# Climate Change Analyses Using CMIP6 in Pakistan

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## ABSTRACT

The hydrological cycle is critical for sustain Earth's ecosystems, and it may influence the periodic and stochastic patterns of precipitation components. This study assessed the 11 General Circulation Models of CMIP6 developed by the Intergovernmental Panel on Climate Change, for estimating temperature and precipitation. The best precipitation model for Islamabad, Lahore, Karachi and Chhor is FIO-ESM-2-0. Meanwhile, BCC-CSM2-MR clearly shown a superior estimate for temperature in both Karachi and Islamabad, moreover, HadGEM3-GC31-LL and FIO-ESM-2-0 were both strong predictors for Chhor and Lahore, respectively. These models were selected for future forecasts under two Shared Socioeconomic Pathways scenarios: 245 represents average greenhouse gas emissions, and 585 denotes extreme emissions. Furthermore, based on the Standardized Precipitation Index, Karachi and Chhor are expected to experience droughts more often in the coming SSPs. SSP 585 shown prolonged droughts in the mid-21st century. Meanwhile, Islamabad and Lahore expected to receive regular and severe rainfall in both scenarios. Furthermore, Chhor will receive a greater quantity of precipitation than Islamabad according to SSP585. Coastal cities observed high forecasted temperatures above 35°C annual average under SSP 5.85 by 2100. Furthermore, the northern cities have observed a modest fluctuation in temperature, topping 31°C from an annual normal of 27°C, causing glaciers to melt with high concentration.

**Keywords:** CMIP6, Climate Change, SSP Scenarios, SPI, Flood Risk.

## INTRODUCTION

Severe weather occurrences, like quickly glaciers melting, changes in temperature relate to the strength and length of precipitation (both wet and dry days), have recently increased (Panday *et al*., 2015). Heavy rain can cause glacial lake dams to collapse, resulting in catastrophic environmental devastation. In the hydrological cycle, all living beings and ecosystems rely on constant distribution and access to water. This mechanism of Earth allows to support life and maintain an environmentally favorable atmosphere (Osman *et al*., 2021; Wang *et al*., 2021). Climate change affects the cycle by disrupting the historic stochastic and periodic precipitation and temperature pattern fluctuations (Harris *et al*., 2020; Tabari, 2021).To better understand these climatic patterns, the Coupled Model Intercomparison Project (CMIP) has developed the World Climate Research Programme (WCRP). The IPCC's sixth assessment report, CMIP6, has superior model algorithms than CMIP5 in terms of overestimation of yearly and seasonal climate change (Rivera and Arnould, 2020). Furthermore, seasonal precipitation study shows partially increasing trends throughout all seasons (Nanda *et al*., 2020).

## OBJECTIVE

This paper determine the best-fit CMP6 model for precipitation and temperature for the four cities (Islamabad, Lahore, Karachi and Chhor) of Pakistan. This study provides the information regarding the flood risk and temperature rising in these study cities by approaching the future Shared Socioeconomic Pathways Scenarios from present to 2100.

## METHODOLOGY

This study used various technique to recognize the best fit model for each city. In order to homogenize the CMIP6 city data with the observed data, it is important to use better methods for downscaling and bias correction to gather more accurate rainfall data. This paper chose best consistent CMIP6 models based on achieving maximum correlation values for all cities observed data. Moreover, linear slope, the Mann-Kendall test and the Sen's slope estimations are also utilised to asses' homogeneity between models and the observed data series. Finally, the goodness of fitting of the selected models implemented by analysing coefficient of determination, $R^2$, values. Furthermore, the Standardized Precipitation Index support to determine the intensity in precipitation. Additionally, these results are crucial for grasping how various kinds of storage sizes influence the risk of flooding and have practical effects on flood risk management in these cities.

## CONCLUSION/ RESULT

The precipitation and temperature patterns were studied using CMIP6 Global Circulation Models (GCMs) in four cities of Pakistan. Overall, CMIP6 accurately captures climate change fluctuations at the regional and temporal scales. The FIO is found as the finest CMIP6 precipitation prediction model for all four cities. Moreover, the BCC produced accurate temperature model for Islamabad and Karachi, whereas. The FIO and HADGEM were successful models found for Lahore and Chhor, correspondingly. Furthermore, it is observed that the variable patterns of precipitation in each city were influenced by their geographic locations as well. This is the reason that Karachi (coastal) and Chhor (deserted near coastal) go through long periods without rain, but they sometimes have heavy rain occasions. On the other hand, Islamabad and Lahore are greatly affected by the monsoon, regularly receiving a lot of rain and experiencing a mix of wet and dry weather. Similarly, temperature reflects seasonal variations for Lahore and Islamabad, furthermore, Chhor showed more intense variation as compared to Karachi's temperate.

These results highlight how monsoon systems and local weather conditions contribute to creating weather patterns that influence water supply, farming, and the ability of cities to withstand these challenges in the area. Moreover, by 2100, these coastal cities are expected to experience high annual average temperatures around 35°C according to SSP5.85. Furthermore, temperatures in northern cities have risen somewhat, topping 31°C from an annual average of around 27°C which cause melting of glaciers rapidly in future.

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