*Proceedings of the Pakistan Academy of Sciences: B*
*Life and Environmental Sciences* 63(2): ------- (2026)

ISSN (Print): 2518-4261; ISSN (Online): 2518-427X
http://doi.org/10.53560/PPASB(63-2)1133

Pakistan Academy of Sciences

Research Article

# Factors Influencing Wheat Production in Pakistan: An Empirical Cobb–Douglas Production Function Analysis

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**Abstract:** Current research study examines the effect of various input factors, including wheat cultivated area, agriculture credit disbursement, improved seed distribution and availability of water on the wheat crop production in Pakistan by considering time series data of Economic Survey of Pakistan from 1990 to 2023. In order to analyse input data in present study, the log linear Cobb-Douglas production function was considered. Economic findings illustrated that availability of water, agriculture credit disbursement and cultivated area for wheat crop has statistically significant positive effect on wheat crop production. Moreover, unit root testing (Augmented Dickey-Fuller) and cointegration analysis are also used for econometric analysis. However, results also showed that although improved seed distribution has a positive association with wheat production, but this relationship is insignificant. Furthermore, econometric analysis of the regression model showed that a one percent rise in cultivated area for wheat crop would increase wheat production by 1.17%. Similarly, 1% increase in amount of water availability would lead to a rise in wheat crop production by 0.30%. Moreover, wheat crop production exhibits a 0.05% increase for every 1% rise in agricultural credit disbursement. It is suggested that there should be formulation of policy frameworks regarding to improve yield of wheat crop, water-use efficiency, credit disbursement, effective research on climate resilience strategies for wheat crop and adoption of modern technology in agronomic prospective. Policies should be formulated in order to tackle the climate change negative impacts (less water availability) on wheat production.

**Keywords:** Agriculture Credit, Cultivated Area, Improved Seed, Production Function, Water.



## 1. INTRODUCTION

The agriculture sector functions as the backbone of Pakistan's economy, which is supporting national growth and it contributes 23.4% to Gross Domestic Product (GDP) and accounts for 33.1% of employment [1]. Wheat contains vitamins and minerals, including thiamine, niacin, riboflavin, calcium, fiber, iron and vitamin D [2]. Wheat as a staple food crop, plays major role for food security in Pakistan, making the country the seventh position globally in total wheat production [3]. The Global wheat production for top ten countries is shown in Figure 1. Wanzala *et al*. [4] reported that the role of agricultural credit is significant in order to increase modernization and technological advancement in the prospective of agriculture development. According to the World Bank report, agricultural credit enables the farmers' communities to use advanced input technologies more efficiently for growing of crops and for the purpose to meet one of economy objective of poverty alleviation in rural areas [5].

Majority of small and marginalized rural farmers in Pakistan consider two primary sources of agriculture credit (non-institutional and institutional) to manage their routine agricultural related expenses. The non-institutional sources comprise the commission agents working in agricultural produce markets, fellow farmers, relatives and friends. Chandio *et al*. [6] revealed that

Received: July 2025; Revised: May 2026; Accepted: July 2026
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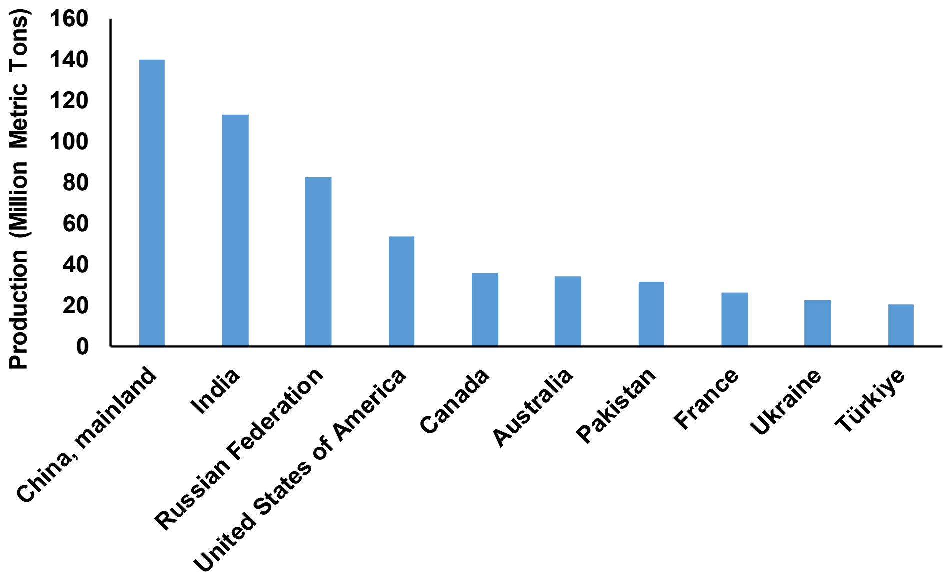


**Fig. 1**. Wheat production of top ten countries [3].



most of the time the amount of funds obtained from the non-institutional sources are often inadequate to cover the necessary agricultural operational expenses. However, Iqbal *et al*. [7] reported that various formal sources including Zarai Taraqiati Bank Limited (ZTBL), Cooperatives Societies and some Commercial Banks also play an important role in agricultural production. Provision of agriculture credit from these formal institutions to the farmers would assist them for purchase of various farms inputs and consequently it contributes in development of agriculture sector. The relationship between agriculture credit disbursement and wheat crop production over the time span in Pakistan is shown in Figure 2 and it shows that from 1994 to 1998 there were large gap between agriculture credit disbursement and production of wheat crop but after 1998 mostly both these variables move at constant direction.

Most of the area under agriculture sector is affected due to adverse effects of climate change and consequently productivity in agriculture sector is negatively impacted in Pakistan [8]. Such situation has resulted to be major hurdle in the way of enhancing the production of many crops including wheat in Pakistan. Moreover, same piece of land is repeatedly divided among the individuals of next generation and pressure on the land increases due to rising population growth [9]. Aslam and Fazal [10] reported that the land fragmentation negatively impacting the agricultural output from the land. According to the study of Ren *et al.* [11], it was concluded that farm size has a positive and substantial impact on the farm's net income earned from efficient production. Furthermore, relationship between cultivated area and production of the wheat crop in Pakistan from 1990 to 2023 revealed that cultivated area for wheat crop and production of wheat crop has an upward trend over the period of time.

Farooq *et al.* [12] observed that shortage of the water is a restrictive factor to increase winter wheat production. The Foulkes *et al.* [13] concluded that the prominent variations in the level of water stress sensitivity have been empirically confirmed for wheat crop cultivars in the case of United Kingdom. However, well designs research related to wheat production system is still a task for future innovative research which would be consistent to local natural conditions, input use efficiency and resilience capacity to the concern climate change factors. The trend between water availability (canal water supply for wheat season and rainfall) and wheat production with reference to Pakistan and it indicates that although production of wheat crop has been increasing over the span of time but water availability is not increasing rather recently it showed decreasing trend due to climate change.

The proper availability of good quality seed plays an important role in ensuring optimum wheat production. Further, the optimum rate of seeding is

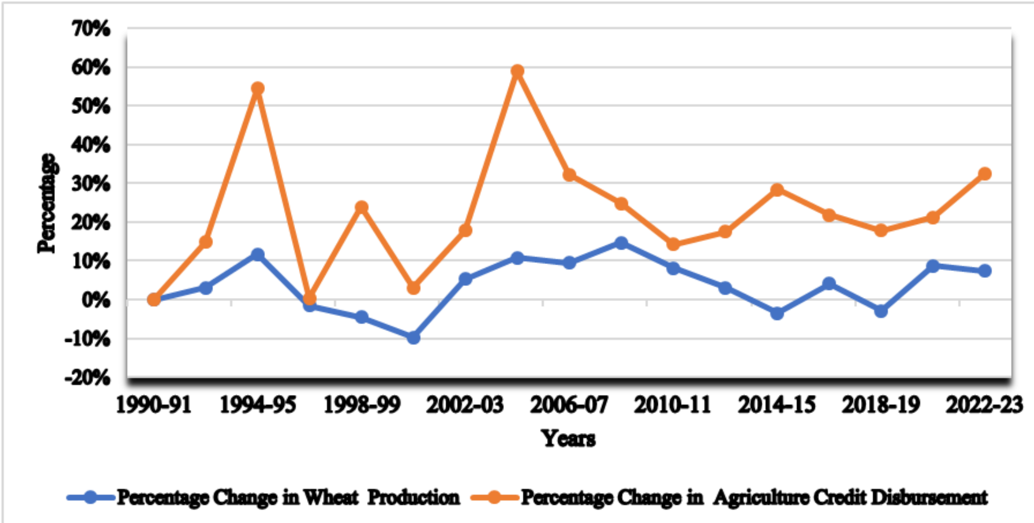


**Fig. 2**. Analysis of relationship between agriculture credit disbursement and wheat production for the period 1990 to 2023.
Source: Economic Survey of Pakistan, 2024.



taken as significant management influencing factor for improving yield of wheat production. Lloveras *et al*. [14] indicated that under the cropping system, seed rate is prime importance in case of wheat production as farmer can have control on it.

The trend between improved seed distribution of wheat crop and wheat production over the time period of 1990 to 2023 indicates that mostly there is a direct relationship between improved seed distribution and wheat crop production across Pakistan. Mainly because majority of wheat farmers perceived that there is an important role of improved seed availability for the rise in production of wheat crop. It is evident that improving the effective use of agricultural inputs to increase wheat crop production would play significant role for further raising production aspect of wheat crop of Pakistan at national and global levels. The countries which are ahead from Pakistan regarding wheat production are getting significantly higher yields due to some factors as mentioned in the literature, including seed quality, water availability, access to credit, and farm area enhancement which all contribute to higher production of wheat crop. No recent comprehensive study has been conducted for economic analysis of all these factors with reference to wheat production.

Pakistan is currently facing prolong period of drought which may cause water stress and impacting the productivity of various Rabi crops especially in rain fed region of Pakistan. The water level has been decreasing in major reservoirs of Pakistan due to climate change and consequently it impacted irrigation water availability for various crops including wheat. Main objective of the present research study is to analyze the impact of cultivated area under the wheat crop, availability of water, agricultural credit disbursement, and distribution of improved seed on the production of wheat crop in Pakistan.

This study introduces the latest and novel analytical framework with reference to prolonged drought period in Pakistan. While, existing literature is primarily focus on past data and not considered all the input factors with reference to Pakistan in recent time span. Keeping in view recent prolonged drought period in Pakistan, this study would also suggest which input factor further need to be utilized in an efficient way so that wheat production would be achieved in sustainable way in Pakistan.

## 2. MATERIALS AND METHODS

The annual data ranging from 1990 to 2023 (34 years), taken from Economic Survey of Pakistan (2023-24), is used in the present study for analysis [15]. The major purpose of this research is to investigate the impact of key farm input factors on production aspects of wheat crop in Pakistan. The present study used five variables including total wheat production (twp) in thousand tons, area under wheat cultivation (auwc) in thousand hectares, agriculture credit disbursement (acd) in million rupees, water availability (wa) in million-acre feet, and improved seed distribution (isd) in thousand tons in Pakistan. These variables have an important relationship with the wheat crop production in Pakistan.

### 2.1. Specification of the Model

For data analysis through the model, this research considered time series data which was collected from a secondary source that is also a government institution [1]. In order to analyze the impacts of various inputs on the output, agricultural economists widely employed Cobb-Douglas production function. For the purpose of analyzing input data, a log linearized Cobb-Douglas production specification was applied in this study. Further, Cobb-Douglas production is considered because it estimates the magnitude of changes in dependent variable because of variation in independent variables. Secondly, it measures elasticity of output to different farm inputs [16].

The following specified model is estimated:

$$\ln(twp) = \beta 0 + \beta 1 \ln(auwc) + \beta 2 \ln(acd) + \beta 3 \ln(isd) + \beta 4 \ln(wa) + \mu \ldots.$$

Where,

ln(twp): Log-transformed total wheat production in thousand tons
ln(auwc): Log-transformed area under wheat cultivation in thousand hectares
ln(acd): Log-transformed agriculture credit disbursement in million rupees
ln(isd): Log-transformed improved seed distribution for wheat in thousand tons
ln(wa): Log-transformed water availability in million-acre feet
and μ: Error term

Dickey-Fuller unit root test is applied in Cobb-Douglas time series modelling in order to check whether input variables and production variable contain unit root or not in the model. In the present study we considered Augmented Dickey-Fuller (ADF) as a unit root test. Dickey and Fuller [17] methodology has been applied for unit root test to determine the stationarity aspect of the concern variables. Considering projected output of unit root test, Johansen and Juselius [18] approach is used for estimation of co-integration technique. The Johansen cointegration test is employed in case of Cobb-Douglas production function to determine long run elasticity coefficients and by avoiding spurious regressions. These tests have a significant role to examine the time series data in econometric prospective. The optimal lag-length selected by estimating an unrestricted Vector Autoregression (VAR) model and by identifying lags which minimizes Akaike Information Criterion (AIC). Moreover, the Johannsen-Juselius Co-integration test used trend without intercept and with intercept. The main condition justifying the application of Johansen cointegration analysis is that all variables should be non-stationary at levels and integrated of the same order I(1), and share a long run equilibrium relationship. Furthermore, Johansen Co-integration technique has been applied for the examination of long-run association among the variables of interest [19]. In addition, this study applied Durbin-Watson test which is used for evaluating the aspect of autocorrelation [20].

The data of time period 1990-2023 analyzed by using STATA 17 version software for estimating the impacts of cultivated area under the wheat, water availability, disbursement of agricultural credit, improved seed distribution on total wheat production of Pakistan.

## 3. RESULTS AND DISCUSSION

It has been observed that non-stationary can lead to spurious type of regression output; consequently, findings of stationary can be vague. Hence, it is essential to confirm that input data in the question is stationery. Table 1 shows the results of estimated economic analysis of ADF, these results indicate that all variables are non-stationary at their level (0). However, again stationarity was checked for similar order of integration, and stationarity of all the variables achieved upon taking their first difference which is denoted as I(1). Hence, at the 5% significance level, the test rejects the presence of unit root (non-stationarity) in this study.

### 3.1. The Co-Integration Test

The Johansen Co-integration procedure applied for checking long-run association between the concern variables [19]. The estimated results of co-integration test, both with and without intercept,

**Table 1.** The unit root test.

| Series | Integration at Level I(0) | | | First Differenced I(1) | | |
|---|---|---|---|---|---|---|
| | ADF Test Statistics | Critical Value Estimates | | ADF Test Statistics | Critical Value Estimates | |
| lntwp | -1.249 (0.639) | 1% level | -3.661 | -10.702 (0.000)* | 1% level | -3.661 |
| | | 5% level | -2.960 | | 5% level | -2.960 |
| | | 10% level | -2.619 | | 10% level | -2.619 |
| lnisd | -0.749 (0.819) | 1% level | -3.653 | -5.638 (0.000)* | 1% level | -3.670 |
| | | 5% level | -2.957 | | 5% level | -2.963 |
| | | 10% level | -2.617 | | 10% level | -2.621 |
| lnwa | -2.023 (0.275) | 1% level | -3.653 | -5.732 (0.000)* | 1% level | -3.661 |
| | | 5% level | -2.957 | | 5% level | -2.960 |
| | | 10% level | -2.617 | | 10% level | -2.619 |
| lnacd | 0.327 (0.976)* | 1% level | -3.653 | -5.640 (0.000)* | 1% level | -3.661 |
| | | 5% level | -2.957 | | 5% level | -2.960 |
| | | 10% level | -2.617 | | 10% level | -2.619 |
| lnauwc | -1.801 (0.373)* | 1% level | -3.653 | -4.487 (0.001)* | 1% level | -3.679 |
| | | 5% level | -2.957 | | 5% level | -2.967 |
| | | 10% level | -2.617 | | 10% level | -2.622 |

Note: *indicates 1% level of significance
Source: Author's own calculations.

are reported in Tables 2 and 3. The trace statistic values (152.891, 178.298) are greater than critical value estimates (76.972, 88.803) and these results illustrate that among the concern variables there is presence of long run relationship. Therefore, the no co-integration (null hypothesis) is rejected at chosen significance level. The statistical result of Trace test reveals four co-integrating equations for both cases by considering threshold significance level of 5%.

### 3.2. Regression Analysis

Keeping in view regression result, the $R^2$ is 0.95% which demonstrate that the model has good overall fitness indicating that 95% of changes in production of wheat crop explained by four explanatory input variables including Area under the cultivation of wheat, Water availability, Agricultural credit disbursement and Improved seed rate distribution. Moreover, it is also noted that probability value of F-statistics is highly significant in this regression model. Below mentioned Table 4, represents the concern estimated findings of regression examination.

As per findings of regression model, it seems that variable area under the wheat cultivation has most important impacts on wheat production because it has comparatively large value of coefficient. The present model shows that the coefficient value (1.176) of area under the wheat crop cultivation is statistically significant at 10% significance level and validate a significant



**Table 2.** Johansen-Juselius co-integration test including intercept without trend.

| Variables: ln(twp), ln(isd), ln(wa), ln(acd), and ln(auwc) | | | | |
|---|---|---|---|---|
| Lags Length: 1 to 3 | | | | |
| Eigenvalue Estimate* | Trace Stat. Estimate | Critical Value Estimate (5%) | Prob value* | Null Hypothesis ($H_0$) |
| 0.839 | 152.891 | 76.972 | 0.000 | None* |
| 0.827 | 99.838 | 54.079 | 0.000 | At most 1 |
| 0.602 | 48.798 | 35.192 | 0.001 | At most 2 |
| 0.401 | 22.074 | 20.261 | 0.027 | At most 3 |
| 0.219 | 7.201 | 9.1645 | 0.116 | At most 4 |

The Trace test indicates 4 co-integrating equations at 5 percent level, and * denotes rejection of the hypothesis at 5 percent level
Source: Author's own calculations.

**Table 3.** Johansen-Juselius co-integration test including intercept and trend.

| **Variables: ln(twp) ln(isd) ln(wa) ln(acd) ln(auwc)** | | | | |
|---|---|---|---|---|
| **Lags specification: 1 to 1** | | | | |
| **Eigenvalue Estimate*** | **Trace Stat. Estimate** | **Critical Value Estimate (5%)** | **Prob Value*** | **Null Hypothesis ($H_0$)** |
| 0.882 | 178.298 | 88.803 | 0.000 | None* |
| 0.839 | 116.263 | 63.876 | 0.000 | At most 1 |
| 0.720 | 63.236 | 42.915 | 0.000 | At most 2 |
| 0.499 | 26.233 | 25.872 | 0.045 | At most 3 |
| 0.191 | 6.146 | 12.517 | 0.441 | At most 4 |

The Trace test shows 4 co-integrating equations at 5 percent level, and * denotes rejection of the hypothesis at 5 percent level

Source: Author's own calculations.

**Table 4.** Regression results.

| **Dependent Variable**: ln(twp) | | | | |
|---|---|---|---|---|
| **Method:** Least Squares | | | | |
| **Sample:** 1990- 2023 | | | | |
| **Included observation**: 34 | | | | |
| **Explanatory Variables** | **Coefficient** | **St. Error** | **t-statistics** | **Prob.** |
| C | -3.179 | 2.758 | -1.152 | 0.258 |
| lnwa | 0.303 | 0.179 | 1.691 | 0.101 |
| lnauwc | 1.17630 | 0.320 | 3.672 | 0.001 |
| lnisd | 0.0546 | 0.0445 | 1.226 | 0.230 |
| lnacd | 0.059 | 0.021 | 2.781 | 0.009 |
| R-squared | 0.952 | Adjusted R square | 0.945 | |
| Durban-Watson Stat | 2.178 | | | |
| Prob (F-Statistics) | 0.0000 | | | |

Source: Author's own calculations.



relationship between wheat cultivated area and wheat production. Moreover, the coefficient value of 1.176 indicates that for one percent expansion in area under the cultivation for wheat crop leads to 1.17% increase in production of wheat crop. These results are in line with the results of Larik *et al*. [21] which was conducted with reference to Pakistan, and revealed that agricultural credit and increase in sowing area play a positive role in the production of wheat crop. Moreover, the coefficient of water availability has also significant impact at level of significance of 10 percent and it demonstrates that a significant relationship existed between water availability and production of wheat crop. As per value (0.303) of coefficient of water availability, it is understood that for 1% increase in the amount of water availability, there would be 0.3% rise in total wheat production. Likewise, the regression results of Cobb-Douglas production functions reveal significance of coefficient value of agriculture credit disbursement at 10% level of significance. It shows prominent relationship between production of wheat crop and agricultural credit disbursement as far as Pakistan is concerned. In addition, the coefficient of agriculture credit disbursement shows that for every one percent rise in agriculture credit disbursement, then 0.05% would be enhancement in wheat production. The findings of Chandio *et al*. [22] justified that credit disbursement from all institution has strong relationship with agriculture productivity and in their concern research study the agriculture credit disbursement have coefficient value (0.125) and it shows for a 1% rise in agricultural credit disbursement lead to enhancement in total wheat production by 0.12% tons by using secondary data over the time span of 1996-2015. Chandio *et al.* [23] also produced the same result by applying Cobb-Douglas production function and reported that institutional agriculture credit plays an important role in the improvement of wheat crop production. Furthermore, coefficient values of all independent variables in the present study have positive signs. Further, all these concern variables except improved seed distribution are statistically significant at significance level of 10%. However, improved seed distribution of wheat crop is non-significant and it is due to the reason that farmers didn't utilize seeds in adequate quantity along with proper agronomic practices. The government of Pakistan should formulate policy regarding to increase wheat production by considering proper collaboration among various allied departments within the agriculture sector. There should be more allocation of subsidized credits availability to wheat growing farmers so that farmers would be able to purchase require inputs in order to increase wheat productivity on their lands. Moreover, it is recommended that water losses should be minimized along the water channels in agriculture growing areas so that require water would be available to wheat growing areas. Due to increasing population and denser industrialization, it is noticed that wheat cultivating areas has been decreasing in Pakistan. There should be formulation of land use policies, which must restrict the use of wheat growing land for non-agricultural use beyond certain limits. Finally, the value of Durbin-Watson statistic (2.17) shows no autocorrelation in the model.

## 4. CONCLUSIONS

The present study economically investigated the effects of various inputs including area under the wheat cultivation, improved seed distribution of wheat crop, agriculture credit disbursement and water availability on the dependent variable (total wheat production) for the period of 1990-2023. It is concluded that improved seed distribution, availability of water, wheat cultivated area and disbursement of agriculture credit have positive relationship with production of wheat crop while improved seed distribution has insignificant relationship with wheat production. It is recommended to expand the area under wheat crop cultivation, effective distribution of improved seed and promotion of drought resistant varieties for wheat crop.

## 5. ACKNOWLEDGEMENTS

We are greatful to the Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi for provision of technical support regarding to perform research analysis.

## 6. ETHICAL STATEMENT

This study did not involve human or living subjects; therefore, ethical approval was not required.

## 7. CONFLICT OF INTEREST

The authors declare no conflict of interest.

## 8. FUNDING

No funding was received to conduct this research.

## 9. AUTHORS CONTRIBUTION SATEMENT

Hafiz Saqib Habib conceived the idea, performed data analysis and drafted full manuscript. Nasir Mahmood provided technical input at every major step of the study.

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