# Changes in the Winter-Spring Center Timing Over Four Major River Basins in Pakistan

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**(a) Purpose of study or research hypothesis**
Rivers from Himalayas are the critical water resources for the agriculture sector in Pakistan. The agriculture sector contributes to the economy of Pakistan by about 20% of the GDP and 42% of the labor force. Recent reports have found that Pakistan is vulnerable country to climate change that can cause water and food scarcity, which is a big challenge to local communities.

**(b) Key issue(s) or problem(s) addressed**
While the impact of climate change on the trend of streamflow has been well studied, understanding of the seasonal change in the regional hydrologic regimes remained limited. To overcome the future water and food scarcity issues, proactive plans for the crop growing and water management is warranted.

**(c) Methodology or approach used**
In this study, we used the daily stream flow records for four major river basins of Pakistan (Chenab, Indus, Jhelum, and Kabul) over 1962 - 2019. We also used the temperature and precipitation data to investigate their relationship with change in the seasonality. Utilizing the daily river discharge data, we calculated the winter-spring center time (WSCT). Here WSCT is defined as the day of the calendar year when half accumulated streamflow volume over the first six months (January-June) was exceeded.

**(d) Results or conclusions derived from the project**
Results show that the four river basins experienced a statistically significant decreasing trend of WSCT, which means the onset of spring becomes earlier in the future. We also used the Climate Research Unit (CRU) climate data comprising of the average temperature and precipitation for the four basins and found that the increasing average temperature value causes the early melting of the snow covers and glaciers that resulted in the decreasing of 1$^{st}$ center time value by 4 to 8 days. The findings of this study inform an alarming situation for the agriculture sector in Pakistan.

**(e) Implications of the project relevant to congress themes**
The findings of this research suggest that the agriculture sector in Pakistan is more vulnerable due to the future seasonal change and water availability, which requires more efficient water resources management and planes in securing sustainable water resources.

**Keywords** : Key words: Winter-spring center timing, Climate Change, Upper Indus River