Effects of Global Emission of Greenhouse Gases- CO_2, N_2O, and CH_4 on Climate Change of Dhaka City

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Abstract: Geographically Bangladesh situated in the tropical region where natural disaster is a common incident and still now Bangladesh is facing a plethora of natural disasters. Climate change is the main reason behind it as the emissions of different greenhouse gases like CO_2, N_2O, and CH_4 are increasing. Bangladesh is one of the most vulnerable countries to climate change and hunger and according to Global Hunger Index- 2020, it's under serious condition. In this study, climatic parameters (maximum temperature and minimum temperature) variations were studied for the last 31years (1988-2018) and variations of maximum rainfall and humidity were studied for the last 10 years of Dhaka city, Bangladesh. Global emission of CO_2, N_2O, and CH_4 was calculated to find the effect on climate change of Dhaka city. From the study it is found that global emission of CO_2, N_2O, and CH_4 gas are affecting the climatic parameters of Dhaka city. To predict future maximum and minimum temperature, maximum rainfall and maximum humidity four regression models have been established.

Keywords: *Climate Change, Temperature, Rainfall, Humidity, Greenhouse gases, CO_2, N_2O, and CH_4*

1. Introduction

Greenhouse effect is the process where planet's surface is getting warmer due to the radiation that comes from planet's atmosphere. Greenhouse gases hinder this infrared radiation from escaping directly from the surface of the earth to space. From the very beginning the global climate changed due to the natural disasters but now it is mostly changing due to human abnormal activities. After the formation of Intergovernmental Panel on Climate Change (IPCC), the drastic output of climate change can be easily understood. From 1750 when the industrial revolution took place, one of the greenhouse gases, carbon dioxide, has increased up to 30% [1] and the concentration in the atmosphere is increasing. Not only carbon dioxide but also other greenhouse gases like nitrous oxide and methane are responsible for thickening the natural layer which leads to "Global Warming". As a consequence more evaporation took place and causes an increase of temperature in the greenhouse layer [2]. At the end of the year 2100 the predicted average global temperature could raise 1.8˚ to 4 ˚C, although it can be as high as 6.4˚ C [3].

Effects of climate change can be easily seen in Bangladesh. Average temperature of Bangladesh could increase up to 2.4 degree Celsius higher than the current average temperature by 2100, which will create hotter summer and very cold winters. The rainfall could also be increased up to 10% within 2021 [4]. The International Panel on Climate Change (IPCC) predicts that by 2050 Bangladesh will lose approximately 17% of its land and 30% of its food production which will increase the poverty [5]. With compared to the developed countries Bangladesh is little responsible for global warming but it is one of the worst sufferers.

Dhaka is the capital of Bangladesh. So the average temperature of different months is studied and the hottest and coldest month is found. Some important climatic parameter like rainfall and humidity are also analyzed. The trend of maximum and minimum temperature, maximum humidity and maximum rainfall are analyzed and significant effect is found. By introducing a mathematical model, future climate parameter of Dhaka city can be predicted and thus hazardous effect of greenhouse gases can be controlled.

The main objective of this study is to find out relationship among the emissions of different greenhouse gasses like CO_2, N_2O, and CH_4 with the maximum and minimum temperature, humidity and rainfall of Dhaka city. Here temperature plays a dominant role on global warming which is very concerning issue for future days. By this study, the atmospheric scenario of Dhaka city based on rainfall intensity, humidity and temperature can be predicted. After analyzing the climate pattern a regression model is developed.

2. Climate Condition of Dhaka City

In the center-north the climate of Bangladesh is subtropical and in the south it is tropical. From November to February the weather is pleasant, warm and sunny winter, from March and May a short hot spring and due to the summer monsoon a long rainy season from June to October [6].

2.1. Average Maximum and Minimum Temperature

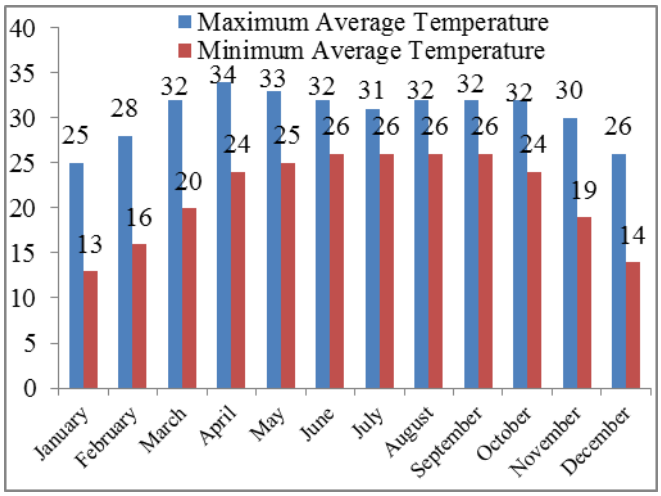

Fig.1.*Maximum and Minimum Average Temperature (degree Celsius) of different months of Dhaka city (1988-2018) [6, 7]*

From Fig. 1 it is seen that April is the month when the average temperature is maximum. It is around 34 degree Celsius. On the other hand in January and December the average maximum temperature is lowest. It is also seen that January is the coolest month with lowest minimum temperature of 13 degree Celsius.

2.2. Average Maximum and Minimum Temperature

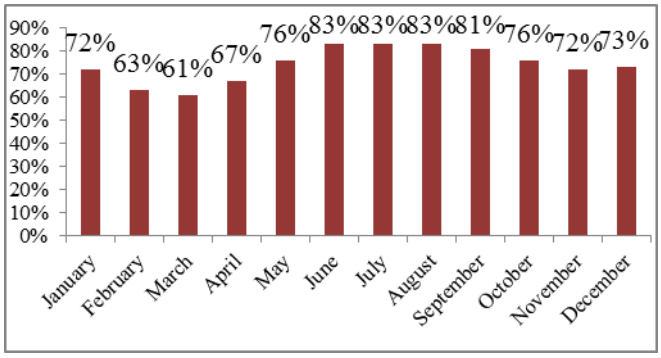

Fig. 2. *Average Humidity (percentage) of Dhaka city (2009-2018) [8]*

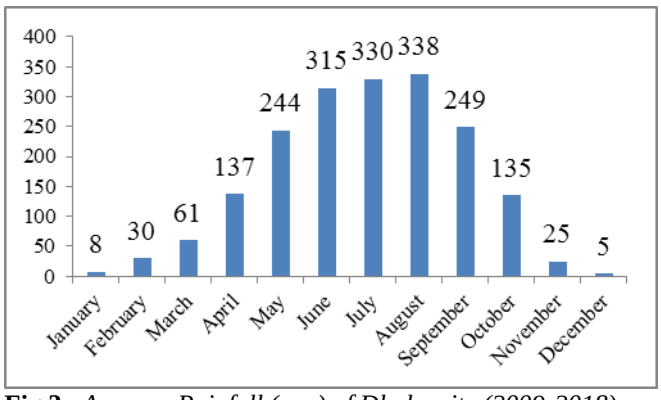

Fig.3. *Average Rainfall (mm) of Dhaka city (2009-2018) [6, 7]*

From Fig. 2 and Fig. 3 average humidity and rainfall of different month of Dhaka city from 1988-2018 can be seen. Average humidity is maximum in June, July and August. Maximum humidity is 83%. On average, August is the most humid. On average, March is the least humid month with 61% humidity. Average rainfall is maximum in august with 338 mm. December has the least rainfall with only 5 mm precipitation. January is also dry with only 8 mm precipitation.

3. Methodology

In this study SPSS is used to find the climatic pattern of different month of Dhaka city for the last 31 years. Variations of maximum temperature, minimum temperature, maximum humidity and maximum rainfall of Dhaka city for the last 31 years are found. After that a multiple linear regression model is developed. In order to estimate the relationship among variables, Regression analysis is one of the best statistical processes. With regression analysis we can predict the behavior of dependent variable with respect to independent variables. As the objective of this study is to establish the relationship of maximum average temperature, minimum average temperature, humidity and maximum rainfall with emission of CO_2, N_2O, and CH_4, so here multiple linear regressions is performed.

$$Y = a + bX_1 + cX_2 + dX_3 + \epsilon \quad (1)$$

Where,
$Y = Independent\ Variable$
$a = Intercept$
$b, c, d = Slopes$
$\epsilon = Residual$
$X_1, X_2, X_3 = Dependent\ Variables$.

4. Results

An easy way to comply with the requirements stated in the Author Guide [1] is to use this document as a template and simply type your text into it. PDF files are also accepted, so long as they follow the same style.

4.1. Climatic Parameters Analysis of Dhaka

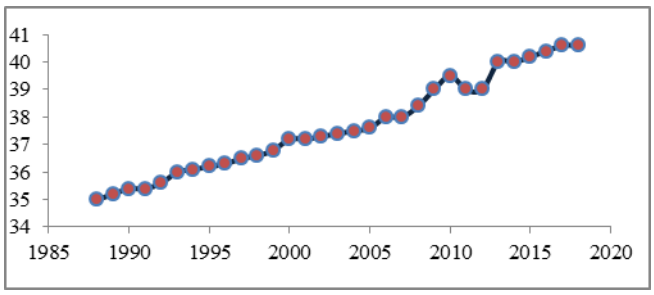

Fig. 4. *Maximum temperature (degree Celsius) variations in Dhaka (1988-2018) [9]*

From Fig. 4 it can be seen that from the year 1988-2000 the maximum temperature is fluctuating in between 37-38 degree Celsius. But from the year 2000-2018 the maximum temperature is fluctuating in between 37-40 degree Celsius. The temperature in Dhaka was 40.2 degrees Celsius on April 22, 2014, the highest in the capital in five decades [10].

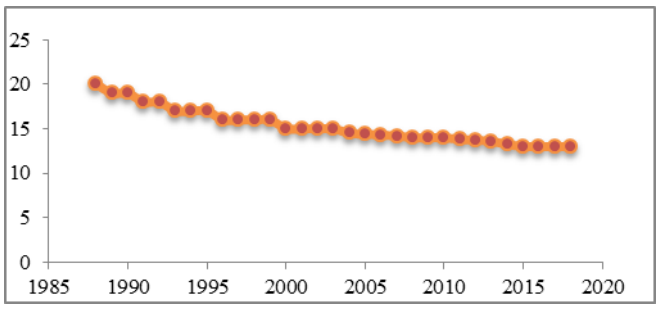

Fig. 5. *Minimum Temperature (degree Celsius) variations in Dhaka city (1988-2018) [9]*

From Fig. 5 it can be seen that, from the year 1988-2000 the minimum temperature is fluctuating in between 15-18 degree Celsius but from 2000-2018 the minimum temperature is fluctuating in between 13-15 degree Celsius. So the minimum temperature is decreasing and it was recorded 9.5 degree Celsius [9].

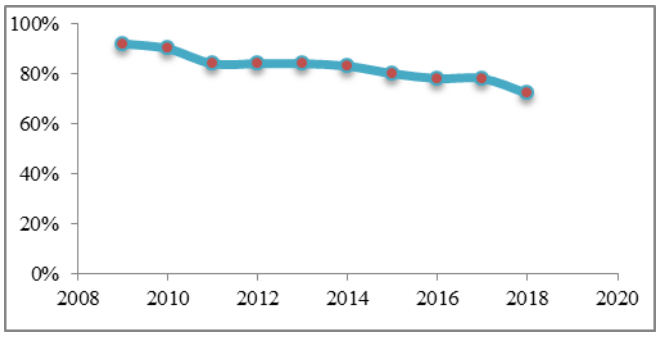

Fig. 6. *Maximum Humidity variations in Dhaka City (2008-2018) [9]*

From Fig. 6 it can be found that from 2008-2012 the maximum humidity is fluctuating in between 92-80% but from 2013-2018 the value is in between 80-72%.

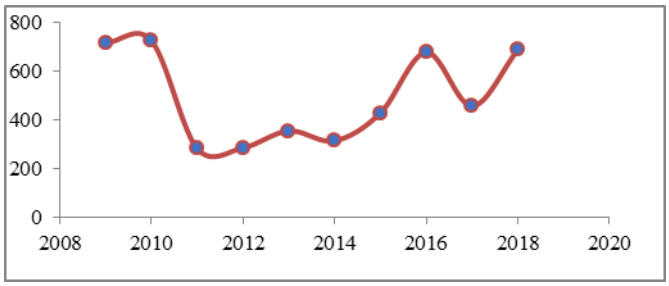

Fig. 7. *Maximum Rainfall (mm) variation of Dhaka city (2008-2018) [9]*

From Fig. 7 it is found that there is no specific pattern for rainfall/precipitation for Dhaka city. As the Winter Rainfall is increasing in Dhaka city the rainfall pattern is also changing.

4.2. Global Emissions of CO_2, CH_4 and N_2O

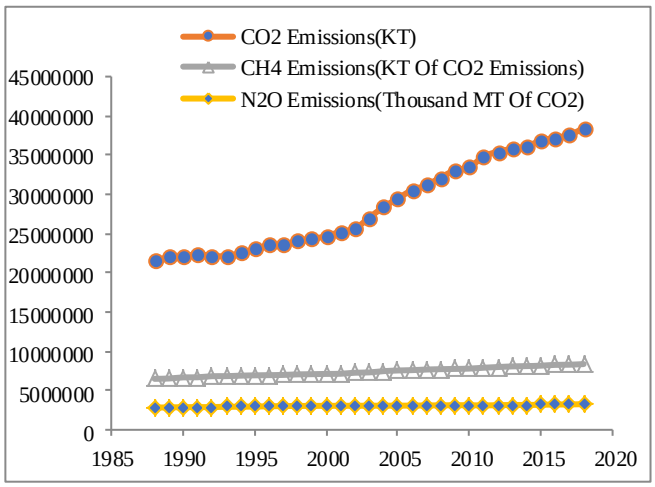

Fig. 8. *Emissions of Global CO2, CH4 and N2O Gas (1988-2018) [11]*

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4.3. Regression Models

4.3.1 For Maximum Temperature (Degree Celsius) of Dhaka city:

Table 1: Descriptive Statistics for Model 1

	Mean	Std. Deviation	N
Maximum Temperature	37.6774	1.75456	31
CO2 Emission (X_1)	28619363.8065	5869252.38579	31
CH4 Emission (X_2)	7426202.3871	567440.37197	31
N2O Emission (X_3)	3072538.7710	114125.49473	31

From Table 1 it can be seen that the mean of maximum temperature of Dhaka city for the last 31 years is 37.6774 degree Celsius. The mean global emission of greenhouse gases like CO_2, CH_4 and N_2O is also mentioned in the table 1 for the last 31 years.

Table 2: Model Summary for Model 1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.991[a]	.983	.981	.24291	1.318

a. Predictors: (Constant), N2O_Emission, CO2_Emission, CH4_Emission

b. Dependent Variable: Maximum_Temperature

Table 2 presents the Model summary for Maximum temperature with the global emission CO_2, CH_4 and N_2O Gas. Here the value of R is .991 which indicates a higher degree of linear relationship between maximum temperature with global emission of CO_2, CH_4 and N_2O Gas. The value of correlation coefficient is .983 which interprets the variation

of maximum temperature with the emission of CO_2, CH_4 and N_2O Gas.

Table 3: ANOVA[a] for Model 1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	90.761	3	30.254	512.723	.000[b]
	Residual	1.593	27	.059		
	Total	92.354	30			

a. Dependent Variable: Maximum_Temperature

b. Predictors: (Constant), N2O_Emission, CO2_Emission, CH4_Emission

ANOVA table explains how well the regression equation fits the data. The significance value is 0.000 which is less than 0.05. So the regression model developed here is statistically significant and it can predict output variable.

Table 4: Coefficients[a] for Model 1

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	13.125	2.545		5.1	.000
	CO2 Emission	1.650E-7	.000	.552	2.6	.014
	CH4 Emission	2.309E-7	.000	.075	.24	.807
	N2O Emission	5.896E-6	.000	.384	3.0	.005

a. Dependent Variable: Maximum_Temperature

The Coefficients table is the most important table that provides us information to predict the maximum temperature for Dhaka city as well as whether global emission of CO_2, CH_4 and N_2O Gas contributes statistically significantly to the model. From table 4 it can be seen that the global emission of CH_4 is not statistically significant as the significance value is .807 which is greater than 0.05. But other two variables are statistically significant as the significance value for both cases are less than 0.05. That implies that these two variables can be used to predict the maximum temperature for Dhaka city. So the equation to predict the maximum temperature for Dhaka city can be written as:

$$T_{Max} = 13.125 + 1.65 \times 10^{-7} X_1 + 5.896 \times 10^{-7} X_3 \quad (2)$$

Where,
T_{Max} = Maximum Temperature (Degree Celsius)
X_1 = Emissions of CO_2 (KT)
X_3 = Emissions of N_2O (Thousand MT of CO_2)

From the Eq[n]. (2) it is found that the maximum temperature is increasing with the increase in the emission of greenhouse gases CO_2 and N_2O. From the Fig. 8 it is seen that CO_2 and N_2O emissions are globally increasing. All the coefficients are positive in Eq[n]. (2). So the maximum temperature of Dhaka city is also increasing. If we know the global emissions of greenhouse gases like CO_2 and N_2O we can use Eq[n]. (2) to predict the maximum temperature of Dhaka city.

4.3.2 For Minimum Temperature (Degree Celsius) of Dhaka city:

Table 5: Descriptive Statistics for Model 2

	Mean	Std. Deviation	N
Minimum Temperature	15.3129	1.97514	31
CO2 Emission	28619363.8065	5869252.38579	31
CH4 Emission	7426202.3871	567440.37197	31
N2O Emission	3072538.7710	114125.49473	31

From Table 5 it can be seen that the mean of minimum temperature of Dhaka city for the last 31 years is 15.3129 degree Celsius.

Table 6: Model Summary[b] for Model 2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
2	.976[a]	.952	.947	.45679	1.147

a. Predictors: (Constant), N2O_Emission, CO2_Emission, CH4_Emission

b. Dependent Variable: Minimum_Temperature

Table 6 explains the Model summary for Minimum temperature with the global emission CO_2, CH_4 and N_2O Gas. Here the value of R is .976 which indicates a higher degree of linear relationship between minimum temperature with global emission of CO_2, CH_4 and N_2O Gas. The value of correlation coefficient is .952 which interprets the 95.2% variation of minimum temperature with the global emission of CO_2, CH_4 and N_2O Gas.

Table 7: ANOVA[a] for Model 2

Model		Sum of Squares	df	Mean Square	F	Sig.
2	Regression	111.401	3	37.134	177.9	.000[b]
	Residual	5.634	27	.209		
	Total	117.035	30			

a. Dependent Variable: Minimum_Temperature

b. Predictors: (Constant), N2O_Emission, CO2_Emission, CH4_Emission

The significance value is 0.000 which is less than 0.05. So the regression model can predict the minimum temperature with the global emission of CO_2, CH_4 and N_2O Gas

Table 8: Coefficients[a] for Model 2

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
2	(Constant)	69.012	4.78		14.4	.000
	CO2 Emission	2.674E-7	.000	.795	2.25	.032
	CH4 Emission	-4.007E-6	.000	-1.151	-2.2	.031
	N2O Emission	-1.028E-5	.000	-.594	-2.8	.008

a. Dependent Variable: Minimum_Temperature

From Table 8 it can be seen that all the independent variables are statistically significant as the significant value is less than 0.05. That means minimum temperature of Dhaka city is dependent on the global emission of CO_2, CH_4 and N_2O Gas. So the equation to predict the minimum temperature for Dhaka city can be written as:

$$T_{min} = 69.012 + 2.67 \times 10^{-7} X_1 - 4.007 \times 10^{-6} X_2 - 1.028 \times 10^{-5} X_3 \quad (3)$$

Where,

T_{Min} = Minimum Temperature (Degree Celsius)

X_1 = Emissions of CO_2 (KT)

X_2 = Emissions of CH_4 (KT)

X_3 = Emissions of N_2O (Thousand MT of CO_2)

From the Eq[n]. (3) it is found that the minimum temperature is decreasing with the increase in the emission of greenhouse gases CH_4 and N_2O. The effect of the emission of CO_2 is not as great as CH_4 and N_2O in case of decrease in minimum temperature. From the Fig 8 it is seen that CH_4 and N_2O emissions is globally increasing. So the minimum temperature of Dhaka city is decreasing. If we know the global increase in greenhouse gases like CO_2, N_2O and CH_4 we can use Eq[n]. (3) to predict the minimum temperature of Dhaka city.

4.3.3 For Maximum Humidity (%) of Dhaka city:

Table 9: Descriptive Statistics for Model 3

	Mean	Std. Deviation	N
Humidity	.8250	.05874	10
CO2 Emission	35901728.1000	1741185.81745	10
CH4 Emission	8094461.6000	210372.72835	10
N2O Emission	3191304.4000	53364.33316	10

From table 9 it can be seen that the mean of Maximum humidity of Dhaka city for the last 10 years is 82.50%.

Table 10: Model Summary[b] for Model 3

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
3	.989[a]	.979	.968	.01054	2.585

a. Predictors: (Constant), N2O_Emission, CO2_Emission, CH4_Emission

b. Dependent Variable: Humidity

Here the Value of R is .989 which is very near to 1 and indicates a good linear relationship between maximum humidity with global emission of CO_2, N_2O and CH_4. 97.9% variation of humidity with the variation of global emission of CO_2, N_2O and CH_4 gas.

Table 11: ANOVA[a] for Model 3

Model		Sum of Squares	df	Mean Square	F	Sig.
3	Regression	.030	3	.010	91.11	.000[b]
	Residual	.001	6	.000		
	Total	.031	9			

a. Dependent Variable: Humidity

b. Predictors: (Constant), N2O_Emission, CO2_Emission, CH4_Emission

The significant value is .000 which is less than 0.05. That indicates our data is well fit for the model 3.

Table 12: Coefficients[a] for Model 3

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
3	(Constant)	.992	.558		1.77	.01
	CO2 Emission	-8.0E-8	.000	-2.393	-3.9	.00
	CH4 Emission	4.79E-7	.000	1.716	2.44	.05
	N2O Emission	-3.5E-7	.000	-.327	-1.8	.11

a. Dependent Variable: Humidity

Global emission of N_2O gas is statistically not significant as the significant value is greater than 0.05. That means Maximum humidity of Dhaka city is not dependent on N_2O gas global emission. Global emission of CO_2 and CH_4 is statistically significant and Maximum humidity of Dhaka city depends on these.

$$H_{Max} = .991689 - 8 \times 10^{-8} X_1 + 4.79 \times 10^{-7} X_2 \quad (4)$$

Where,

$\boldsymbol{H_{Max}}$ = Maximum Humidity (%)

$\boldsymbol{X_1}$ = Emissions of CO_2 (KT)

$\boldsymbol{X_2}$ = Emissions of CH_4 (KT)

From Eq[n]. (4), the maximum humidity is decreasing with the increase in emissions of CO_2 as the value of Coefficient is negative. From different climate model it can be seen that relative humidity is increasing slightly over the oceans but decreasing in land as the climate warms. [12]. As the Dhaka is far away from the ocean so the maximum relative humidity is decreasing in comparison to ocean.

4.3.4 For Maximum Rainfall/precipitation (mm) of Dhaka city:

Table 13: Descriptive Statistics for Model 4

	Mean	Std. Deviation	N
Precipitation	494.3700	188.45470	10
CO2 Emission	35901728.1000	1741185.81745	10
CH4 Emission	8094461.6000	210372.72835	10
N2O Emission	3191304.4000	53364.33316	10

From table 13 it can be seen that the maximum mean of Precipitation of Dhaka city for the last 10 years is 494.37mm.

Table 14: Model Summaryb for Model 4

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
4	.927[a]	.859	.789	86.56539	2.120

a. Predictors: (Constant), N2O_Emission, CO2_Emission, CH4_Emission

b. Dependent Variable: Precipitation

Value of R is .927 which indicates a perfect linear relationship between maximum precipitation with global emission of CO_2, N_2O and CH_4. 85.9% variation of maximum precipitation with the variation of global emission of CO_2, N_2O and CH_4 gas.

Table 15: ANOVA[a] for Model 4

Model		Sum of Squares	df	Mean Square	F	Sig.
4	Regression	274675.158	3	91558.38	12.2	.006[b]
	Residual	44961.403	6	7493.567		
	Total	319636.561	9			

a. Dependent Variable: Precipitation

b. Predictors: (Constant), N2O_Emission, CO2_Emission, CH4_Emission

The significant value is .006 which is less than 0.05. That indicates our data is well fit for the model 4.

Table 16: Coefficients[a] for Model 4

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
4	(Constant)	-12973.1	4583		-2.83	.03
	CO2 Emission	.000	.000	-1.156	-.745	.48
	CH4 Emission	-.001	.002	-.842	-.469	.656
	N2O Emission	.008	.002	2.135	4.758	.00

a. Dependent Variable: Precipitation

Global emission of N_2O gas is statistically significant as the significant value is less than 0.05. That means Maximum precipitation of Dhaka city is only dependent on N_2O gas global emission. Global emission of CO_2 and CH_4 is statistically not significant and Maximum precipitation of Dhaka city is not depending on these gases.

$$R_{Max} = -12973.2 + 0.008 X_3 \quad (5)$$

Where,

R_{Max} = Maximum Rainfall (mm)

X_3 = Emissions of N_2O (Thousand MT of CO_2)

Without an overall global average there is not a clear prediction on how local total precipitation amounts should change, [13]. To find the maximum precipitation Eq^n. (5) is suggested. The coefficient of emission of global N_2O gas is positive, so with the increase of emission of this gas the maximum precipitation will increase

5. Conclusions

Maximum Temperature, Minimum temperature, maximum humidity and maximum rainfall plays a more significant role then average temperature, average humidity and average rainfall. So in this paper we focus on the maximum conditions. Global increase of greenhouse gases like CO_2, CH_4 and N_2O affects the climate of Dhaka city. Maximum temperature is increasing up to 1-2 degree Celsius in the last few decades. If the rate of emission of greenhouse gases continues than temperature will increase up to 3-4 degree Celsius within 2030.The minimum temperature is decreasing. As a result winter season will become hazardous to the people of Dhaka city. Minimum temperature is decreasing up to 2-3 degree Celsius. As a result winter rainfall is increasing. The rate of humidity in the land area is decreasing at a high rate. It affects the overall climate of Dhaka city. The rainfall becomes unpredictable. Even the rainfall variations are high at different parts of Dhaka city. As local affects are considered with the global change of greenhouse gases so some assumption was made. 4 equations are suggested to find the relation of local climate with the emissions of greenhouse gases. With the help of this equation we can predict the future maximum temperature, minimum temperature, maximum humidity and maximum rainfall of Dhaka city and we can take some actions to control the climate of Dhaka city.

6. Recommendation

- As the data is not available in online or offline sources some thumb rules are used.
- The data related to maximum humidity and maximum precipitations is not available. So only 10 years (2009-2018) data is analyzed.
- For a better correlation more data should be analyzed.
- Here only regression model is used without knowing the exact relation of the variables. So better mathematical model is suggested to find the exact relation.
- Here only CO_2, CH_4 and N_2O are considered. But there are many more greenhouse gases like SO_2, CFC, SF_6 etc. But the data is not available. So finding the exact effects of greenhouse gases this data should be analyzed.
- Some comparison with other developing countries is suggested to find the exact impact of these models

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