# Climate Change and Food Security in Pakistan: A Time Series Analysis

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## Abstract

*Climate change has a severe impact on the accessibility of various resources on earth. The present study determines the impact of climate change on food availability for 27 years from 1990-2016. An ARDL model is used in order to find out the long-run and short-run relationships. The result shows that average temperature shows a negative relationship with food security, as the temperature is increasing the food security is decreasing Food security has a positive relation with agriculture credit since as the agriculture credit increases it will increase the production of agriculture sector which in result increase the supply of food and increase the food security in the country. Fertilizer consumption also has a positive effect on food availability, which is obvious as more and more food is provided with the increased use of fertilizer.*

**Key Words*:*** Temperature, Agriculture Credit, Food Production Index, Fertilizer Consumption

**JEL Classification:** Q54, Q18.

## Introduction

Climate change is becoming a very common phenomenon all over the world, especially the third world countries like Pakistan. Most of the underdeveloped countries are facing very serious climatic conditions because of environmental pollution. The increase in manual air temperature is not only the cause for climate change but the increase in the number of greenhouse gases is also the major cause of climate change. During the last 100 years, the average mean temperature of the world has increased by 0.74 degrees Celsius, and this is changing day by day. This increase in temperature is showing an alarming situation all over the world. Because of this high temperature, the glaciers are melting very quickly which result in floods every year, which is resulting in the depletion of water resources. These floods are also causing a problem of food shortage for the underdeveloped countries as they are unable to store the crops and they are unable to buy food form the world market at higher prices.

Agriculture productivity is directly affected by the change in weather. Continuous changing in climate change has been affecting crop growth significantly. Pakistan is also experiencing a seasonal variation in temperature, especially in winter as compared to

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summer. The weather is becoming hotter and hotter every year, and the average temperature of the city is increasing rapidly. The condition of food security in Pakistan is very poor from the last few decades. Pakistan is ranked as 11th country of the world which is facing the condition of food security. In the case of Pakistan, one-third of the population is living under the poverty line. People of Pakistan are not capable to meet up their basic requirements. Rural areas have a comparative high poverty rate (35 percent) as compared to urban areas (26 percent). One third of the children under 5 years of age are underweight and also malnourished.

In Pakistan, food security has been the main objective of every government. So, why are the policymakers not spending a lot of time in making such kind of policies that can resolve the problems of food security? Various dimensions of food security have been given in various literature such as availability of food, utilization of food, the openness of food, and the steadiness of food.

**Food Security**

Food security exists in the country when all the people of the country have at all time economic and physical access to enough secure nutritious food which meets their dietary needs and food preferences for a vigorous and fit life.

**Dimensions of Food Security**

   **i.   Food Availability**

Food availability describes the supply side of food security. It explains the permanent provision of sufficient food items and enough quantities with good quality along with good taste. This dimension of food security is determined by the production of food, stock level and the volume of trade. Food accessibility is exaggerated by a number of factors including production, processing, storage, allocation, marketing systems, and technologies.

   **ii.   Economic and Physical Access to Food**

Economic and physical access is another key indicator of Food Security. The accessibility to food depends on factors like earnings, a resource of income including transmittal, income disparities, real food prices, gender, literacy, and employment status. First, it is the need to improve these factors by better government policy regarding employment, education, and health. It can also be improved through regional trade. It will create employment opportunities that lead to improving HDI. Sen's (1995) important role in this area is to emphasize the fact that even with existing food supplies, lack of access can lead to susceptible households facing starvation and malnutrition, as happened in the Indian Famine in West Bengal in 1943.

   **iii.   Food Utilization**

Food utilization means how the majority have used the food available.

**Stability of Food**

This dimension of food simply implies that people have access to food whenever they need it. They do not face any risk of losing physical availability and accessibility of food.

Sometimes, the constancy of food is shocked due to natural disasters like floods, earthquakes, rain, and tsunamis, or sometimes, it is due to a war situation.

## Objectives of the study

- To find out the effect of climate change on food availability
- To analyze the impact of agriculture credit on food security
- To see whether the current level of fertilizer consumption has an affirmative effect on food security
- To suggest specific guidance for the improvement of food security

## Literature Review

There is a number of studies in which the issue of food security has been analyzed at the national level in Pakistan. Mahmood & Shaikh (1991) investigated the factors of lower food security, low literacy rate, large household size, and low level of purchasing power. Another study by Ahmed & Siddique (1995) analyzed the situation of food security of Pakistan and found that continuous increase in the growth of population, varying form of income distribution and higher intensity of urbanization has prejudiced the require for food. On the other hand, the deficiency in machinery and increasing cost of irrigation are also a cause of the low level of production of agriculture. Schichting and Ahmadi-Esfahani (2004) examined the relationship between food security and earning for northern areas of Pakistan by using household-level data. Their finding shows that nutrient demand is highly affected by the level of income; people are unable to buy the food because of the low level of income.

Anum et al. (2014) examined the relationship between food security and climate change in the case of Pakistan. Their study focuses on the impact of climate change on the production of wheat in the province of Punjab. They selected the different areas of the Punjab and separated them into two divisions e.g. irrigated land area and non-irrigated land area. They used time-series data from the years 1980-12 and employed the OLS method to find out the effect of climate change on food security. They also used maximum and minimum temperatures for every year and concluded that minimum temperature is positively related to the production of wheat in the month of November and February. They also concluded that in Pakistan the average temperature is increasing every year. They argue that by considering an increase of 3 degrees Celsius in 2050, the per capita wheat availability would decrease to 84 kg per annum as it was 198 kg per annum in 2012. Another study by Janjua et al (2010) stated that wheat is the staple food crop in Pakistan, and the heavy rainfall during the harvesting period can damage the wheat production on a large scale which may result in the problem of food insecurity.

Hertel and Baldos (2014) investigated the link between climate change and agriculture productivity. They used time-series data in their study and then forecast the food security for year up to 2050. They concluded that climate change uncertainty will affect the production of crops and which result in food insecurity for the global world.

Kumar and Gotham (2014) examined the link between climate change and agriculture productivity for India. They use agriculture productivity as a dependent variable whereas climate change and rainfall are the explanatory variables in their study. Their study shows that India is going through serious global warming conditions and this change in

temperature is increasing day by day. This all has a significant negative impact on the production of the agriculture sector.

Hussain and Mudaser (2007) investigated the link between climate change and productivity yield for Sawat and Chitral and found the rise in temperature up to 1.5 degrees Celsius would increase the yield by 14 % in case of Chitral while decreasing the yield by 7% in case of Sawat.

Manan & Rasool (2014) examined the major determinant of food security in Pakistan using household-level data for a sample of 90 respondents from Lahore city. Their findings show that consumption of food relevant items have a positive relationship with food security, but on the other hand, there are some variables which have a negative relation with food security like infant mortality rate and sick persons.

Khan et al. (2012) examined the determined food security for rural areas of Pakistan. Their finding suggests that only 40 districts are food secure and 80 districts are food insecure. Furthermore, they concluded that out of these 40 food-insecure districts, 38 districts are highly food insecure.

Hazarika and Khasnobis (2005) have investigated children's food security in Pakistan. They have used education, work, and age of the mother at first marriage. Their finding shows that food security and status of women in the household are positively related. Another study at household level food security has been done by Haile, et. al. (2005) for Ethiopia. They used primary data in their study and applied logistic regression model. The study concluded that food intake and required levels have big differences.

There are some studies that have been done to investigate the agriculture sector in the context of food security. Most studies take food availability as a major component of food security. Anderson (2001) concluded that mechanization in the agriculture sector can increase the food supply and food security and decreases poverty. According to Pretty (2001), with the proficient use of water, fertilizers, and pest control we can increase agricultural production and this will increase food security. Pingali (2001) suggests that with the use of modern biotechnology we can increase crop productivity, this will increase food availability and ultimately it will increase food security.

**Material and Methods**

Our primary concern is to explore the shock occurring due to climate change in Pakistan, with reference to food security. For this purpose, a linear production function used by McCarl et al. (2008) is used for estimation. Food production index (FPI) is taken as a dependent while climate change, fertilizer consumption, and agriculture productivity areused as explanatory variables.

$$Y_t = \alpha_0 + \beta_0 X_1 + \beta_1 X_2 + \beta_2 X_3 + \mu \tag{1}$$

Where $\alpha_0, \beta_{0,} \beta_{1,} \beta_2,$ are the parameters and

$Y_t = food\ production\ index$

$X_1 = Agriculture\ credit$

$X_2 = Temparature$

$X_3 = Fertilizer\ consumption$

$\mu = Error\ term$

## Food Production Index (FPI)

It covers all the food crops which contain nutrients and are edible. Coffee and tea are not included in this index, they are edible, but they did not contain any nutrients so we did not include these two in the food production index.

## Agriculture Credit

Agriculture credit contains those funds which are given to the farmer so that they can purchase necessary input for agricultural production. The interest rate on these loans is very low. Short term loans are given to farmers so that they can purchase seeds and other basic inputs. The medium-term loans are given for the purpose of purchasing fertilizers. The long term loan is given to farmers so that they can purchase machinery like tractors, and harvesters.

## Climate Change

Climate change is the continuous change in the overall weather condition of the country. In this study, we take the average temperature of the country as a proxy for climate change and check its impact on the food production index.

## Fertilizer Consumption (FC)

It measures the total quantity per unit of arable land of plant nutrients used. The major products of fertilizers are Nitrogenous, Phosphate, and Potash. Fertilizers are used to increase the production of the land. They play a positive role in the production of the goods of the economy.

## Estimation of the Model

Firstly, we check stationarity through unit root by apply augmented Dicky Fuller test, which confirms the use of ARDL after showing the order of stationarity at levels and at first difference

Following is the main equation used in the ARDL model

$$FPI = \alpha + \sum_{i=1}^{p} \omega i \, (FPI)_{t-i} + \sum_{i=0}^{p} \emptyset i \, (TEMP)_{t-i} + \sum_{i=0}^{p} \theta i \, (AC)_{t-i} + \sum_{i=0}^{p} \delta i \, (FC)_{t-i} + \delta_1 (FPI)_{t-1} + \delta_2 (TEMP)_{t-1} + \delta_3 (AC)_{t-1} + \delta_4 (FC)_{t-1} + \epsilon_t$$
$$(2)$$

Equation (2) examined the impact of temperature (TEMP), agriculture credit (AC), and fertilizer consumption (FC) on food production index (FPI). This link was being tested by bound test. To apply this test a combined test was done.

$$H_0 \; all \; delta's \; are \; zero$$
$$H_1 \; all \; are \; non \; zero$$

If the long-run relationship exists between the variables, then we modified the equation no 2 into 3 and then modified in equation 4 respectively

$$FPI = \alpha + \sum_{i=1}^{p} \omega i \, (FPI)_{t-i} + \sum_{i=0}^{p} \emptyset i \, (TEMP)_{t-i} + \sum_{i=0}^{p} \theta i \, (AC)_{t-i} + + \sum_{i=0}^{p} \delta i \, (FC)_{t-i} + \mu_i$$
$$(3)$$

The ARDL specification for the short-run dynamics can be derived by the error correction model of the following form

$$FPI = \alpha + \sum_{i=1}^{p} \omega i \, (FPI)_{t-i} + \sum_{i=0}^{p} \emptyset i \, (TEMP)_{t-i} + \sum_{i=0}^{p} \theta i \, (AC)_{t-i} +$$
$$+ \sum_{i=0}^{p} \delta i \, (FC)_{t-i} + \delta(ECM)_{t-i} + v_i \qquad\qquad (4)$$

Where $(ECM)_{t-1}$ is the lagged value of ECM. For the existence of short-run relationship the, coefficient value of ECM must be negative and significant.

## Results

Equation (1) was formed in order to check the impact of climate change on the food security of Pakistan. Equation (2) is the ARDL equation. Before moving further, we check at which order variables are integrated. To obtain the integration order Augmented Dickey Fuller test. These results are shown in the following table.

**Table 1.** Results of Augmented Dickey Fuller Test

| Variables | Intercept/Trend | Level | First Difference | Decision |
|---|---|---|---|---|
| FPI | I | ------ | −5.843831*** | I (1) |
| TEMP | I | ------- | −5.824620*** | I(1) |
| FC | I | −5.228378*** | | I (0) |
| AC | I | ------- | -4.131997* | I(1) |

*, ** and *** show significant at 1, 5 and 10 percent point

As the result shows that some variables are integrated at I (1) and some are integrated at I (0), so it is suitable to use a bound testing approach along with the ARDL. For this purpose equation (2) which was a modified form of equation (1) was analyzed and the following results were obtained.

**Table 2.** F-Bound Test Results

| Test-statistics | Value | Significance | I (0) | I (1) |
|---|---|---|---|---|
| F-stat | 12.50512 | 10% | 2.37 | 3.2 |
| k | 3 | 5% | 2.79 | 3.67 |
| | | 2.5% | 3.15 | 4.08 |
| | | 1% | 3.65 | 4.66 |

Our calculated value of the F-statistics is 12.50512, which is greater than the upper bound I (1) and lower bound I (0), and implies that there exists a long run co-integration between the variables.

**Table 3.** Long run Relationships and Short run Convergence Results

| Variables | Long-run Coefficients | P-values |
|---|---|---|
| TEMP | −6.435287* | 0.0414 |
| FC | 0.021140* | 0.0001 |
| AC (-2) | 0.000248* | 0.0084 |
| C | 162.0391* | 0.00124 |
| ECM(-1) | −0.737390* | 0.0000 |

*, ** and *** show significant at 1, 5 and 10 percent point

The above table shows the long run and existence of the convergence of the short-run results. All the coefficients are highly significant as the p-values of all the coefficients are less than 0.05. The sign of all the variables is also economic theory. The first variable for climate change is temperature (TEMP). The sign of the temperature is also according to the theory and significant. The sign of temperature is negative. The coefficient value of temperature is -6.435287 which means due to 1 unit increase in the temperature the food security will decrease by 6.43587 units. The reason for this negative relation is that when the temperature is increasing the ice on the glaciers is melting and this will make many floods in Pakistan every year. So the first loss is that we lost so many crops due to heavy floods. The second effect of the increase in temperature in those areas where the mode of agriculture totally depends on rain. When there is no rain the water in the wells goes deeper and deeper and the tube wells are not working properly, especially in the provinces of Sindh and Balochistan. This all decrease the production of the agriculture sector, and consequently, there is a decrease in the supply of agricultural goods in the market. So, as a result, there is a decrease in food security. The next variable is fertilizer consumption (FC). Its sign is also positive and significant, but its coefficient is very low. The coefficient value of fertilizer consumption is 0.021140 which means due to 1 unit increase in fertilizer consumption the food security will increase by 0.021140units. This is true when the farmers are using the fertilizer in their fields and this will increase their per acre production.

The fertilizer keeps the land fresh and helps the crops to grow quickly. Due to all this the supply of food items increases in the market. This will increase food security. The reason for the small coefficient is that in Pakistan most of the farmers are poor: they have not enough money to purchase the fertilizers because in Pakistan there are very few firms who are making the fertilizers, so in order to meet the demand of the country, we have to import it from foreign countries. When we import fertilizer from foreign countries, they become more costly and not in the reach of every farmer, so their use is much lower in case of Pakistan, and their effect on food security is also much lower. The last variables are agriculture credit. Its value is also positive and significant. We take the two lags of agriculture credit in our estimation. The reason behind this is that the effect of agriculture credit takes some time. Farmers will take a loan from the banks and from that loan they will buy inputs for agriculture, so when they use these agriculture inputs it will take some time to give an output. The coefficient value of agriculture credit is very low because in Pakistan most of the loan is captured by the landlords and they do not use this loan in the agriculture sector, so the small farmers can't take any advantage from this loan. That's why the impact of this loan on food security is very low.

The value of ECM (-1) is also according to the theory and is highly significant. For the convergence condition, the ECM sign must be negative and must be significant. In the case of our results, both of our conditions are full filled. The coefficient value of the ECM is -0.737390, which indicate that 0.73% error is cover in this year.

## Conclusion and Policy Recommendations

Food security has always been the main focus of every country. So as in the case of Pakistan, every government wants food security for its people. Climate change has to affect food security greatly in the past few decades. In Pakistan every year there is rainfall in great amounts, but we are unable to store that water. If we make more dams for storing that water then we can increase the food security in our country. We can supply this stored

water in those areas where there is a shortage of water and very few rains in the season. The environment is more polluted because of the larger number of industries and there is a continuous increase in the temperature, so we should make some serious policies in order to minimize $CO_2$ emissions. The food security can be increased by following the given policy recommendations

i.   First of all, the government should build more dams so the water can be stored and this will also help for controlling the floods.
ii.  The government should give direct loans to the small farmers so that we can take maximum benefits from that loan.
iii. We should educate our farmers regarding the use of different varities of wheat that can bear the effect of the hot temperature. This will increase the production of the agriculture sector.
iv.  The government should build more fertilizer industries in our own countries, so the farmers can purchase the fertilizers at a low rate.

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