the period. The lowest (18.97°C) and the highest (21.28°C) annual minimum temperature were in 1986 and 1999 respectively.

Yearly total rainfall has shown a decreasing trend over the study period (1972-2002) (Fig. 8). The estimated simple regression of yearly total rainfall shows an average annual decrease of 9.99 mm over the mentioned period. The highest yearly total rainfall (5523 mm) and the lowest (3280 mm) were observed in 1989 and 1980 respectively. It is found that humidity have increased with a rate of 0.10% per annum. Over the study period, the highest difference, 5%, was observed between the highest and the lowest yearly average humidity.

Table 2: Results of correlation analysis between climate related variables and malaria case detected of Sylhet

| | Climate variables | Value of Correlation Coefficient |
|---|---|---|
| n=31 | Annual average maximum temperature | + 0.51 |
| | Annual average minimum temperature | + 0.56 |
| | Annual total rainfall | -0.36 |
| | Annual average humidity | + 0.36 |

**Correlation Between Climate Related Variables and Malaria Case Detected:** Statistical data from the year 1972-2002 were used to find the correlation between climate variables (i.e. annual average maximum temperature, annual average minimum temperature, annual total rainfall and annual average humidity) and malaria case detected. Table 2 shows MCD is positively correlated with 3 climate factors out of used 4. MCD were found to be positively correlated (+ 0.51) with annual average maximum temperature over the period. The negative correlation (-0.36) of MCD was observed with annual total rainfall while the positive correlation (+0.56) and (+0.36) were found with annual average minimum temperature and annual average humidity respectively.

The trends of MCD and climate variables for the period of 1972-2002 are also shown in graphical presentation. The following graphs represent positive correlation between MCD and annual average maximum temperature, annual average minimum temperature, annual average humidity and negative correlation with annual total rainfall.

**Climate Change and Climate Variability Issues in Malaria Non-endemic and Non-Epidemic Prone Area: Impacts on Mcd (Faridpur):** Out of 50 malaria non-endemic and non-epidemic prone districts, we randomly selected Faridpur as study area. In the district, MCD shows increasing trend during 1972-2002.However, the increasing trend was sometime relatively sharp and sometime gradual. A significant fluctuation in MCD was observed during the period. A sharp rise and sharp fall was observed in the year 1992 add 1999. The highest MCDs (252586 per 1.00 million BSE) were observed in 1999 and the lowest MCDs (260 /million BSE) was in 1972.

**Climate Statistics:** Data for weather parameters for malaria non-endemic and non-epidemic prone district Faridpur over the period 1972-2002 was analyzed to find annual and decadal changes. Regression of annual maximum temperature for the period 1972-2002 shows an average rise of 0.02 °C(Fig.11) and the highest temperature (31.18 °C) was in 1987 and the lowest annual maximum temperature (29.63 °C) was observed in 1981.

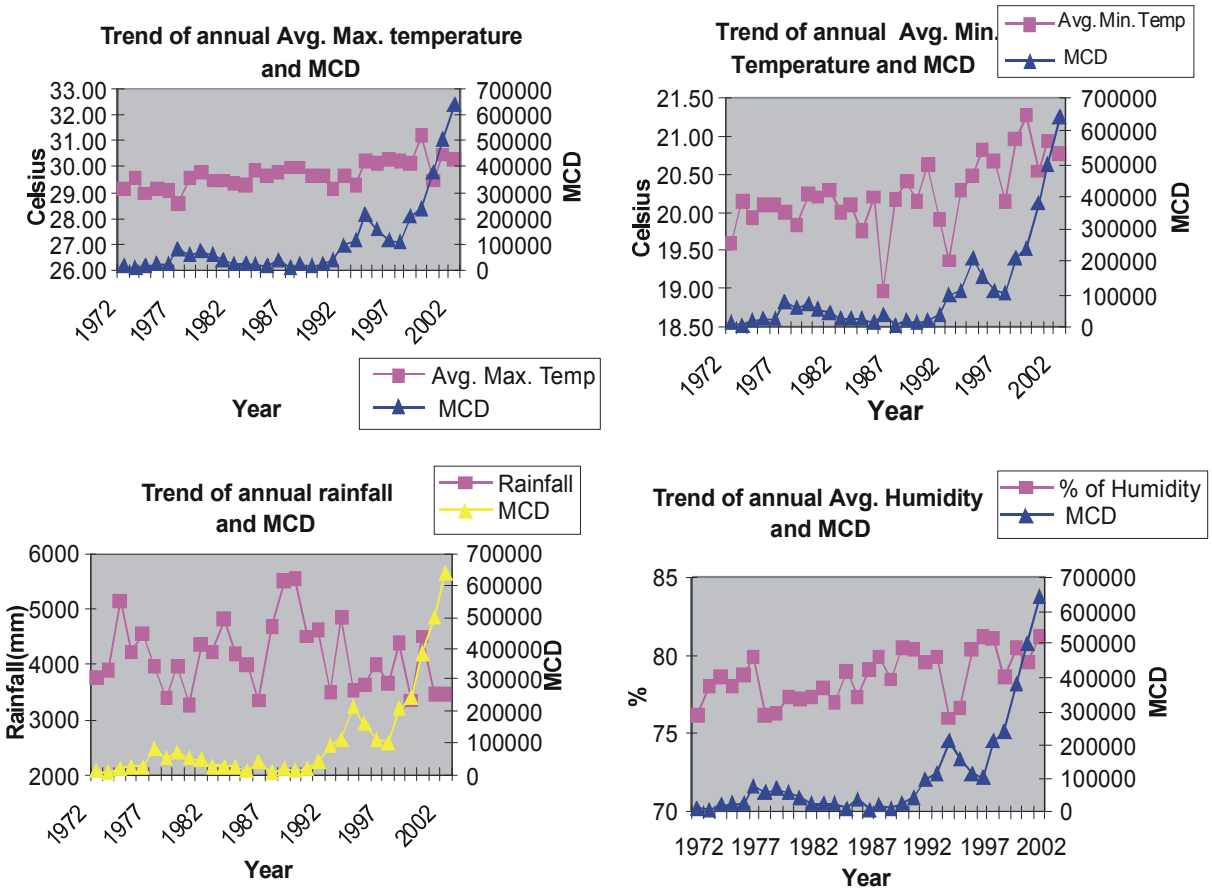


Fig. 9: Trend of climate variables and MCD in study area Sylhet

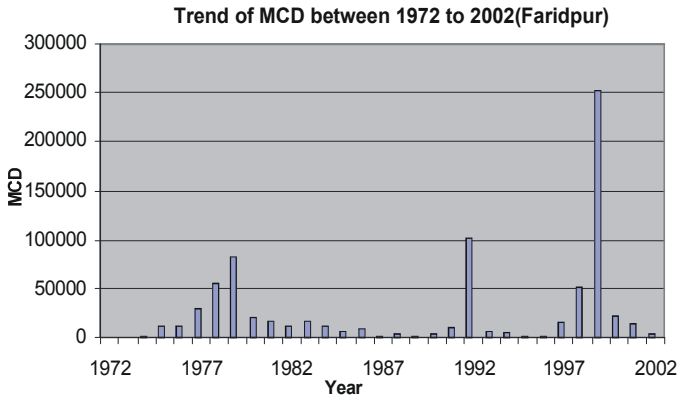


Fig. 10: Changes in Malaria Case Detected frequency in Faridpur from 1972-2002

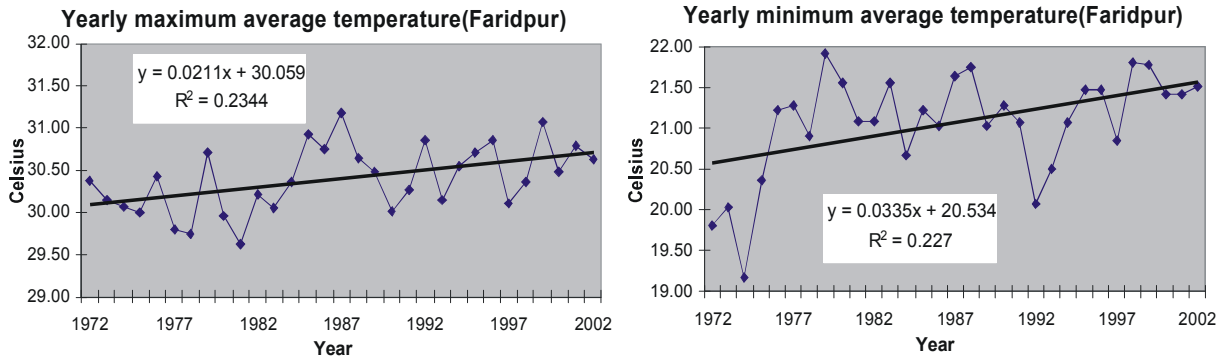


Fig. 11: Trends of yearly maximum and minimum average temperature

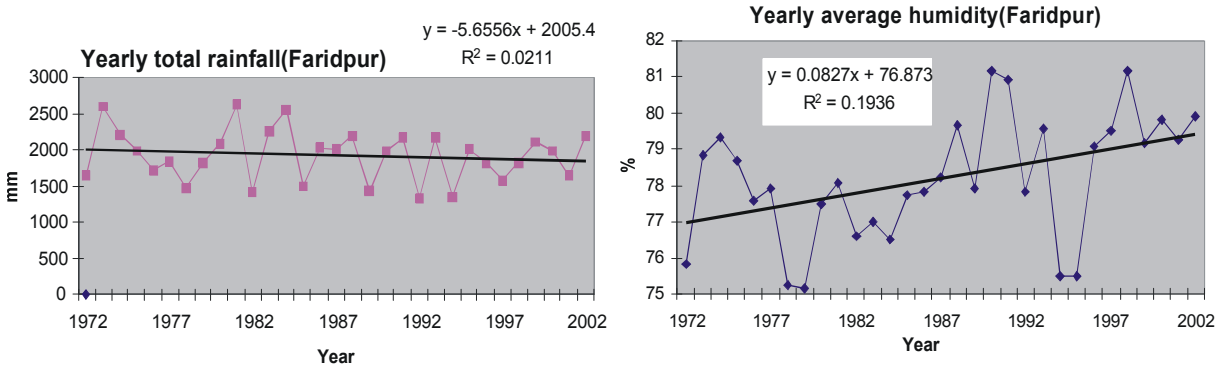


Fig. 12: Trend of yearly total rainfall and yearly average humidity

The annual minimum temperature is also found by an increasing trend of 0.03°C during the period. The lowest (19.17 °C) and the highest (21.83 °C) annual minimum temperature were in 1974 and 1979 respectively.

Annual total rainfall has shown a decreasing trend over the study period (1972-2002) (Fig. 11).The estimated simple regression of yearly total rainfall shows an average annual decrease of 5.66 mm over the mentioned period. The highest yearly total rainfall (2604 mm) and the lowest (1438 mm) were observed in 1981 and 1989 respectively. It is found that humidity have increased with a rate of 0.08% per annum. Over the study period, the highest difference, 6%, was observed between the highest and the lowest yearly average humidity.

**Correlation Between Climate Related Variables and Malaria Case Detected:** Faridpur was one of the three areas where the study was undertaken to explore the association between climate factors and human health. Statistical data from the year 1972-2002 were used to find the correlation between climate variables (i.e. annual average maximum temperature,

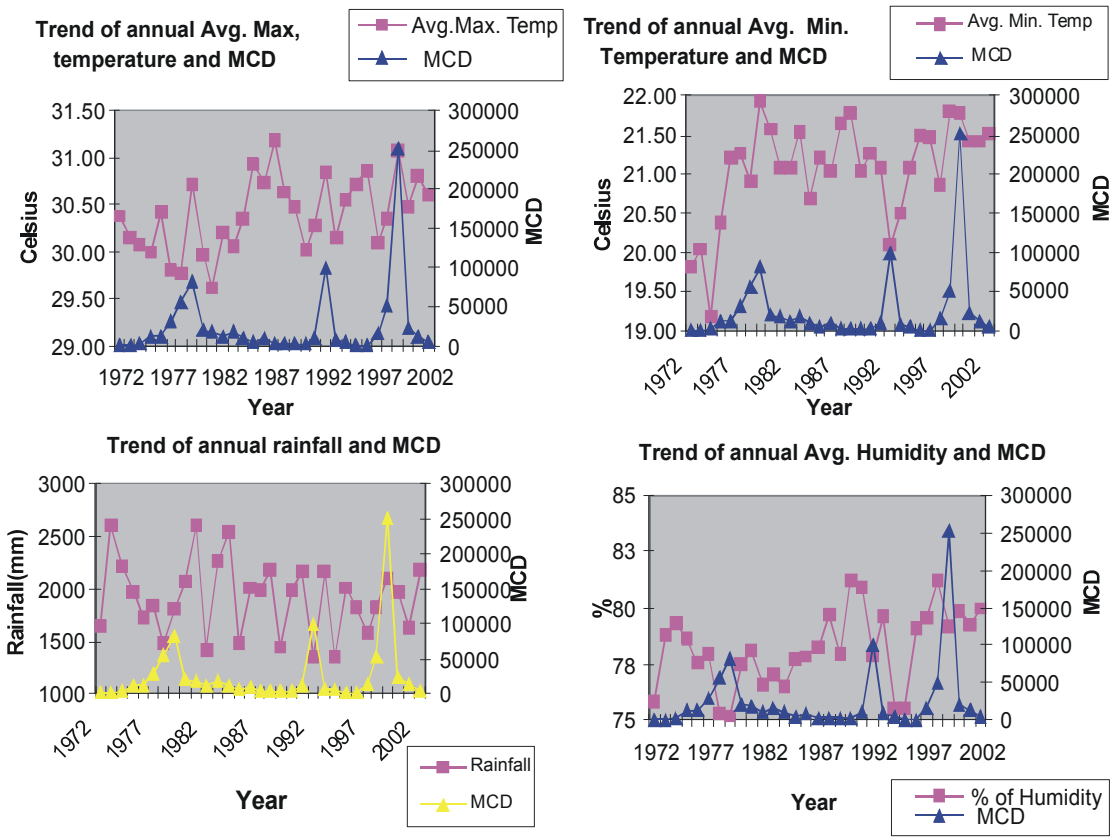


Fig. 13: Trend of climate variables and MCD in Faridpur during 1972-2002

Table 3: Results of correlation analysis between climate related variables and malaria case detected of study area Faridpur

| | Climate variables | Value of Correlation Coefficient |
|---|---|---|
| n=31 | Annual average maximum temperature | + 0.28 |
| | Annual average minimum temperature | + 0.22 |
| | Annual total rainfall | -0.07 |
| | Annual average humidity | -0.01 |

annual average minimum temperature, annual total rainfall and annual average humidity) and malaria case detected. Table 3 presents that MCD is positively correlated with 2 climate factors out of used 4. MCDs were found to be positively correlated (+ 0.28) with annual average maximum temperature over the period. The negative correlation (-0.07) of MCD was observed with annual total rainfall. The correlation between MCD and annual average humidity was also negative (-0.01).

The trends of MCD and climate variables for the period of 1972-2002 are also shown in graphical presentation. The following graphs represent positive correlation between MCD and annual average maximum temperature, annual average minimum temperature, annual average humidity and negative correlation with annual total rainfall.

Based on the result of the study, it can be concluded that the three study areas Rangamati, Sylhet and Faridpur districts were found to have an increasing trend in maximum, minimum temperature and humidity and Rangamati was found to have an increasing trend in rainfall while in both Sylhet and Faridpur the trend was declining over the period.

Considering all other factors (non-climatic) remaining as it is, it is also concluded that the correlation coefficients between climate factors and MCD varied among the study areas. Malaria prevalence was found to have positive correlation with yearly average maximum temperature, yearly total rainfall and yearly average humidity in Rangamati, with yearly average maximum and minimum temperature in Sylhet and Faridpur while yearly average minimum temperature in Rangamati, yearly total rainfall in Sylhet and Faridpur and yearly average humidity in Faridpur were found to be negatively correlated with malaria prevalence. The negative correlation might have happened due to non-climatic factors as well as improved health services.

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