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Climate Change

Climate Change in Bangladesh: a closer look to temperature and rainfall data

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ABSTRACT

Bangladesh is identified as being at specific risk from climate change due to its exposure to sea-level rise and extreme events and concentrated multidimensional poverty. Bangladesh's population is at risk of sea-level rise which is predicted to grow to 27 million by 2050. The country has a sub-tropical humid climate characterized by wide seasonal variations in rainfall and moderately warm temperature and high humidity. The broad aim of this research is to analyze the temperature and rainfall dynamics of the Bangladesh during the period from 1091 to 2015 and future trends of temperature and rainfall pattern till 2050 through ARMA model and CMIP5 model. This research has been carried out on the basis of secondary data. Temperature and rainfall data recorded at different metrological stations over the time period 1901-2015 were used to assess recent changes in the climate of Bangladesh.

The results depict that temperature is increasing day by day whereas precipitation reducing. The result also shows that the climate change and global warming is currently happening in Bangladesh and in 2050 the scenario of country will be worse. This research analyzes the temperature and rainfall dynamics of Bangladesh that would be helpful for planning in climate change mitigation and adaptation.

Key words: climate change, exposure, sea-level rise, temperature rise, rainfall, dynamic changes, global warming.

1. INTRODUCTION

The International Panel on Climate Change (IPCC) has named Bangladesh as one of the most vulnerable countries in the world due to climate change (IPCC, 2007). It has been predicted that due to climate change, there will be a steady raise of temperature and change in rainfall pattern which might have a number of implications in agriculture (Karim et al., 1999), water resources (Fung et al., 2006) and public health (Shahid, 2009) in Bangladesh. Due to climate variability, the impact of higher temperatures, more extreme weather events such as floods, cyclone, severe drought and sea-level rise are already being felt in South Asia and will continue to intensify. At present the average temperature of Bangladesh ranges from17^0 C to 20.6^0 C during winter and 26.9^0 C to 31.1^0 C during summer (Shahid, 2008). In the rainfall variability, the timing, location and the extent of it depends on in the entire Ganges, Brahmaputra and Meghna (GBM) basin. During the months with less precipitation increasing temperature may as a result of climate change, will increase evapotranspiration and create circumstances like water loss from soil and resultant reduced crop yield, lower level of water both in surface and ground water systems, higher microbial concentration and their growth rate and accompanying with desertification processes as a consequences of increased surface temperature in different parts of the country (Rajib et al., 2010). In recent years, Atmospheric-Ocean General Circulation Models (AOGCMs) have been used in dynamic atmospheric feature's study to predict the climatic consequences of increasing atmospheric concentrations of greenhouse gases (GHG) (McCarthy et al., 2001). These calculations may be plenty for areas where the terrain is reasonably flat, uniform and away from coasts. Though in SAARC areas, coasts and mountains have significant effects on the weather. Therefore scenarios based on global models are unable to capture the local-level details needed for assessing impacts at national and regional scales. In this context the regional climate models (RCMs) can provide an opportunity to do dynamical downscaling of climate features such as increasing of temperature and rainfall variability with regional detail of specified regions. Global circulation model (GCM) have been used in a study to show that sea and air ten percents will keep increasing, sea level is rising, intense storms and rainfall will become more frequent (Murphy & Mitchell, 1995). The broad aim of this study is to analyze the dynamics of temperature and rainfall of Bangladesh in last recent years and a projection for 2050 in trends of temperature and rainfall pattern of the country.

2. METHODOLOGY

Study Area

Bangladesh is officially the People's Republic of Bangladesh. The country is in South Asia. Its area is 147,570 km^2. It shares land borders with India and Myanmar (Burma). Most parts of it is less than 12m (39.4 ft) above sea level, and it is estimated that about 10% of its land would be flooded if sea level rise by 1m (3.28 ft). 17% of the country is covered by forests and 12% is covered by hill systems. The country's haor wetlands are of significance to global environment science (Banglapedia, 2018).

Data Sources

The study has been done with a large number of data. All the data of the study are secondary data. The source of the data is Intergovernmental Panel on Climate Change (IPCC). From their provided data the study reached to the result.

In the study of the temperature rise and precipitation scenario in Bangladesh and doing the projection for 2050, there are two models analysis have been done. One is Autoregressive-moving-average (ARMA) Model and another one is Coupled Model Inter-comparison Project Phrase-5 (CMIP5) Model. Though the future is unpredictable but by these model calculations we can get an approximate prediction for the future.

ARMA (p,q) Model was used for time series analysis from 1901-2050. This trend analysis was done for forecasting of temperature and precipitation as well as the future situation of climate change in Bangladesh's perspectives. In the model 'p' is the order of the autoregressive (AR) component model, Θ_1, Θ_2, Θ_3.....Θ p are the AR (p) model coefficients, 'q' is the order of moving average (MA) component, Θ1, Θ2, Θ3.....Θ q are the MA (q) model coefficient (Hossain et al., 2015).

The equation of ARMA Model is

$$x_t = \left[\sum_{i=1}^{p} \emptyset_{\ i} x(t-i)\right] + \left[\sum_{j=1}^{q} \emptyset_{\ j} x(t-j)\right]$$

CMIP5 Model was used as it promotes a standard set of model simulations in order to; evaluate how realistic the models are in simulating the recent past; provides projections of future climate change on long term time scales; understand some of the factors responsible for differences in model projections, including quantifying some key feedbacks such as those involving clouds and carbon cycle. It is a software base model (CMIP5, 2013).

3. RESULTS AND DISCUSSION

The monthly anomaly of the recent past year temperature in average scenario has shown in the Figure 1 by the standard deviation the figure has become more specify. From the WB (World Bank) data source the figure we can observe that in recent past years April to June months were high in temperature and lowest month of temperature was remain January though temperature starts to downward from the month October and starts to rise from the March month of the year.

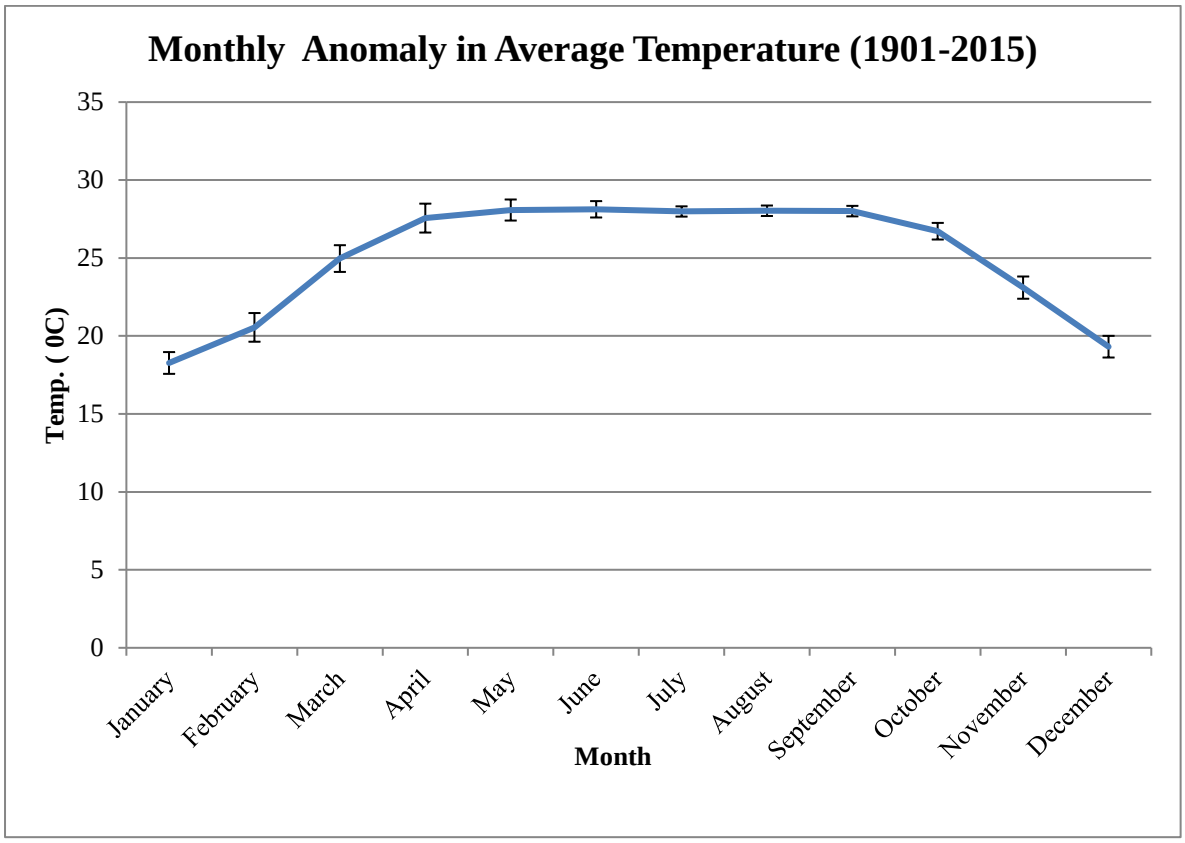

Figure 1
Showing the monthly anomaly in average temperature (1901-2015)

The continuous temperature changing from 1901 to 2015 with the prediction of 2050 from World Bank (WB) and IPCC are shown Table 1. On the basis of WB data the ARMA model has made and shown the change differences in monthly average temperature. There are positive and negative both types of result found. Beneath of it the CMIP5 model has shown by the IPCC data source. The changes of temperature can identify easily. The change difference of the model is showing all the positive result. From the observation of both the models indicates that temperature will increase in 2050.

Table 1 Showing the change of temperature on average data on the basis of ARMA Model.

Year	Sources	Change in Temperature											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1901-2015	WB	18.30	20.55	24.80	27.56	28.08	28.13	27.99	28.03	28.01	26.72	23.10	19.31
2016-2050	ARMA Model	18.27051	20.5511	24.96519	27.5634	28.08879	28.12427	27.98762	28.03365	28.0158	26.72448	23.11989	19.30632
2015- 2050	Change difference	0.001143	-0.00052	-0.00109	0.002771	0.009842	-0.00136	0.001578	0.001832	0.006906	0.004341	0.017615	-0.00677
1901-2015	IPCC	14.10881	16.89841	21.31597	25.16719	26.75377	26.79496	25.6412	25.06424	24.40828	22.06901	18.06516	14.55153
2016-2015	CMIP5 Model	15.37759	18.19718	22.60811	26.43841	27.94954	27.87845	26.66581	26.05285	25.44842	23.18281	19.23118	15.73062
2015 - 2050	Change difference	1.26878	1.29877	1.29214	1.27122	1.19577	1.08349	1.02461	0.98861	1.04014	1.1138	1.16602	1.17909

In the following Figure 2 is the prediction for 2050 of the change in temperature from 2015. From the figure-2 we can notice that the temperature for 2050 will be increased and the highest average temperature will be on April month of the year. There will be two seasons existence; one is very hot summer and very cold winter. The fluctuation of temperature will adverse to our environment. The temperature scenario for 2050 will be so much different from now. The model is created by ARMA model on the basis of last 1901 to 2015 years data.

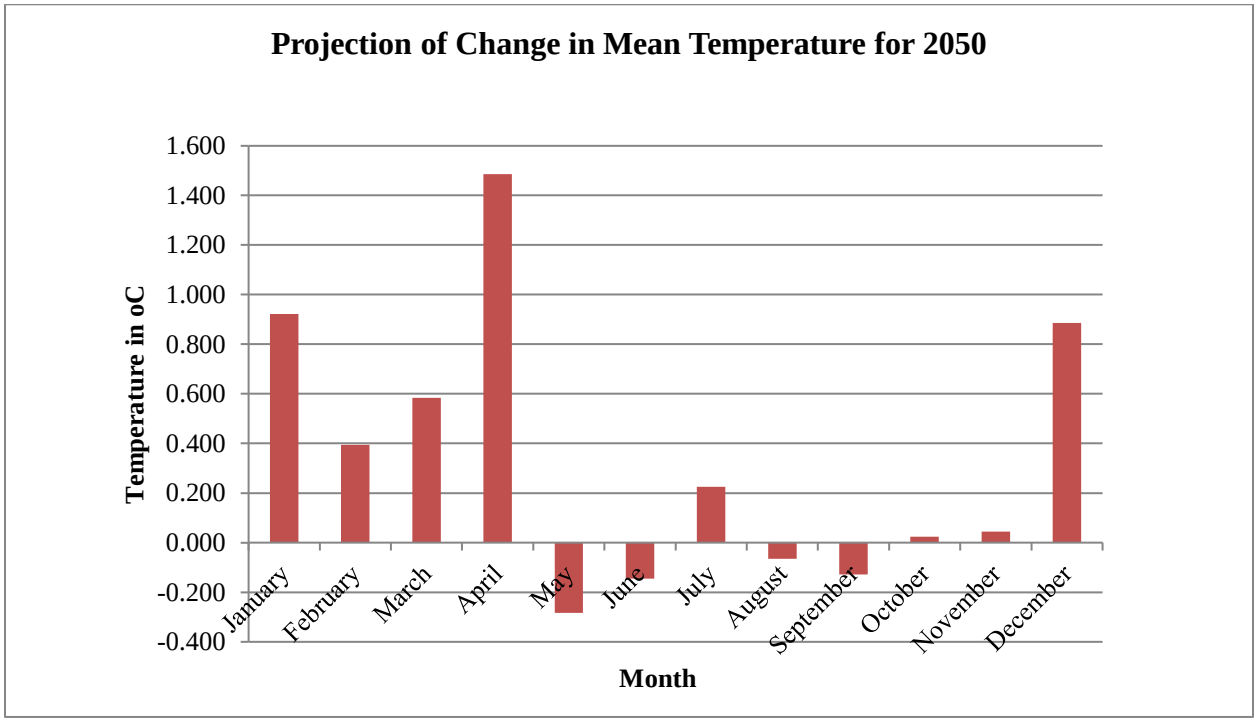

Figure 2
Showing the projection for 2050 in the change of mean temperature by ARMA model.

In the Figure 3 the precipitation of recent past years, monthly average has found. It is showing the curve of the average monthly anomaly of precipitation. Where we can become aware of that the months June, July and August are the most precipitation

happens. From the 1901 to 2015 the July month remains as the highest of average precipitation. The precipitation decreases from the November, December and January months. The least precipitation occurs in January.

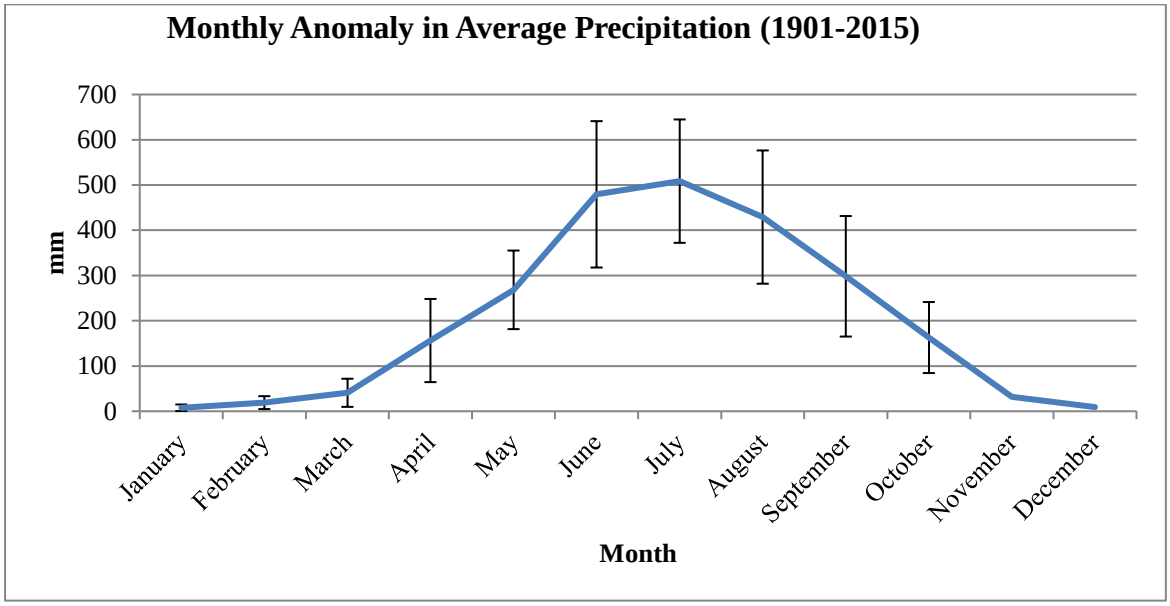

Figure 3
Showing the monthly anomaly in average precipitation from 1901 to 2015

Here is a table to show the data of average precipitation, average of maximum precipitation and average of minimum precipitation and also the standard deviation of average precipitation from 1901 to 2015. The data has shown the changes in months. The table is to understand our present day's scenario of precipitation pattern. The data source of the table is World Bank (WB).

Table 2 Showing the data in anomaly average of precipitation from 1901 to 2015

Year (1901-2015)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Average	7.67566	19.10344	40.8284	156.3294	268.3318	479.3737	508.5388	429.1116	298.26306	162.9193	32.158633	9.5917428
Min	0.00955	0.04255	0.15963	6.05971	6.05971	6.05971	6.05971	6.05971	6.05971	6.05971	0.11352	0.00593
Max	30.1831	65.7807	122.767	455.717	507.806	898.765	827.916	883.506	1005.33	433.365	136.571	319.67749
STD	7.299498	14.2524	31.07579	91.90888	86.851	161.727	136.3106	147.2617	133.17089	78.47941	35.071301	30.861229

In the following Figure 4 is a projection for 2050 on the basis of Intergovernmental Panel on Climate Change (IPCC) database of 1901 to 2015. The projection is done with the software of CMIP5. Where the columns are showing the precipitation frequency increases in the future. The June, July, August and September months will be rises in frequency of mean precipitation in 2050. The highest month of average precipitation will be July and the second highest month will be August. There will be increases of precipitation frequency in pre-monsoon and post- monsoon seasons according to the projection of 2050.

Here is another projection model in figure-5 of the changes in mean precipitation for 2050 on the basis of World Bank database of 1901 to 2015. This projection is done with the ARMA model. The projection shows that the precipitation pattern can be decreased in the monsoon season and there will be a negative scenario in that season. The frequency of precipitation will be decreased and only March, May, October and November months will take as season to precipitate. By the observation of the model the May month will be the month of highest average precipitation for 2050 and on the other hand the December month will be the lowest of average precipitation for 2050.

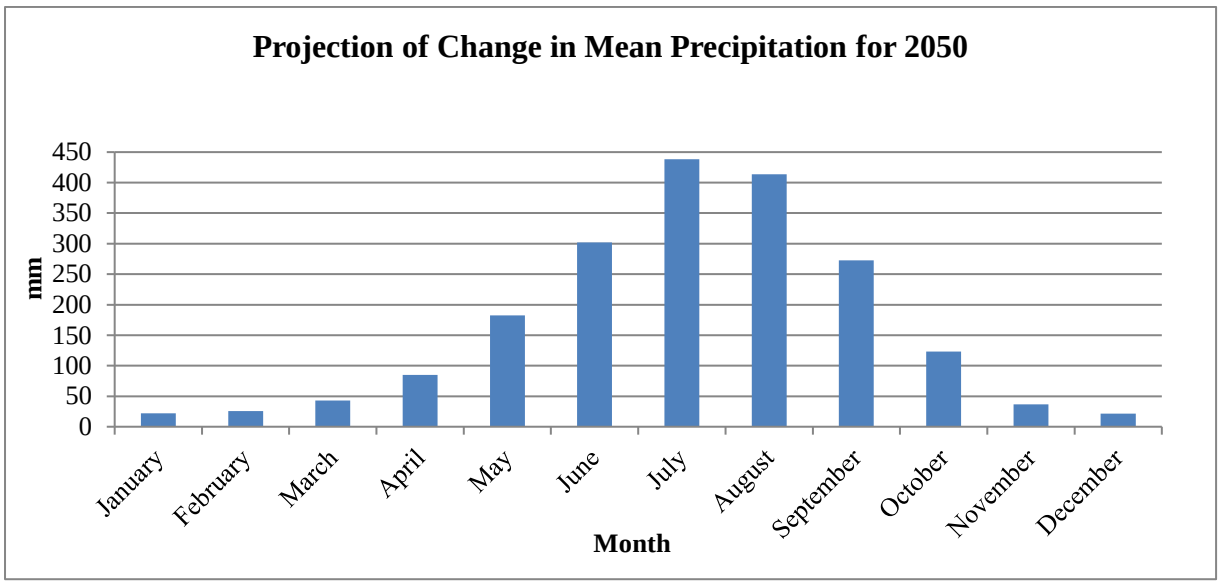

Figure 4
A chart to show the projection of change in mean precipitation for 2050 by CMIP5 model

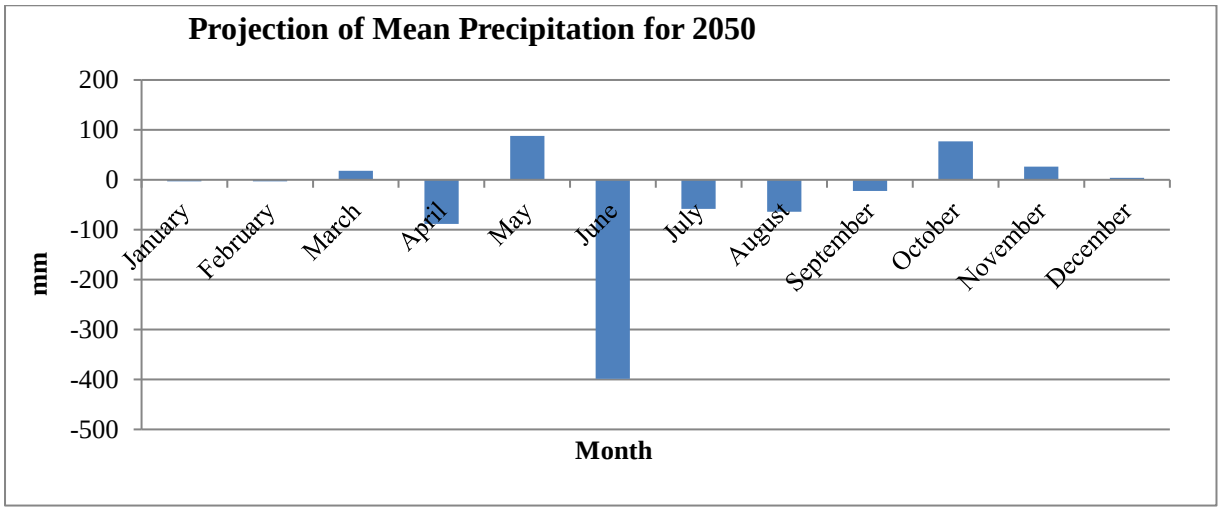

Figure 5
A chart to show the projection for 2050 of mean precipitation by ARMA model

In the Table 3 the changes in average precipitation in recent last years from 1901 to 2015 has shown. There is a continuous change in precipitation pattern from the recent past years to predicted 2050. There are two sources of the data in the table; one is World Bank (WB) and another one is Intergovernmental Panel on Climate Change (IPCC). The ARMA model prediction based on WB data and the CMIP5 model is based on IPCC data. The result of change differences is in mean precipitation from 2015 to 2050. According to ARMA model there are both positive and negative result found, which means the average precipitation will increase and decrease in month wise. On the other side the table is showing the change difference by CMIP5 model. In the result of the model is also showing the positive and negative scenario, which means that the average precipitation will increase and decreases in the 2050 projection model.

Table 3 Showing the change of precipitation on average data on the basis of ARMA model and CMIP5 model

Year	Sources	Change in Precipitation											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1901-2015	WB	7.68	19.10	40.83	156.33	268.33	479.37	508.54	429.11	298.26	162.92	32.16	9.59
2016-2050	ARMA Model	7.63	19.28	40.35	156.70	266.62	480.78	508.80	429.31	299.01	164.16	31.65	9.68
2015 - 2050	Change difference	-0.045	0.178	-0.48	0.37	-1.70995	1.41	0.26	0.19	0.74	1.24	-0.51	0.09
1901-2015	IPCC	24.09	26.04	41.01	81.57	171.67	294.47	429.01	405.13	264.37	120.60	38.61	24.18
2016-2050	CMIP5 Model	22.21	25.54	43.047	84.81	182.68	302.13	438.10	413.46	272.58	122.98	36.51	21.23
2015 - 2050	Change difference	-1.88	-0.49	2.04	3.24	11.01	7.66	9.09	8.33	8.20	2.38	-2.11	-2.95

From the study we can say that by ARMA model and CMIP5 model showed that the climate is changing and the temperature is raising with the changing of precipitation pattern in Bangladesh.

4. CONCLUSION

Due to climate change the temperature of Bangladesh is changing. From 1901 to 2015 the temperature being rising due to global warming. In this hundred and fifteen years there have been few changes have noticed by ARMA model and CMIP5 model. On the basis of 1901 to 2015 years temperature data the models have created. According to ARMA model the change differences in temperature is found on the basis of the 1901 to 2015 for projected 2050. The analysis shows that temperature will increase in the most of months of Bangladesh in 2050. In the mean while the precipitation scenario is also changing from the early 1901 to 2015 according to WB data and the changing pattern will continue to 2050 according to ARMA model. In the ARMA model the projection of changes in mean precipitation showed that the frequencies of precipitation will not same as it is in 2015. There will be large differences in precipitation from now. The results show the large differences of mean precipitation for 2050 from present year, there are positive and negative both the situation projected in change difference. The mean precipitation will increase in the month of pre-monsoon and post-monsoon. According to projection the precipitation pattern will be changed by 2050 in Bangladesh.

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