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**RESEARCH PAPER**

# Assessing Climate Change Impacts on Maize Production across Agroecological Zones of Balochistan

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## ABSTRACT

This study evaluates the impact of climate change on maize crop in Balochistan, Pakista
focusing on key agroecological zones. Climate change has significantly changed t
temperature and precipitation patterns, affecting agriculture in the region. Using panel da
from the last 34 years (1986-2019) and the Feasible Generalized Least Squares (FGLS) mod
the study assesses maize production across districts Zhob, Jaffarabad, Panjgur, and Lasbe
The results indicate that a 1% increase in cultivated area leads to a 0.807% rise in maize outp
A 1% rise in temperature initially boosts production by 150.304%, but further increases cau
a 2.563% decline. Rainfall has a positive effect, with a 1% increase raising output by 1.881
while humidity exerts minimal influence (0.122%). The study recommends adopting climat
smart agricultural practices and implementing region-specific strategies to enhan
agricultural resilience in Balochistan.

**KEYWORDS** Balochistan, Climate Change, FGLS, Maize, Panel Data

## Introduction

Aggressive Climate change, characterized by long-term alterations in temperature and typical weather patterns within a specific region, poses a substantial risk to environmental stability and global economic development. These changes can persist for decades to millions of years, affecting average weather conditions like temperature and precipitation, as well as the frequency of extreme weather events such as droughts, floods, and storms. The widely accepted definition highlights changes in the statistical properties of the climate system over extended periods (Nwankwoala, 2015). In recent decades, climate change has become a pressing environmental and economic issue. The Intergovernmental Panel on Climate Change (IPCC) has reported significant impacts on various systems, including water resources, coastal areas, freshwater habitats, vegetation, agriculture, forests, snow cover, and geological processes. These effects are anticipated to worsen, leading to severe long-term repercussions for food security, human health, and the planet as a whole (Alcamo et al., 1999; Malla, 2008; Jayaraman and Murari, 2014). The global consequences of climate change are apparent, as noted by Atapattu (2009). Over the past century, the global mean temperature has risen markedly, with projections indicating an increase of 2.4 to 4.8°C by 2050-2100. Additionally, the global sea level has risen by approximately 0.19 meters from 1901 to 2010, with an accelerated rise expected in the future. Changes in global rainfall patterns have also been documented. Alongside shifts in temperature, rainfall, and sea level, the frequency and intensity of extreme climatic events—including heatwaves, cyclones, and floods—are predicted to increase (IPCC, 2014).

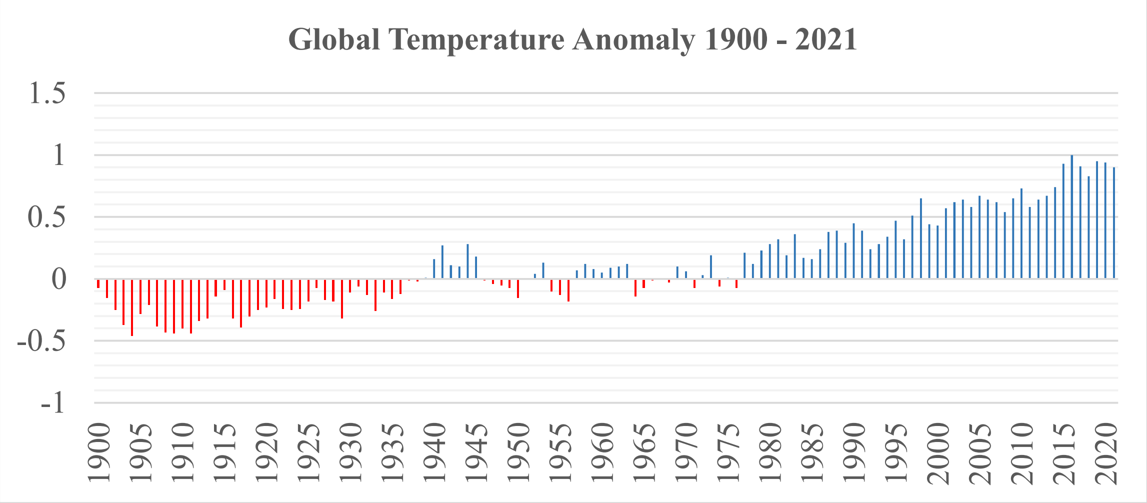

Figure 1 Global Temperature Anomaly 1900-2021

Source: *NOAA, 2021.*

The phenomenon of climate change is not a recent occurrence; Earth's climate has always been dynamic (Kumar and Gautam, 2014; Firth and Fisher, 2012). Climate experts have identified both natural and anthropogenic factors contributing to climate change. Natural causes include variations in Earth’s orbital characteristics, fluctuations in atmospheric carbon dioxide, volcanic eruptions, changes in solar output, plate tectonics, and thermohaline circulation (Nwankwoala, 2015). In contrast, human activities such as urbanization, industrialization, fossil fuel combustion, deforestation, construction, commercialized farming, and rapid population growth are significant contributors as well (Praveen and Sharma, 2020; NASA, 2011). Since 1750, it is widely believed that human actions have led to increased concentrations of greenhouse gases, driving global warming and climate change, with about 50% of these emissions occurring in the past 40 years (IPCC, 2007a, 2014).

Climate change is a global issue impacting communities worldwide (Schmidt et al., 2013), though its effects vary by region (Sayed and González, 2014). Developing economies are particularly susceptible to these negative impacts due to limited financial resources that hinder effective climate change management (Wijaya, 2014). The economies of these countries, along with the livelihoods of many people, rely heavily on agriculture and related sectors, which are directly threatened by climate change (Nyanga et al., 2011). Many developing nations already experience food insecurity exacerbated by climate change, rapid population growth, inefficient natural resource use, poverty, and soil erosion (Smit and Pilifosova, 2003). Pakistan, like many developing countries, faces severe threats from climate change. The Global Climate Risk Index (GCRI) ranked it 5th and 8th among the most climate-affected countries globally for the periods 1998-2018 and 2000-2019, respectively (Eckstein et al., 2019; 2021). Despite being a minor contributor to global greenhouse gas emissions, Pakistan suffers significant climate change impacts (Yousuf et al., 2014), with increasing frequency and intensity of climate-induced disasters like floods, droughts, and storms expected to rise further (Ullah and Takaaki, 2016; UNICEF, 2020).

Agriculture is the backbone of Pakistan's economy, contributing approximately 19.2% to the GDP and employing 38.5% of the total labor force (GoP, 2021). Climate plays a vital role in determining agricultural productivity, with temperature and precipitation being crucial drivers of crop production (Quaye et al., 2018). Consequently, any alterations in these climatic factors due to climate change can have significant repercussions on agricultural productivity, crop efficiency, farmland value, and farm income (Kurukulasuriya and Ajwad, 2007; Massetti and Mendelsohn, 2011; Moore and Lobell, 2014; Chatzopoulos and Lippert, 2015; Arshad et al., 2017). Pakistan's agriculture sector is already facing substantial economic and physical losses attributed to climate change, including rising temperatures, intense rainfall, floods, and droughts. Projections suggest that by 2050, the sector could incur economic losses of $19.5 billion, with productivity declines in major food crops—wheat, rice, and maize—estimated at 11%, 8%, and 3.3%, respectively (Khan et al., 2020; Chaudhry, 2017). The diverse geography of Pakistan means that climate change impacts vary by region. Northern areas are prone to snowstorms, landslides, and floods, while coastal regions face risks from floods and cyclones. Central regions and mid-river basins are primarily at risk from flooding, whereas southern Punjab, Sindh, and Balochistan experience droughts due to climate change (Sayed and González, 2014). Balochistan, Pakistan's largest province by area, has a semi-arid to arid climate, with mean annual rainfall ranging from 200-350 mm, often falling below 50 mm in many areas, making rain-fed agriculture difficult (GOB, 2021; PDMA, 2020). The province faces various climate-related challenges, including extreme temperatures (up to 53.5°C in Turbat), recurrent droughts, and devastating floods (Hameed et al., 2022; Naz et al., 2020; Ahmed et al., 2019). The economy of Balochistan heavily relies on agriculture, which climate change directly threatens. The floods of 2010 and 2012 rendered thousands of acres of arable land barren, destroying approximately 452,588 acres of crops across the province (Baloch, 2013). Moreover, climate-induced extreme events have long-term indirect effects on income, nutrition, and livelihoods through groundwater depletion (IRP, 2019).

While numerous studies have explored the impacts of climate change on crop yields in various regions of Pakistan, research specifically focusing on maize crops in Balochistan is notably limited. Understanding how climate change affects maize across the diverse agroecological zones of Balochistan is essential for effective agricultural planning and resilience strategies. This study aims to fill this critical gap in the existing literature.

## Literature Review

Maize (Zea mays L.), a vital cereal crop globally, ranks third in production after wheat and rice (Piperno and Flannery, 2001). Its cultivation as a staple food and feed crop is crucial in both developed and developing countries, contributing significantly to food security and economic development. However, climate change poses a severe threat to maize production, with various studies highlighting how temperature increases, erratic rainfall, and extreme weather events adversely affect crop yields (Ray et al., 2019; Sultan et al., 2013). For instance, global warming has been linked to declining maize yields, with studies predicting potential reductions of up to 50% by 2050 in some regions due to rising temperatures and changes in precipitation patterns (Leng and Huang, 2017; Lobell et al., 2011).

Temperature extremes, particularly heat stress, have been identified as one of the most detrimental factors to maize productivity. Research shows that high temperatures during critical growth stages can significantly reduce yields (Schauberger et al., 2017). For example, Lobell et al., (2011) demonstrated that each degree Celsius increase in global temperature could reduce maize yields by up to 7.4%, a trend corroborated by other studies focusing on regional impacts of heat stress on maize (Ammani et al., 2012; Leng and Huang, 2017). In contrast, Khan et al., (2019) found that while temperature negatively impacts maize yields, precipitation has a positive and significant effect, mitigating some of the adverse effects of temperature rise. Similarly, Abbas et al., (2017) emphasized that rainfall plays a crucial role in maize growth, with variations in precipitation patterns directly affecting crop productivity.

The impact of water scarcity due to climate change could exacerbate maize yield losses. Water shortage during the critical physiological stages of maize growth can reduce maize yield (Cairns et al., 2013). Studies suggest that drought-tolerant maize varieties and improved irrigation techniques could help mitigate these losses, highlighting the need for climate-resilient agricultural practices (Cairns et al., 2013; Bänziger et al., 2000). Precipitation patterns, particularly the frequency and intensity of rainfall, are crucial in this regard. Research conducted by Sultan et al., (2013) found that changes in rainfall patterns are likely to influence maize production, with regions experiencing both more intense and erratic rainfall facing challenges in managing water resources for optimal crop growth.

Non-climatic factors such as the area under cultivation, fertilizer use, and access to formal credit also influence maize yields. These factors interact with climatic variables to shape maize productivity trends. For instance, Rehman et al., (2016a, 2016b) pointed out that improved management practices, including the use of fertilizers and the expansion of maize-cropped areas, have contributed to increased yields in some regions despite climatic challenges. The role of technology adoption, particularly climate-smart agriculture, is also gaining attention. Adaptation strategies such as the use of drought-resistant seeds, improved irrigation methods, and shifting planting seasons are crucial in enhancing maize resilience to climate stressors (Miller et al., 2018; Rehman et al. 2019; Cicchino et al., 2020).

## Material and Methods

This section describes the selected districts for the sample, data sources, and variables used, as well as the model specification. It also outlines the tests and methods employed to assess the impact of climate change on maize crop production across Balochistan's agroecological zones.

### Selection of Sample Districts

The study was conducted in Balochistan, Pakistan's largest province, situated between latitudes 22° to 32° North and 66° to 70° East. This province has a semi-arid to arid climate, with annual rainfall averaging between 200 and 350 mm, and some areas receiving as little as 50 mm annually (PDMA, 2020). The Pakistan Agriculture Research Council (PARC, 1980) has categorized Balochistan into four agroecological zones: Highlands, Plains, Desert, and Coastal zones. Table 1 outlines the distribution of districts within these zones.

**able 1**
**Agroecological zones and districts of Balochistan, Pakistan**

| Province | Agroecological Zone | Districts |
|---|---|---|
| Balochistan | Highlands | Barkhan, Duki, Harnai, Kalat, Khuzdar, Killa Abdullah, Killa Saifullah, Kohlu Loralai, Mastung, Musakhail, Muslim Bagh, Pishin, Quetta, Shaheed Sikandarabad, Sherani, Zhob, Ziarat, |
| | Plains | Dera Bugti, Jaffarabad, Jhal Magsi, Kachchi Lehri, Nasirabad, Sibi, Sohbatpur |
| | Deserts | Awaran, Chaghi, Kharan, Noshki, Panjgur and Washuk. |
| | Coastal | Gawadar, Kech/Turbat and Lasbela. |

Source: *PARC 1980.*

To analyze the effects of climate change on maize production across different agroecological zones, one district was selected from each zone: Zhob from the Highlands, Jaffarabad from the Plains, Panjgur from the Deserts, and Lasbela from the Coastal zone. This selection was based on the availability of statistical data regarding climatic and agricultural variables. Figure 2 illustrates the study area map and the locations of the selected districts.

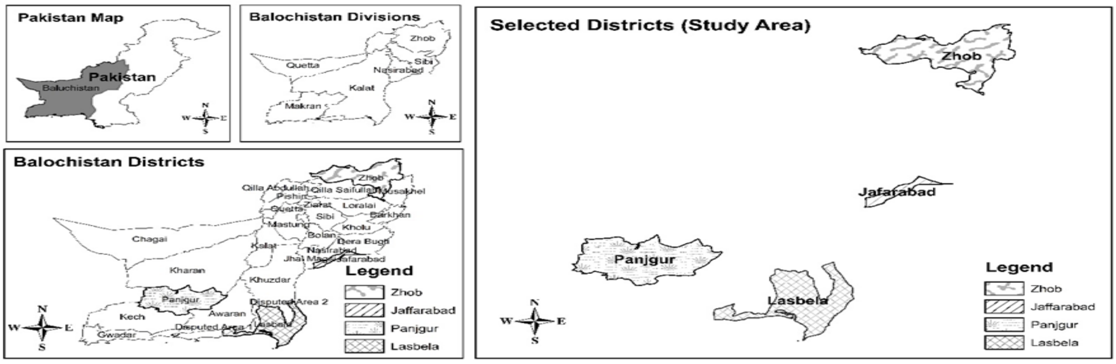

Figure 2 Balochistan map, agroecological zones selected districts on the mapSource: *Authors' compilation from PARC, 1980; GoB, 2020.*

## Data Source and Variables

The study utilizes panel data covering climatic and non-climatic variables from 1986 to 2019. Climatic variables include temperature (°C), rainfall (mm), and humidity (%), while non-climatic variables encompass maize production (tons) and area under maize (hectares). Mean values of climatic variables for the maize harvesting period were calculated to compile the panel data. Data sources include the Pakistan Meteorological Department (PMD) for climatic variables and the Crop Reporting Service (CRS) of the Agriculture & Cooperatives Department of Balochistan for non-climatic variables. Figure 3 illustrates trends in maize production, area under maize, temperature, rainfall, and humidity across the selected districts.

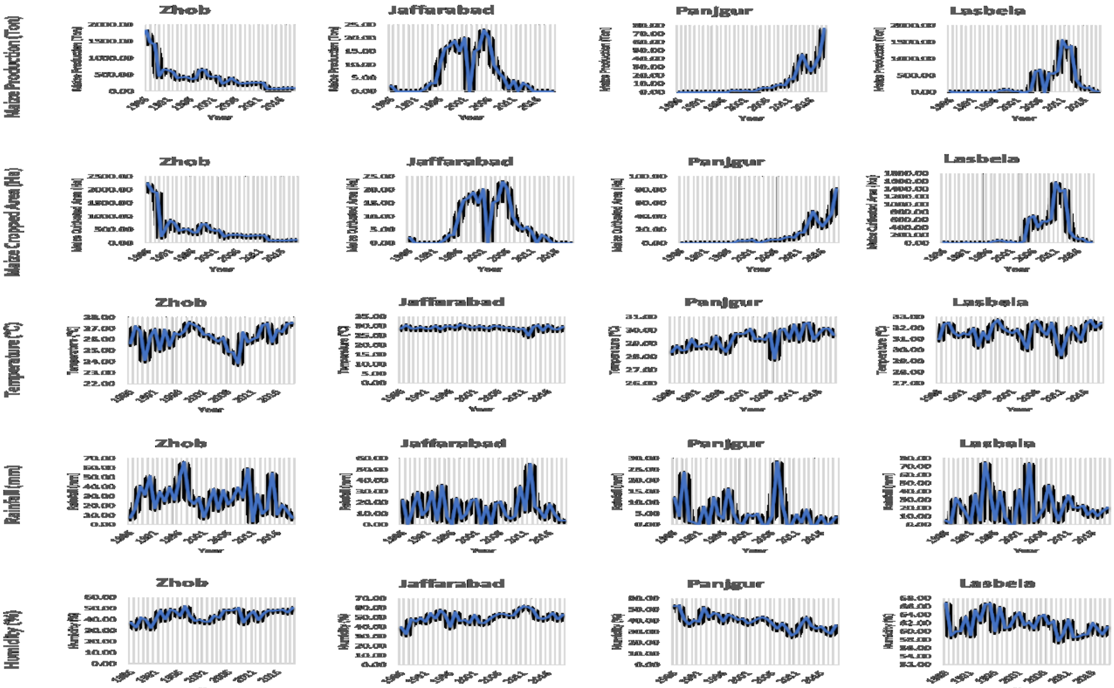

Figure 3 Trend of climatic and non-climatic variables in selected districts for the period 1986 – 2019 Source: Author's Compilation based on Data from the Pakistan Meteorological Department

## Model Specification

Maize crop production is influenced by both climatic and non-climatic factors. Recognizing this, the present study follows the approaches of Ali et al. (2017), Chandio et al.

(2020), and Pickson et al. (2021), who included the area under crop as a control variable among the explanatory variables in their models. Consequently, the relationship between maize production and the relevant climatic and non-climatic variables can be expressed as follows:

$$MP_{it} = f(AR_{it}, TEM_{it}, RF_{it}, HUM_{it})$$

$$\ln MP_{it} = \beta_o + \beta_1 \ln AR_{it} + \beta_2 \ln TEM_{it} + \beta_3 \ln RF_{it} + \beta_4 \ln HUM_{it} + \mu_{it}$$

Where MP represents maize production (Ton), AR denotes the area cultivated for maize, TEM indicates temperature (°C) during the maize harvesting period, RF refers to rainfall (mm) during the same period, and HUM signifies humidity (%) during the harvesting period. Additionally, $\beta_o$ is the model intercept, $\beta_i$ is the coefficient for each respective variable, μ is the white noise error term, *i* denotes the cross-section, and *t* represents the time series.

## Testing for Unit Roots

Before estimating the impact of climate change on maize crop production across the selected districts, it is essential to test the stationarity of the chosen variables. Conducting unit root tests is crucial for indicating the potential for cointegration among the selected panels and for preventing biased estimations. This study utilized the Im, Pesaran, and Shin (IPS) tests as outlined by Im et al. (2003). The null hypothesis of these tests posits that the panels contain unit roots, while the alternative hypothesis suggests the opposite. Thus, if the p-value is $\leq 0.05$, the null hypothesis will be rejected; otherwise, it will not be rejected.

## Testing for Cross-Sectional Dependence

Cross-sectional dependence in panel data occurs when all units within the same cross-section are correlated, often due to unobserved factors affecting all units similarly. This issue typically arises in large panel datasets where the time series (T) dimension exceeds the cross-sectional (N) dimension (Kumar et al., 2016). Such dependence can undermine the consistency of estimated results. To assess cross-sectional dependency, the Breusch-Pagan Lagrange Multiplier (BP-LM) test was utilized, as proposed by Breusch and Pagan (1980). The null hypothesis for this test posits that there is no cross-sectional dependence, while the alternative hypothesis implies the presence of such dependence.

## Testing for Heteroskedasticity

Heteroskedasticity arises when the standard errors of the studied variables are not constant, potentially leading to less precise estimates (Gujarati et al., 2012). In panel data, heteroskedasticity can be detected using the Modified Wald Test (Greene, 2018). The null hypothesis for this test asserts homoskedasticity, while the alternative hypothesis indicates the presence of heteroskedasticity.

## Testing for Autocorrelation

Autocorrelation in the fixed effects model leads to correlated outcomes of variables over time, potentially resulting in inefficient estimates in panel data regression (Gujarati et al., 2012; Born and Breitung, 2016). To detect autocorrelation, the Wooldridge test was employed, as proposed by Wooldridge (2002). The null hypothesis of this test posits that there is no autocorrelation, while the alternative hypothesis asserts the presence of autocorrelation. This testing is crucial for ensuring the reliability of the regression estimates in the analysis.

## Feasible Generalized Least Squares Model

Panel data can present multiple simultaneous and complex issues that conventional estimation models may struggle to address. Failure to tackle these issues can lead to spurious and inefficient estimations in conventional panel regression models. Typically, three models are employed to handle such complexities: the Driscoll-Kraay Standard Errors Corrected model, the Panel Corrected Standard Errors model, and the Feasible Generalized Least Squares (FGLS) model. The first two models are suitable when the time dimension (T) is greater than or equal to the cross-sectional dimension (N), while FGLS is used when T is less than or equal to N (Reed and Ye, 2011). Given that the panel data in this study is characterized by T ≤ N and faces issues of cross-sectional dependence, heteroskedasticity, and autocorrelation (Table 3), the FGLS model was chosen to obtain efficient and reliable estimates.

## Results and Discussion

Table 2 presents a comprehensive overview of the descriptive statistics for key variables related to maize production and climatic conditions. A total of 100 observations were recorded for each selected variable. Observations with zero maize yields were excluded to prevent spurious results, focusing only on non-zero yields reported between 1986 and 2019. The average maize production was 239.31 tons, demonstrating considerable variability with a standard deviation of 182.90. The average area cultivated for maize was 263.67 hectares, with a significant range from 1.00 to 2,228.00 hectares and a standard deviation of 222.70. Temperature data revealed an average of 28.94°C, with values ranging from 23.86°C to 32.72°C, resulting in a moderate variation indicated by a standard deviation of 2.22. Rainfall averaged 18.25 mm, with a standard deviation of 14.84, covering a wide range from 0.00 mm to 65.57 mm. Humidity averaged 47.68%, with observations spanning from 26.60% to 66.80%, and a standard deviation of 10.11%. The squared temperature variable had a mean of 842.96, with a range from 569.41 to 1,070.59 and a standard deviation of 127.80, suggesting a significant gap between the values. These statistics provide critical insights into the relationship between maize production and climatic factors in the studied regions.

**Table 2**
**Descriptive statistics of the selected variables**

| Variable | Observations | Mean | Min | Max | Std. Dev. |
|---|---|---|---|---|---|
| Maize Production (Ton) | 100 | 239.31 | 1.00 | 1830.00 | 182.90 |
| Maize Cultivated Area (ha) | 100 | 263.67 | 1.00 | 2228.00 | 222.70 |
| Temperature (°C) | 100 | 28.94 | 23.86 | 32.72 | 2.22 |
| Rainfall (mm) | 100 | 18.25 | 0.00 | 65.57 | 14.84 |
| Humidity (%) | 100 | 47.68 | 26.60 | 66.80 | 10.11 |
| Sq. Temperature | 100 | 842.96 | 569.41 | 1070.59 | 127.80 |

Source: Secondary Data Analysis (1987 - 2019)

The results of various diagnostic tests are shown in Table 3. The IPS unit root test for stationarity confirms that all selected variables are stationary at both levels I(0) and I(1). Therefore, it can be concluded that there are no unit roots, which also eliminates the possibility of cointegration among the selected variables.

**Table 3**
**Diagnostic test for estimating panel data**

| Variable | Test for Stationarity | |
|---|---|---|
| | IPS Unit Root Test | |
| | I(0) | I(1) |
| LnMP | -1.63** | -4.84*** |
| LnAR | -0.31** | -4.53*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| LnTEM | | -3.92*** | | | -5.67*** | |
| LnRF | | -4.19*** | | | -4.70*** | |
| LnHUM | | -2.87*** | | | -5.19*** | |
| $LnTEM^2$ | | -3.92*** | | | -5.67*** | |
| **Test for Cross-sectional Dependence** | | | | | | |
| | **$H_0$** | **$H_1$** | **chi2(6)** | **P-value** | **Remarks** | |
| Breusch-Pagan Lagrange Multiplier | No Cross-sectional Dependence | Cross-sectional Dependence | 5.787 | 0.447 | $H_0$ Accepted | $H_1$ Rejected |
| **Test for Heteroskedasticity** | | | | | | |
| Modified Wald Test | **$H_0$** | **$H_1$** | **chi2 (4)** | **Prob > chi2** | **Remarks** | |
| | Homoskedasticity | Heteroskedasticity | 372.65 | 0.000 | $H_0$ Rejected | $H_1$ Accepted |
| **Test for Autocorrelation** | | | | | | |
| Wooldridge Test | **$H_0$** | **$H_1$** | **F (5, 131)** | **Prob > F** | **Remarks** | |
| | No Autocorrelation | Autocorrelation | 0.572 | 0.504 | $H_0$ Accepted | $H_1$ Rejected |

Note: *** and ** show significance levels at 1% and 5% respectively. **Source:** *Secondary Data Analysis (1987 - 2019)*

The panel data for this study exhibited no cross-sectional dependence or autocorrelation, but it did show issues with heteroskedasticity. To analyze the relationship between the dependent variable, maize production, and independent variables—namely maize cultivated area, temperature, rainfall, and humidity—across the agroecological zones of Balochistan, the Feasible Generalized Least Squares (FGLS) model was employed, as recommended by Baltagi (2021). The empirical results obtained from the FGLS model are detailed in Table 4.

The findings indicate that all climatic and non-climatic variables, except for humidity, significantly affect maize production. Specifically, the cultivated area under maize and rainfall were highly significant at the 1% level, while temperature and its squared term were significant at the 5% level. The coefficient estimates for the independent variables, presented in Table 4, illustrate their respective impacts on maize production while holding other factors constant. The coefficient for the log of the area under maize (LnAR) was 0.807 ($p < 0.000$), suggesting a substantial positive effect. This means that a 1% increase in the area cultivated for maize results in an approximate 0.81% increase in maize production. This strong significance underscores the critical role of cultivated area in enhancing maize yields, aligning with findings by Babar and Amin (2014), who also reported a positive association between cultivated area and crop production. For temperature, the coefficient (LnTEM) was 150.304 ($p = 0.012$), indicating a significant positive relationship between temperature and maize production. This suggests that within the observed range, higher temperatures are beneficial for maize growth, potentially increasing yield by 150.30% for every 1% rise in temperature. However, the squared term of temperature ($LnTEM^2$) was negative and significant at the 5% level, with a coefficient of -2.563 ($p = 0.014$). This indicates a non-linear, inverted U-shaped relationship between temperature and maize production, meaning that while moderate temperature increases can be advantageous, extreme temperatures may negatively impact yields. These findings are consistent with those of Khan et al. (2018), who observed a similar non-linear response of maize to temperature changes. Rainfall exhibited a highly significant positive effect on maize production, as shown by the coefficient for the log of rainfall (LnRF), which was 1.881 ($p < 0.000$). This result implies that a 1% increase in rainfall leads to a 1.88% increase in maize production. The strong positive correlation highlights the essential role of adequate rainfall in supporting maize growth and productivity, corroborated by Dwamena et al. (2022), who also found a significant positive effect of rainfall on maize yields. In contrast, the coefficient for humidity (LnHUM) was 0.122 ($p = 0.847$), indicating a non-significant effect on maize production. This suggests that humidity does not significantly influence maize yields compared to other climatic factors such as temperature and rainfall, a finding supported by Alvi and Jamil (2018), who reported similar results. The constant term in the model was -2218.12 (p = 0.010), suggesting the influence of other unobserved factors on maize production when all other variables are held constant. These unobserved factors could include soil quality, farming practices, or other climatic conditions not captured by the model. The negative constant term indicates the potential impact of additional variables not accounted for in this analysis, emphasizing the complexity of agricultural production dynamics in the region.

**Table 4**
**Regression estimates through Feasible Generalized Least Squares (FGLS)**

<table>
<tr><td colspan="2"><b>No. of Observations</b></td><td>100</td><td colspan="2"><b>Wald chi2(5)</b></td><td colspan="2">5182.41</td></tr>
<tr><td colspan="2"><b>Number of Panels</b></td><td>4</td><td colspan="2" rowspan="4"><b>Prob > chi2</b></td><td colspan="2" rowspan="4">0.000</td></tr>
<tr><td rowspan="3"><b>No. Obs./Panel</b></td><td><b>Min</b></td><td>21</td></tr>
<tr><td><b>Avg</b></td><td>25</td></tr>
<tr><td><b>Max</b></td><td>34</td></tr>
<tr><td><b>Variable</b></td><td><b>Coefficient</b></td><td><b>Std. error</b></td><td><b>Z</b></td><td><b>P > |z|</b></td><td colspan="2"><b>[95% conf. interval]</b></td></tr>
<tr><td>LnAR</td><td>0.807</td><td>11.938</td><td>67.62</td><td>0.000</td><td>0.783</td><td>0.830</td></tr>
<tr><td>LnTEM</td><td>150.304</td><td>59749.46</td><td>2.52</td><td>0.012</td><td>33.197</td><td>267.411</td></tr>
<tr><td>LnRF</td><td>1.881</td><td>408.166</td><td>4.61</td><td>0.000</td><td>1.081</td><td>2.681</td></tr>
<tr><td>LnHUM</td><td>0.122</td><td>636.863</td><td>0.19</td><td>0.847</td><td>-1.125</td><td>1.370</td></tr>
<tr><td>LnTEM$^2$</td><td>-2.563</td><td>1043.899</td><td>-2.46</td><td>0.014</td><td>-4.609</td><td>-0.517</td></tr>
<tr><td>Cons</td><td>-2218.12</td><td>862385.1</td><td>-2.57</td><td>0.010</td><td>-3908.36</td><td>-527.874</td></tr>
</table>

Source: Secondary Data Analysis (1987 - 2019)

## Conclusion

Climate change has emerged as a critical global issue, with Pakistan identified as one of the top ten countries most affected. The nation has experienced numerous climate-related natural disasters, including rising temperatures, erratic and heavy rainfall, etc. Balochistan, Pakistan's largest province, faces significant challenges due to its arid to semi-arid climate and limited rainfall. The agricultural sector, a vital part of the provincial economy, is particularly threatened by climate change impacts. The prime objective of the study was to assess the magnitude and direction of the impacts of climate change on maize production across Balochistan's four agroecological zones: highlands, plains, desert, and coastal areas. One district was selected from each zone based on data availability, and a panel dataset covering 34 years (1986-2019) was compiled, focusing on both climatic and non-climatic factors. The Feasible Generalized Least Squares (FGLS) model was employed to derive empirical results. Key findings revealed that the area under maize cultivation has a substantial positive impact on production, emphasizing the importance of expanding cultivated land to increase yields. The analysis also uncovers a complex relationship between temperature and maize production; while moderate increases in temperature can lead to positive yield outcomes, excessive temperatures beyond a certain threshold significantly reduce production, as indicated by the negative coefficient of the quadratic term. Furthermore, rainfall showed a strong positive influence on maize yields, highlighting its critical role in crop growth. Conversely, humidity was found to have a statistically insignificant effect on maize production.

## Recommendations

- Promote sustainable farming practices to improve soil health and water usage.
- Invest in efficient irrigation systems to reduce reliance on rainfall.
- Establish weather monitoring systems for timely climate information.
- Encourage the cultivation of climate-resilient maize varieties.
- Provide training on adaptive practices and pest management for farmers.

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