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Climate change and associated spatial heterogeneity of Pakistan: Empirical evidence using multidisciplinary approach

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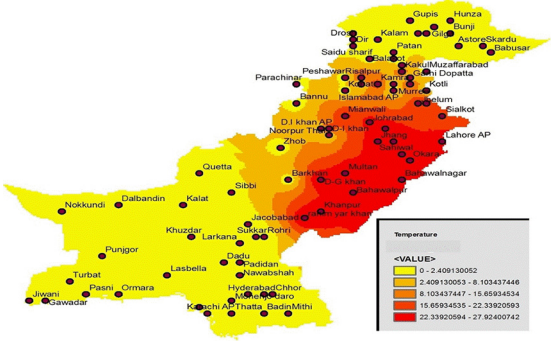
HIGHLIGHTS

- Real time-based quantification of climate change and heterogeneity are explored for Pakistan.
- Empirical changes in climate are analyzed and mapped provincially from 1960 to 2014.
- Econometric assessment of the domestic drivers of climate change
- Mean annual temperature has been increased by 0.57 °C from 1960 to 2000.
- The warmest year—in Pakistan—on record was 2004 followed by 1988.

GRAPHICAL ABSTRACT



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ABSTRACT

Climate change is a multidimensional phenomenon, which has various implications for the environment and socio-economic conditions of the people. Its effects are deeper in an agrarian economy which is susceptible to the vagaries of nature. Therefore, climate change directly impacts the society in different ways, and society must pay the cost. Focusing on this truth, the main objective of this research was to investigate the empirical changes and spatial heterogeneity in the climate of Pakistan in real terms using time series data. Climate change and variability in Pakistan, over time, were estimated from 1961 to 2014 using all the climate variables for the very first time. Several studies were available on climate change impacts, mitigation, and adaptation; however, it was difficult to observe exactly how much change occurred in which province and when. A multidisciplinary approach was utilized to estimate the absolute change through a combination of environmental, econometric, and remote sensing methods. Moreover, the Autoregressive Distributed Lag (ARDL) model was used to ascertain the extent of variability in climate change and information was digitalized through ground truthing. Results showed that the average temperature of Pakistan increased by 2 °C between 1960 and 1987 and 4 °C between 1988 and 2014, and R^2 was 0.978. The rate of temperature increased 0.09 °C between 1960 and 2014. The mean annual precipitation of Pakistan increased by 478 mm, and its R^2 were 0.34–0.64. The mean annual humidity of Pakistan increased by 2.94%, and the rate of humidity has been increased by 0.97% from 1988 to 2014. Notably, Sindh and Balochistan provinces have shown a significant spatial heterogeneity regarding the increase in precipitation. Statistically all variables are significant. This would serve as a baseline information for climate change-related studies in Pakistan and its application in different sectors. This would also serve the plant breeders and policymakers of the country.

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Table 1
Results of bounds F-test.

Critical values at 95% level of significance		F – calculated
Lower bound I(0)	Upper bound I(1)	
4.0461	5.1315	6.0760

1. Introduction

Climate change—the mother of major externalities—has caused extreme weather events like temperature fluctuations, humidity changes, and heavy precipitation, leading to great economic losses (Changnon et al., 2000; Prudhomme et al., 2003; Xia et al., 2012). A recent report from the Intergovernmental Panel on Climate Change (IPCC) revealed that global average temperatures increased by 0.3–1.7 °C (IPCC, 2015). Short-run and long-run extreme events caused changes in climate (Larsen et al., 2011; Mitsch and Hernandez, 2013). Changes in environmental conditions, such as durability and service life of temperature and humidity, affect the structure. Temperature is one of the most typical climatic factors (Liu et al., 2012; Zhulidov et al., 2011). Climate change effects vary in different geographical areas; extreme events show great regional differences in both ways (i.e., positive and negative). There have been significant positive trends observed in Europe (Rajczak and Preethi, 2012), in the UK (Chan et al., 2014; Dos et al., 2011), and in Japan (Kamiguchi and Tamai, 2011); transversely significant trends in the United States (Kunkel et al., 2013) and in Australia (Fiddes et al., 2015); and extreme precipitation and different parameters, including positive and negative amplitude trends, observed in

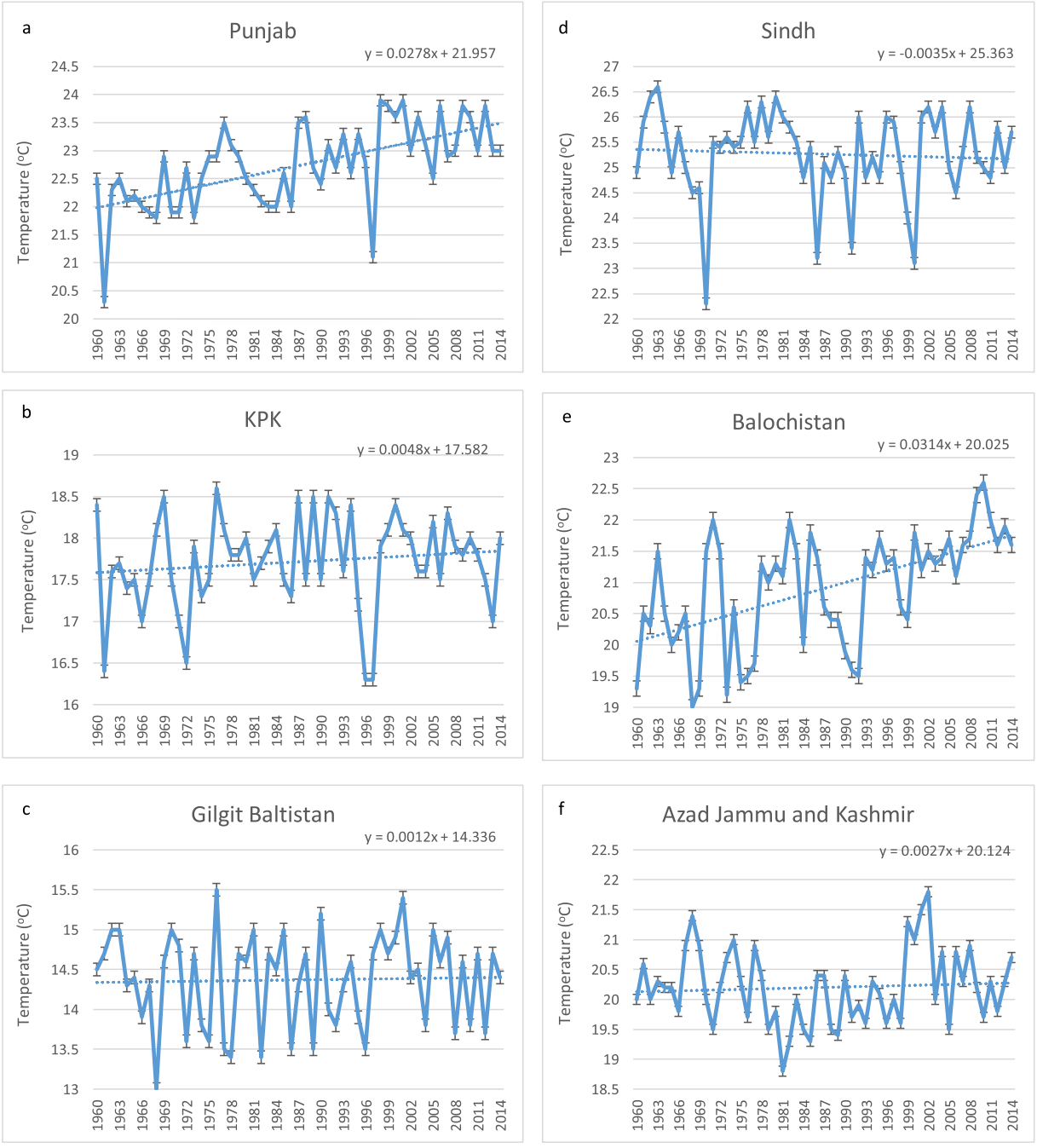

Fig. 1. Temperature trend lines from 1960 to 2014 (a) Punjab province (b) Khyber Pakhtunkhwa province (c) Gilgit Baltistan (d) Sindh province (e) Baluchistan province (f) Azad Jammu & Kashmir.