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Assessing The Impact Of Kisan Credit Cards (KCC), Irrigation And Fertilizer Consumption On Agricultural Productivity In India: An Econometric Analysis

[1]Rukhsana Kouser, Snehin Gupta[2] & Jasbir Singh[3]

[1] PhD scholar, Department of Economics, Jammu University, Jammu & Kashmir

[1] PhD scholar, Department of Economics, Jammu University, Jammu & Kashmir

[1] Professor, Department of Economics, Jammu University, Jammu & Kashmir

Abstract

This study attempts to analyses the impact of Kisan credit cards, irrigation and fertilizer consumption on agricultural productivity in India. The study comprehensively gauges the association between these variables 1998-2021 in India by using ARDL technique as the variables are of mixed integrated order. The ARDL Bound test reveal that there is long run relationship among the variables. Moreover, the findings shows that the impact of KCC and irrigation is positive on agricultural productivity in India and it reveals that the Kisan Credit Card scheme has played a significant role in improving agricultural productivity in India by providing easier access to credit, which has enabled farmers to invest in better agricultural practices. Also, the calculated long and short-run coefficient of irrigation is positive which indicate that irrigation has been a key driver of agricultural productivity in India, enabling more reliable water supply, higher yields, and crop diversification. While fertilizer consumption has negative impact on agricultural productivity in India. The paper suggests that reducing fertilizer dependency and adopting integrated nutrient management systems, including organic and green manure alternatives, are essential for improving the sustainability and productivity of Indian agriculture. Furthermore, a multifaceted approach that includes improved agricultural practices, policy intervention, and

technological advancements is necessary to optimize agricultural productivity while mitigating environmental harm.

Keywords: ARDL, KCC, Agriculture, Irrigation

Jel classification: Q15, Q18, C22

1. Introduction

The agricultural sector is nevertheless vital to development, particularly in low-income nations where it accounts for a sizable portion of the labour force and total income. Agriculture faces a number of difficulties, such as the need to boost productivity in agriculture in developing nations and among smallholder farmers. Several issues must be resolved in order to accomplish this, including rights of ownership, seeds and inputs, irrigation, fertilizer, extension in agriculture, credits, rural infrastructure, storage, and market connectivity, as well as the volatility of food prices, which is frequently caused by circumstances beyond the control of developing nations. A coordinated set of actions could help guarantee that the deprived nations and individuals receive the necessary nutrients (Timmer, 2002).

Indian agriculture is defined by Small, marginal farm holdings with a high percentage of land fragmentation. Small and marginal holdings make up 117 million of the 138 million farm holdings in the nation, which accounts for 44% of the land used for farming (Paramesh et al., 2022). 1.21 billion People who live in India are mostly believed to be dependent on agriculture. According to the 2011 Population Census, almost 60% of Indians find full-time job in farming (Agarwal., et.al 2016).

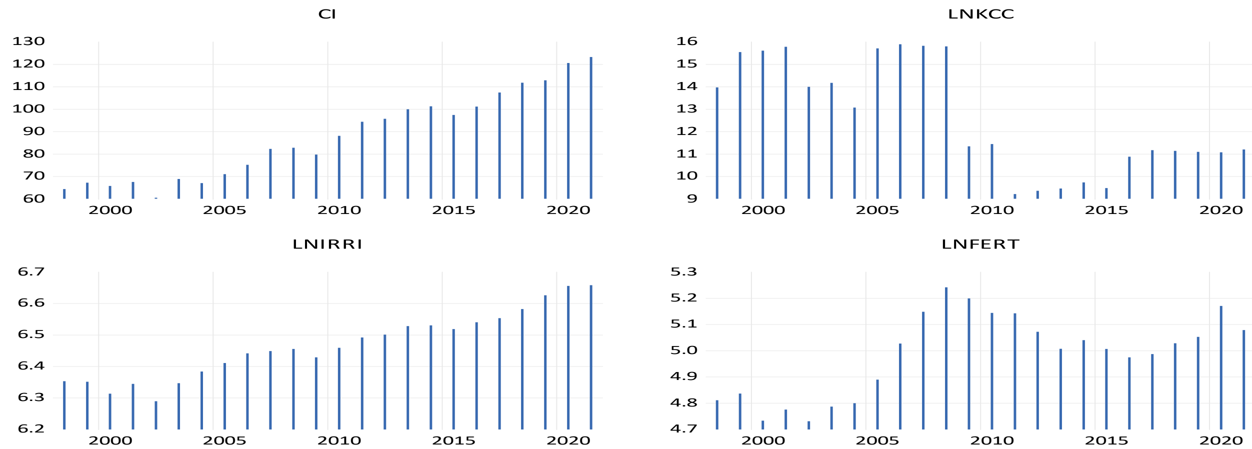
Small holding sizes do not enable economies of scale to function therefore; one of the most important production aspects in the farming industry is credit. Without the funds needed for investments, farmers choose inefficient production practices and become impoverished. Thus, credit appears to be a potent tool for raising agricultural output and raising rural population's requirements for life. Besides the development of various agriculture sectors, credit creation in agriculture plays an important role. Therefore, the government has implemented numerous policy steps to strengthen the farm credit delivery system and provide loans at reduced interest rates to assist the agricultural sector's resource requirements. The focus of these policies has been on supplying adequate and timely credit support to farmers, with a special focus on marginal and small-scale farmers and the weaker segments of society, to empower them to adopt advanced technology and improved agricultural practices in order to increase productivity and production. The government has taken many steps to strengthen the institutional credit system and make it more attentive to farmer demands, like Kisan Credit Card (KCC) with the objective to provide accessible concessional institutional Agri-credit to all farmers' for addressing immediate needs such as purchasing seeds and fertilizers, growing and marketing crops, and production demands. In order to provide farmers with timely finance to meet their short- and long-term agricultural needs, postharvest expenses, and consumer requirements, the (KCC) was introduced in 1998. Beginning in 2006–07, the Interest Subvention Scheme (ISS) aimed to give farmers access to short-term crop loans at a reduced cost, especially those made possible by the Kisan Credit Card (KCC). NABARD started the

Kisan Credit Card (KCC) program after realizing how important it was to improve the supply of credit to the rural sector and lessen farmers' reliance on non-institutional means of finance. The KCC plan, which offers unified institutional access subsidized loans to all farmers, including those engaged in animal husbandry, dairy, and fisheries, has included farmers in these industries. It places particular emphasis on covering PM-KISAN participants (Indian Fisheries Department, 2020-21). Credit is crucial for agricultural development. It seems as an essential asset that makes it possible for farmers to get inputs like fertilizer, irrigation, and more land. By providing a consistent water supply and enabling several cropping cycles, credit-financed irrigation systems lessen dependency on erratic rainfall, increasing agricultural production. Increased production and crop diversification are made possible by loans, which can help with the substantial expenditure needed to expand the area under cultivation (Rajkhowa, 2024). Furthermore, having access to financing enables farmers to purchase high-quality fertilizers, enhancing plant growth and soil fertility. All things considered, credit increases agricultural productivity by facilitating prompt and adequate access to these vital resources (Malik and Malik, 2022).

Trend data shows: 1) Crop Index (CI): The trend is higher from 2000 to 2020, shows that crop productivity has continuously improved over time. 2) Irrigation: The bars start rising in the early 2000s, decrease dramatically, and then begin to rise around 2010, showing initial high irrigation utilization, followed by a decline, and then a revival in irrigation techniques or coverage. 3) Fertilizer: The graph demonstrates a continuous growing trend over the years. This shows a rise in the usage or availability of fertilizers, which could coincide with measures to increase agricultural production. 4) KCC: The trend is basically flat with little activity, followed by a sharp spike beginning in the mid-2000s. This most likely reflects the establishment or expansion of the KCC plan, which aims to provide farmers with access to loans. These trends represent the expansion of agriculture and intensification during the past two decades. Crop productivity (CI) improvements appear to be linked to increased fertilizer and irrigation use. The establishment and expansion of the KCC plan most certainly increased farmers' financial capacity to adopt better farming methods.

This study contributes to the existing literature in two prominent ways. Firstly, the study theoretically and systematically analyses the relationship between KCC, irrigation, fertilizer consumption and agricultural productivity in India. Secondly, in the previous perspective, by examining the interactions between these variables, this study aims to close the gap in the literature in the Indian context. The trend figures are shown in the picture below.

Figure 1: Trend graph of all the variables



Thus, increased agricultural yield is supported by stabilized irrigation, farmed area, and a consistent rise in KCC usage and fertilizer application. But variations in irrigation and land area imply that outside variables such as climate change, water availability, or regulatory modifications may have an impact on general production patterns.

The present study is categorized into six sections. The variety of literature on this area is provided in second section whereas data and methodology are given in third section. Section fourth includes empirical findings, while Section five includes the conclusion and policy suggestions.

2. Literature review

2.1 Kisan Credit Card (KCC) and Agricultural Production

Farmers that make prudent use of additional finance can boost their income and productivity (Singh, 1973). Findings have unequivocally shown that agricultural financing has a favorable effect on the productivity of various crops per hectare (Deorukhakar et al., 2005). The matrix of correlation results shows that the key factors influencing agricultural income were identified to be gross cropped area, chemical fertilizers, and production credit offered under the KCC scheme, agricultural labor, net irrigated area, and electricity used for agricultural purposes (Biradar, 2010). Compared to the other farmers, who reached gross output per hectare of Rs 13,500–25,500, a KCC holder earned gross output of Rs 17,500–31,500 (Samantara, 2010). It was found that the non-KCC holders' overall production, productivity and profitability were lower than those of the KCC holders for a variety of reasons, including slow credit availability, expensive credit, poor investment, etc. The reliance on noninstitutional credit has significantly decreased since the KCC plan was put into place (Kumar, 2011). A one percent increase in loan availability resulted in a 0.30% rise in fertilizer consumption, while a one percent increase in fertilizer consumption raised crop yields by0.14 to 1.13 percent (Ramana, 2011). KCC holders earn 25–30% more than non-KCC holders. Because KCC holders employ high-quality input materials in their agricultural activities, there is a revenue disparity (Meena and Reddy, 2013). There is a significant correlation between the GDP of agricultural and related sectors and the credit provided by the KCC plan (Shaik and Reddy, 2014).

2.2 Irrigation and Agricultural Production

According to United Nations (UN) research, approximately 3.4 billion people will live in water-stressed countries by 2025. Using water resources as efficiently as possible for agricultural production remains a major global concern. Around 40% of the world's food is produced on irrigated land, but only making up around 17% of all cropland (FAO, 2002). Long-term usage of irrigation water with a concentration of more than 0.5 ppm can decrease the output of vegetables; and 2 ppm can decrease the yield of cauliflower and cabbage. Persistent use of irrigation water containing more boron than 0.75 parts per million (ppm) can lower yields of many deciduous trees and crops containing fruits. This is a threshold that must be met in order to successfully use irrigation water that contains boron at or slightly over this level (Grattan, 2002). In order to achieve high nitrogen and water usage efficiency and maximize corn grain yield, nitrogen fertilizer proved to be a very useful management strategy when used in conjunction with subsurface drip irrigation (Lamm & Trooien, 2003). Despite significant expenditures (about US$60 billion), the area irrigated has not expanded, and yields are also remaining flat (Shah, 2011) as cited in (Wani et al., 2016). More effective irrigation techniques can boost crop yields by 20–90% while reducing the amount of water used in agricultural fields by 30–70%. Planning and managing water resources for agricultural production effectively calls for in-depth expertise and creative solutions (Saccon, 2018).

2.3 Agricultural area and Agricultural Production

Deolalikar, (1981) depicts two hypothesis a) the small farm sector generally has greater yields per unit of agricultural land than the large firm market in Indian agriculture b) this yield-advantage associated with the smaller farm sector decreases and in fact reverses with technological advances in agriculture has been tested using regional data from India and both hypotheses appear to be supported by the evidence. Feder, (1985) there will be a consistent (positive or negative) correlation between per-acre productivity and farm size if financing availability is based on land ownership. Assuncao and Ghatak, (2003) found out that in agriculture, the size of farms and production are inversely associated. Moreover, (Verschelde et.al., 2013) reveals that the notion that farm size and productivity are inversely related.

2.4 Fertilizer Consumption and Agricultural Production

Fertilizers are extremely beneficial to plant growth. As an alternative to inorganic fertilizers, organic fertilizers such as sheep, farmyard, and poultry dung may increase crop output (Khan et.al., 2005). According to Hepperly et al. (2009), chemical fertilizers make a pertinent contribution to high productivity of crops. Ilahi et al., (2020) over time, the growing usage of nitrogen in fields upsets the equilibrium between the three nutrients—N, P and K—which results in a deficiency of micronutrients, it harms topsoil as well. Hidayat, (2020) said that the crop productivity and soil fertility are increased by using organic fertilizer.

3. Data and Methodology

3.1 Data Sources

For the purpose of empirical investigation aggregate annual time series data for various variables has been used covering the period 1998-2021. The list of variables, along with their descriptions, units, and sources, is provided below.

Variables	Description	Units	Sources
CI	Crop production index (2014-2016 = 100)	index	WDI(world development indicators)
LNKCC	KCC issuance	Total card issued by different agencies	RBI (Reserve Bank of India)
LNFER	Fertilizers consumption	Fertilizer consumption (kilograms per hectare of arable land)	WDI(world development indicators)
LNIRRI	Irrigation	Measured in (Lakhs Hectares)	RBI(Reserve Bank of India)

3.2 Methodology

ARDL Model

The following equation is the base of our empirical analysis:

$$\text{lnci}_t = \beta_{0+} \beta_1 \text{lnKCC}_t + \beta_2 \text{lnFER}_t + \beta_3 \text{lnIRR}_t + \varepsilon_t \quad (1)$$

Where, log of Ci is ----- (lnCi) is a dependent variable. The explanatory variables include, log of Kisan Credit cards (lnKCC), log of fertilizer consumption (lnFER), and log irrigation (lnIRR). In this equation, "t" denotes the time duration, and "εt" represents the errorterm. The ARDL framework can be inscribed as follows:

$$\Delta\text{lnCI}_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i}\Delta\text{lnCI}_{t-i} + \sum_{i=0}^{n} \beta_{2i}\Delta\text{lnKCC}_{t-i} + \sum_{i=0}^{o} \beta_{3i}\Delta\text{lnFER}_{t-i} + \sum_{i=0}^{p} \beta_{4i}\Delta\text{lnIRR}_{t-i} + \delta_1\text{lnCI}_{t-1} + \delta_2\text{lnKCC}_{t-1} + \delta_3\text{lnFER}_{t-1} + \delta_4\text{lnIRR}_{t-1} + \varepsilon t \quad (2)$$

Here, Δ shows the first difference operator, and δ_1, δ_2, δ_3, and δ_4 are long run coefficients. The null hypothesis of no cointegration $H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$ against the alternative hypothesis $H_1: \delta_1 \neq \delta_2 \neq$

$\delta_3 \neq \delta_4 \neq 0$. β_1, β_2, β_3, and β_4, are short run coefficients. The ideal lag length is generated through the Schwarz Information Criterion (SIC). Once cointegration is established, the next step involves estimating the long-run coefficients from equation 2, followed by determining the short-run dynamics using the ECM as shown below.

$$\Delta \ln CI_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta \ln CI_{t-i} + \sum_{i=0}^{q} \beta_{2i} \Delta \ln KCC_{t-i} + \sum_{i=0}^{r} \beta_{3i} \Delta \ln FER_{t-i} + \sum_{i=0}^{s} \beta_{4i} \Delta \ln IRR_{t-i} + \gamma ECM_{t-1} + \varepsilon_T \quad (3)$$

Results

The study's variables' summary statistics are shown in Table 1. LNIRRI records the lowest mean (1.82), while LNKCC has the highest (13.99). LNKCC has the biggest standard deviation (0.4718), which indicates greater fluctuation, whereas LNIRRI has the lowest (0.0381), which indicates stability. A platykurtic distribution is indicated by skewness values that are near 0 and kurtosis values that are less than 3.

Table 1: Summary Statistics

Measures	LNKCC	LNFER	CI	LNIRRI
Mean	13.99375	6.861573	6.172893	1.819461
Median	13.92057	6.823999	6.091429	1.806881
Maximum	14.71417	7.571378	6.568078	1.882221
Minimum	13.24206	6.270796	5.861390	1.768387
Std. Dev.	0.471832	0.413234	0.237164	0.038146
Skewness	0.087771	0.191847	0.426817	0.394634
Kurtosis	1.679207	1.789075	1.751518	1.729986

Note. LNKCC = Log of Kisan Credit Cards issued; LNFER = Log of fertilizer consumption (kg per hectare of arable land); CI = Crop Production Index (2014–2016 = 100); LNIRRI = Log of net irrigated area (in lakh hectares). Std. Dev. = Standard Deviation.

Discussion and Interpretation

The summary statistics shed some insight into how important economic and agricultural variables behave. A substantial issue of Kisan Credit Cards over time is suggested by the high mean of LNKCC (13.99), which may point to better credit availability for farmers. On the other hand, the comparatively low LNIRRI mean (1.82) indicates that the expansion of irrigation has not kept up with that of other agricultural inputs. With infrequent high values, the positive skewness in CI (0.4268) and LNIRRI (0.3946) indicates that crop production and irrigation have been focused at lower levels. This would suggest that although agricultural output has increased, it hasn't been consistent across time or space. LNKCC had the biggest standard deviation (0.4718), suggesting that loan issuance fluctuated significantly, which would have affected farmers' capacity to spend in inputs like irrigation (LNIRRI) and fertilizer (LNFER). The LNIRRI's low standard deviation (0.0381) indicates that irrigation levels have been largely constant, which would have constrained the growth of productivity. For agricultural progress, the link between these variables is essential. Theoretically, increased loan availability (LNKCC) should encourage more investment in irrigation (LNIRRI) and fertilizers (LNFER), which should increase agricultural yield (CI). The comparatively constant irrigation levels, however, can point to an obstacle in the pursuit of increased agricultural output.

Table 2 shows that at level one variable is non-stationary while rest are stationaryand table 3 depicts that on first difference all variables are stationary. This finding necessitates the application of ARDL model.

Table 2: ADF at Level

Variables	t-stat	p-val
LNKCC	-0.522662	0.8127
LNFER	2.075403	0.9998
CI	0.497775	0.9837
LNIRRI	1.012234*	0.0458

*:denotes 5 % level of significance

Table 3: ADF at First Difference

Variables	t-stat	p-val
Kcc	-4.771963*	0.0007
LFertilizer	-4.976716*	0.0004
Lyield	-4.445267*	0.0016
Irrigation	-4.458456*	0.0015

*: denotes 5% level of significance

4.1 ARDL Results

The below table 4 reveal results of ARDL bound test. The null hypothesis is, there is non-existence of long-run relationship. If the F-value fall between the lower bound and upper bound, result is inconclusive, restrict to go further analysis. For model 1, the computed F-value (13.58310) lie outside the lower and upper bound value for10%, 5%, and 1% level of significance which means rejecting the null hypotheses and there is existence of a long-run relationship.

Table 4: Bound test Results

F-Bounds Test		H0: No levels relationship		
Test Sta	Val	Sig	I(0)	I(1)
F-Stat	6.210129	10%	2.37	3.2
K	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

The table 5 and 6 specify the short and long run effect of KCC, irrigation and fertilizer consumption on agricultural productivity. The predicted long-run coefficient of LKCC is positive and statistically significant at 5%, showing that a 1% rise in KCC will lead to 0.17% gain in agricultural productivity. This result highlights the KCC access increases agricultural productivity. Moreover, the calculated long- run coefficient of LNIRRI is augmenting and significant at a 5% level, which shows that an increasing 1% of irrigation is associated with 0.41% rise in agricultural productivity. Also, at a 5% level of significance, the long-run coefficient of LFER is negative and statistically significant, demonstrating that a 1% spike in fertilizer consumption leads to a 0.23% decline in agricultural productivity. This finding ponders on a point that in India, excessive fertilizers application in the farms lead to poor soil health and nutrient imbalance in soil, the scenario is same for short-run estimation. The value of coefficient of error-correction mechanism (ECM) is negative and significant in the model (-1.634%). This value signifies that the LNKCC, LNIRRI and LNFER adjust to their equilibrium with the speed of 1.634%.

Table 5: Long-Run Results

Variable	Coefficient	t-Stat	P Val
LNKCC	0.169505*	-0.451734	0.0011
LNIRRIGATION	0.412706*	26.02607	0.0000
LNFERTILIZER	-0.231408*	-4.011815	0.0025

*: denotes 5% level of significance

Table 6: Short-Run Results

Variables	Coefficient	t-stat	P Val
COINTEQ(-1)	-1.633737	-6.593247	0.0001
LNKCC	0.252282*	1.463387	0.0002
LNIRRI	0.392312*	3.502477	0.0128
LNFER	-0.438447*	-3.875736	0.0031

*: denotes 5% level of significance

4.2 Structural stability tests

The study applied stability tests to verify the structural stability of the estimated model. The cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) stability tests used by Brown et al. (1975) shown in Fig. 2 and 3, which reveal that the employed model is structurally stable.

Figure 2: Cumulative Sum

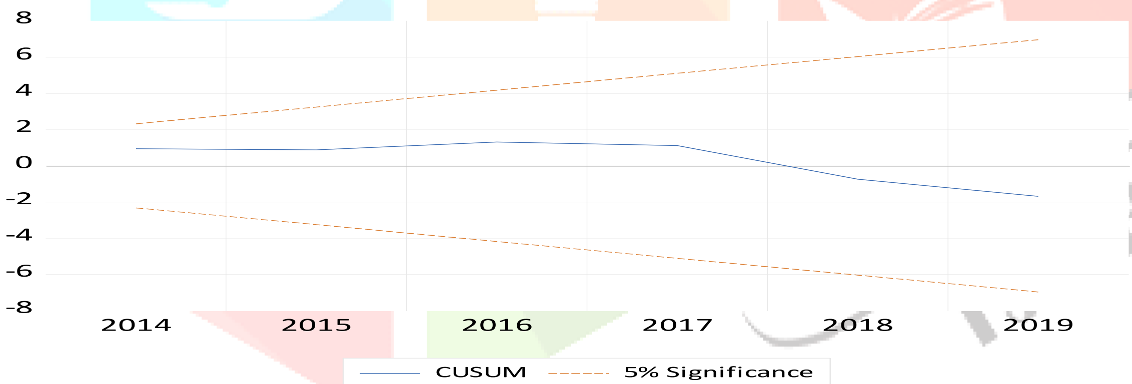
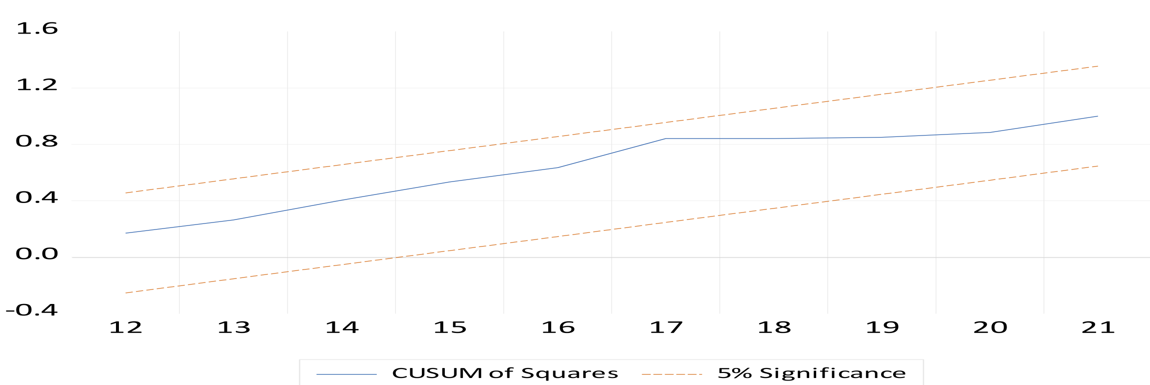


Figure 3: Plot of cumulative sum of squares



3.3 Diagnostic tests

The findings of the diagnostic tests for autocorrelation, heteroskedasticity, and normality for the empirical model are shown in Table 7. They approve the absence of autocorrelation and heteroscedasticity issue in the empirical model. The Jarque-Bera test of normal distribution highlight the variables are normally distributed.

Table 7: Results of diagnostic tests

Diagnostic Tests	F Stat	PVal	Hypothesis	Result
Autocorrelation (Breusch-Godfrey test)	1.29	0.2	Null Hypothesis: No autocorrelation	No autocorrelation
Normality test (JarqueBera test)	2.62	0.26	Null hypothesis: Normal Distribution	Normal Distribution
Heteroskedasticity test (Breusch-Godfrey test)	1.04	0.39	Null hypothesis: Homoskedasticity	No heteroskedasticity

4. Conclusion& policy suggestions

The paper attempts to critically assess the effects of Kisan credit card, irrigation and fertilizer consumption on agricultural productivity in India. The study comprehensively gauge the association between these variables 1998-2021 in India by using ARDL technique as the variables are of mixed integrated orderon time series data ranging from 1991-2021.The ARDL Bound test reveal that there is long run relationship among the variables. Moreover, the findings shows that the impact of KCC and irrigation ispositive on agricultural productivity in India and it reveals that the Kisan Credit Card scheme has played a significant role in improving agricultural productivity in India by providing easier access to credit, which has enabled farmers to invest in better agricultural practices. Also, the calculated long and short-run coefficient ofirrigation is positive which indicate that irrigation has been a key driver of agricultural productivity in India, enabling more reliable water supply, higher yields, and crop diversification. While fertilizer consumption have negative impact on agricultural productivity in India. Hence reveal that it played a role in boosting crop yields in the short term, their negative impacts on soil health, the environment, and long-term agricultural productivity call for more sustainable and balanced nutrient management practices.

The paper suggests that reducing fertilizer dependency and adopting integrated nutrient management systems, including organic and green manure alternatives, are essential for improving the sustainability and productivity of Indian agriculture. Furthermore, a multifaceted approach that includes improved agricultural practices, policy intervention, and technological advancements is necessary to optimize agricultural productivity while mitigating environmental harm. Also, by encouraging collaborations between the government, agricultural research institutions, and private companies' government can accelerate the development of innovative agricultural technologies, including genetically modified crops, efficient irrigation systems, and climate-smart farming practices. To boost agricultural productivity in India, a comprehensive approach is needed, integrating Kisan Credit Cards with robust irrigation solutions, technological innovation, and farmer education. Expanding access to finance, improving water use efficiency, and ensuring policy coherence across programs will be key in enabling sustainable agricultural growth. The study has major limitation as the model estimated could suffer from omission-of-variable bias and also due to lack of data the time period has been reduced which could hamper the precision of the analysis. The study can be further extended by comprehending the linkages among environment, gender and economic growth. Furthermore, state wise analysis can also be performed and lastly the other policies impact can also be assessed.

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