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Does Agricultural Credit Mitigate the Effect of Climate Change on Sugarcane Production? Evidence from Uttar Pradesh, India

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Abstract

This paper examines agricultural financing and technological advances (fertilizer and irrigation) to mitigate the effect of climate change (temperature and rainfall) on Uttar Pradesh. Augmented Dickey–Fuller and P.P. test was used to identify variable unit roots test. Autoregressive distributed lag (ARDL) and Error correction model (E.C.M.) estimated long and short-run parameters for selected variables in Uttar Pradesh from 1990-91 to 2020-21. ARDL bounds testing indicated long-term co-integration between variables. This study revealed that In Uttar Pradesh, rainfall increased sugarcane output Increased, but temperature decreased. Long-term agricultural credit enhanced sugarcane output. The policy implication/recommendation or suggestion that it is used to invest in modern technology to production was maximum. The fertilizer improved and then increased sugarcane yield, showing that technology is crucial. This report recommends more comprehensive agricultural policies to suit the sector's financial demands and boost production technologies.

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Keywords

Agricultural Credit;
ARDL model;
Climate Change;
Sugarcane Production.

Introduction

Climate change has increased in recent decades. Human activities have generated well-mixed greenhouse gas (GHG) concentration rises since 1750. Atmospheric concentrations have increased, and annual averages get as far as 410 ppm for CO2, 1866 ppb for CH4, and 332 ppb for N2O in 2019(AR5, 2011). 6 Over the last 60 years, land and ocean have absorbed 56% of human-caused CO2 emissions, with regional variations (high confidence). Human activity caused the worldwide resort of glaciers during the 1990s and the 40% September and 10% March decline in the Arctic sea ice zone between 1979–1988 and 2010–2019. Due to regionally opposed tendencies and high internal variability, the Antarctic sea ice extent has not changed from 1979 to 2020. Rapid climate change will alter worldwide sugarcane output, particularly agricultural productivity and planting patterns. Sugarcane production will be threatened by global rainfall fluctuations, rising average temperatures, rising carbon dioxide concentrations, and catastrophic

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occurrences like droughts and floods: temperature and rainfall, the most obvious signs of climate change, impact sugarcane development, and maturity. Climate change alters rainfall patterns, affecting agricultural growth. Rainfall helps most Indian crops, while warmth hurts them. Temperature and rainfall changes would reduce India's sugarcane and wheat yields by 15% and 22%, respectively, by 2100. Climate change threatens Bangladeshi agriculture. Climate change will undermine coastal socio-economic position, causing food insecurity. African sugarcane output has also suffered from climate change. Future warming and precipitation changes will reduce the main crop yield in West Africa. India is the second-largest sugar producer, Brazil produces the most sugar. India expected to raise output by 11.56 percent to 468.78 million tonnes in 2022-23 seconds advanced estimated.[1]

Uttar Pradesh, the nation's biggest sugar producer, is expected to produce 178.33 million tonnes of sugar in 2021-22.[1] However, Maharashtra, the country's second-largest sugar producer, is forecast to produce 105.13 million tonnes, and the third-largest producer, Karnataka, is 42.52 Million tonnes.[1] Sugarcane is India's main cash crop and agricultural economy. Nearly six million farmers and agricultural workers cultivate sugarcane. It employs almost half a million trained and semi-skilled rural laborers.[2] Sugar industry provides 7.5% of rural livelihoods. It also produces gasoline and several expensive, value-added items.[2] It dramatically accelerates industrialization and affects rural socioeconomics.[3] The second biggest agro-processing business in India, after textiles, costs about Rs. 30000 crores. 4.4 million hectares of sugarcane produce 68 tonnes/ha. India is a big sugar producer and consumer. It produces 18.9 million tonnes of sugar, 11.8% of global output. India's tropical and subtropical sugarcane crops make up 40-60% of the total cane acreage. Sugarcane plantations are important in India. Sugarcane production and climate change research are scarce. The authors found after considerable literature evaluation that climate change would reduce key food grain and cash crop yield Climate change may boost or reduce sugarcane production.[4]

Sugarcane is Uttar Pradesh's main food crop, independent of planting area or yield. Recent CO2 emission increases in Uttar Pradesh have led the climate to vary, with greater temperatures and less rain. Global warming affects agriculture heavily. Floods and droughts hurt agricultural productivity. Climate change will worsen food production. Climate-change financing plans are essential to combat global warming and boost agriculture. Among various financial services, agricultural lending has helped raise agricultural productivity and rural family income. Agricultural finance boosts agricultural production, rural development, farmer participation in agricultural activities, social, and agricultural transformation. According to empirical research, agricultural loans considerably boosted agricultural production in emerging countries. Agricultural finance boosts rural economies. Financial institutions provide farmers with agricultural financing to invest in agriculture and grow crops. Rural development will suffer without enough agricultural loans. To tackle agricultural development, the rural financial system for farmers must be actively developed, agricultural credit increased, and agricultural funds optimized.

Several studies have examined how climate change affects agricultural productivity in India.[5] In previous research, climate and financial development affected agricultural production.[6] These analyses neglected key sugarcane production drivers, including agricultural financing and technological advancement (i.e., mechanical farming rate). To the authors' knowledge, this work investigates the effects of climatic conditions on sugarcane output utilizing (ARDL) co-integration analysis and bounds testing technique. Previous studies neglected significant aspects like agricultural financing and the mechanized farming rate, but this analysis includes them. This study investigates: There are many studies on the use of sugarcane production, but there is no study regarding the specific in Uttar Pradesh; that's why we tried to find out whether Uttar Pradesh warming hurt sugarcane production. How does Uttar Pradesh's agricultural credit reduce climatic change on sugarcane production? Does fertiliser boost Uttar Pradesh sugarcane production? The first part contains the introduction, and the second contains the literature review. The third part covers research methodology, the fourth covers results and discussion, and the final section covers the paper's conclusion.

Crop growth requires consistent temperatures, rainfall, and sunlight. Drought results from little

precipitation, rising temperatures, or more sunlight. Low temperatures inflict freezing injuries, while excessive precipitation causes floods, which hurt agricultural productivity. Grain production varies by area. High-latitude spring wheat and corn yield may rise with rising temperatures. Grain types respond differently to increasing precipitation during crop development. It boosts spring wheat output in the northwest but hurts winter wheat in the South. Climate change negatively impacts sugarcane output in South China. However, each location is affected differently.[7] In South, Central, and East China, precipitation hurts sugarcane output, while in Southwest China, it helps. The temperature reduces sugarcane yield in South, west, East, and Central China. According to,[8] the temperature rise negatively impacts sugarcane output, especially in the northwest, whereas the increase in precipitation benefits all areas except the South. Most crops produce more in hotter years, so climate change benefits them. Conditions and other considerations make research area sub-divisions challenging. For instance,[9,10] used economic methods to study how climate variables like climate change, affected China's sugarcane and grain output from 1996 to 2009. Farmers need agricultural loans to pay for their operations, which affects sugarcane output. Most researchers agree that agricultural finance improves goods and agricultural economic development. Based on Pakistani survey data, experts examined how long and short-term loan affect grain output. Both credit systems increased wheat output dramatically.[11] The ARDL and (E.C.M.) were utilized to examine how agricultural finance and fiscal spending affected wheat output in major foodgrain- producing regions from 1979 to 2010. Agricultural loans and government spending have enhanced grain production in major regions. credit contribute and sugarcane production in Nigeria from 1981 to 2016 were examined using the (VECM) by.[12] Results showed that loan availability increases sugarcane yield. Investment and labour force will decrease sugarcane output, but the money supply and inflation rate will boost it. Sugarcane producers' sugarcane output may rise with agricultural loans.[13]

Material and Methods

Data and Sources

This research relied on secondary data compiled from a variety of publicly available sources from 1990-91 to 2020-21. In addition, data has been taken for determinants of agricultural growth such as fertilizers, annual rainfall, temperature, net irrigated area, and agricultural credit has been taken.

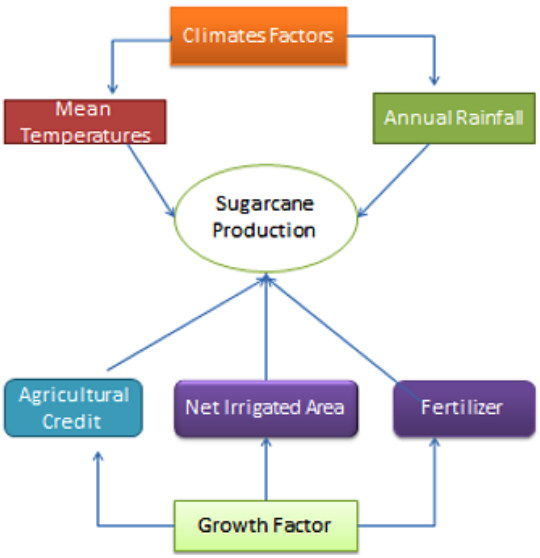
Methods

Previous research has largely used the sophisticated ARDL model.[14,15,16,17,18,19] Suggested this strategy. ARDL study sample model:

$$Y_t=\alpha_0+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\beta_4 X_4+\beta_5 X_5+\beta_6 X_6+e_t \quad ...(1)$$

When the above variables are changed, the following relationship can be found:

$$LNSP_t=\alpha_0+\beta_1 LNSP_t+\beta_2 LNIRR_t+\beta_3 \ LNFR_t+\beta_4 LNTEMP_t+\beta_5 LNARF_t+\beta_6 LNAGC_t+e_t \quad ...(2)$$



To determine the long and short-term link between climate change, agricultural credit, technological advancement, and sugarcane output, this research must continue to refine formula (2), as follows.

$$\Delta LNSP_t = \alpha_0 + \gamma_1 LNSP_{t-1} + \gamma_2 LNIRR_{t-1} + \gamma_3 LNFR_{t-1} + \gamma_4 LNTEM_{t-1} + \gamma_5 LNARF_{t-1} + \gamma_6 LNAGC_{t-1} + \sum_{i=1}^{p} \emptyset 1 \Delta LNSP_{t-1} + \sum_{i=1}^{p} \emptyset 2 \Delta LNIRR_{t-1} + \sum_{i=1}^{p} \emptyset 3 \Delta LNFR_{t-1} + \sum_{i=1}^{p} \emptyset 4 \Delta LNTEM_{t-1} + \sum_{i=1}^{p} \emptyset 5 \Delta LNARF_{t-1} + \sum_{i=1}^{p} \emptyset 6 \Delta LNAGC_{t-1} + e_t \quad ...(3)$$

Equation (4) shows that the ARDL model is made up of parts that look at the long-term and the short-term.

The first half can be used as a long-term analysis if it is taken apart. Here is the specific formula:

$$\Delta LNSP_t = \sum_{i=1}^{p} \emptyset 1 \Delta LNSP_{t-1} + \sum_{i=1}^{p} \emptyset 2 \Delta LNIRR_{t-1} + \sum_{i=1}^{p} \emptyset 3 \Delta + \sum_{i=1}^{p} \emptyset 4 \Delta LNTEM_{t-1} + \sum_{i=1}^{p} \emptyset 5 \Delta LNARF_{t-1} + \sum_{i=1}^{p} \emptyset 6 \Delta LNAGC_{t-1} + e_t \quad ...(4)$$

As a consequence, the error correction model (E.C.M.) is constructed on the basis of the ARDL model so that a more accurate verification of the short-term relationship between the variables can occur. The formula is as follows in its specific form.

$$\Delta LNSP_t = \sum_{i=1}^{p} \delta 1 \Delta LNSP_{t-1} + \sum_{i=1}^{p} \delta 2 \Delta LNIRR_{t-1} + \sum_{i=1}^{p} \delta 13 \Delta LNFR_{t-1} + \sum_{i=1}^{p} \delta 4 \Delta LNTEM_{t-1} + \sum_{i=1}^{p} \delta 4 \Delta LNARF_{t-1} + \sum_{i=1}^{p} \delta 5 \Delta LNAGC_{t-1} + ECM_t + e_t \quad ...(5)$$

The E.C.M. is the error correction term that provides the speed with which the long-term balance can be adjusted based on the coefficients representing the short-term relationship between variables. The E.C.M. must take on a negative value of -0.5 or more to make the connection.

Results and Discussions

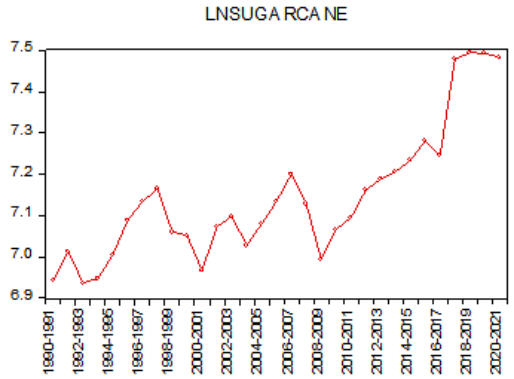
Descriptive Statistics

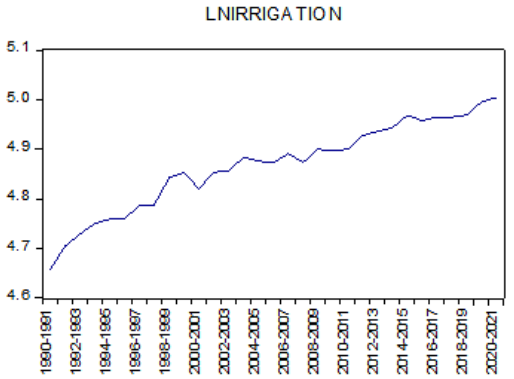
Table 1The mean value of the dependent variable LNSP was given as 7.14, and the standard deviation was given as 0.16. Important independent variables like LNIRR, LNFR, and LNTEMP all had mean values of 4.86, 4.89, and 3.25, and their standard deviations were 0.09, 0.23, and 0.01. Other variables, such as LNARF and LNAGC, had mean values of 6.81 and 5.16, and their standard deviations were 0.15 and 1.51. The trend of the variables over time is shown in Table 1.

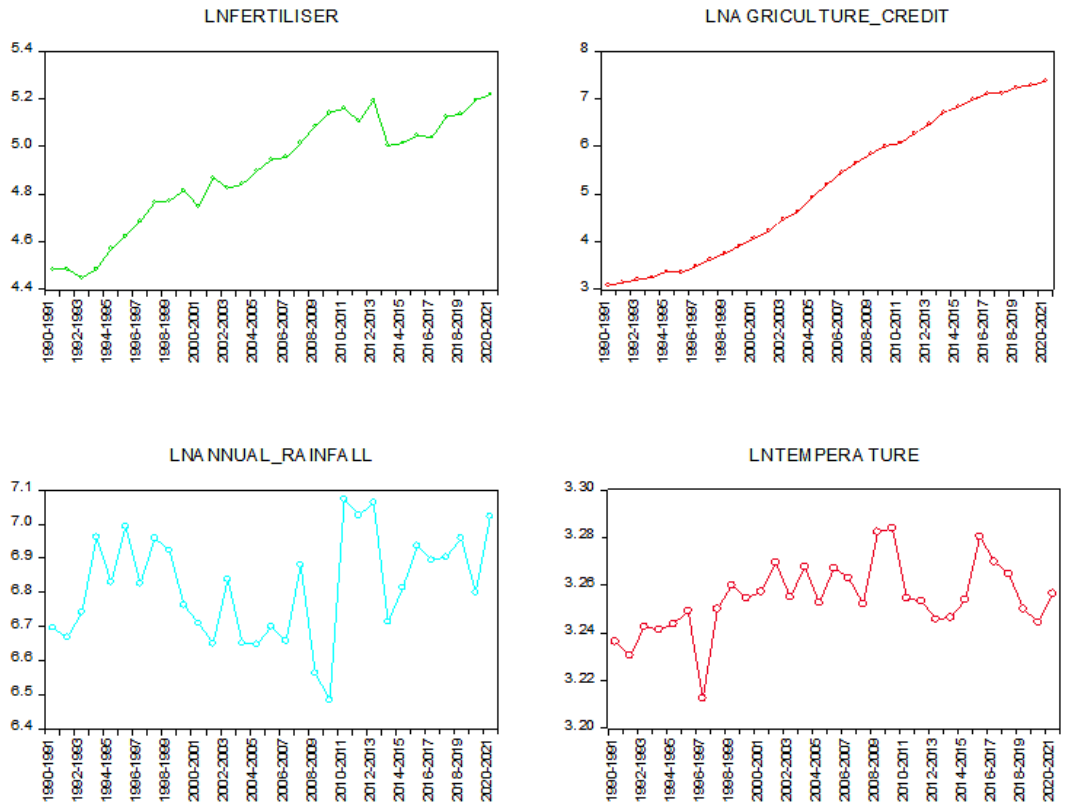
Table 1: Dependent and Independent Variables

	LNSP	LNIRR	LNFR	LNTEMP	LNARF	LNAGC
Mean	7.14	4.86	4.89	3.25	6.81	5.16
Median	7.09	4.87	4.94	3.24	6.82	5.20
Maximum	7.49	5.00	5.21	3.28	7.07	7.37
Minimum	6.93	4.65	4.44	3.21	6.48	3.09
Std. Dev.	0.16	0.09	0.23	0.01	0.15	1.51
Skewness	0.99	-0.50	-0.46	-0.25	-0.13	0.03
Kurtosis	3.21	2.45	2.054	3.83	2.12	1.48
Jarque-Bera	5.12	1.71	2.28	1.23	1.08	2.96
Probability	0.07	0.42	0.31	0.53	0.58	0.22

Sources; Auther calculation E-view 10







Unit Root Test

This study also constructs the ARDL model, which requires that all variables be stable on either I(0) or I(1). This is required for ARDL research. To evaluate the data's unit root, A.D.F., P.P., and other techniques are used. The A.D.F. and P.P. tests are used in conjunction with data traits to determine the unit root of all variable data. Table 3 shows the results of the tests. According to the A.D.F. test, LNSP, LNIRR, LNFR, LNARF, LNTEMP, and AGC are integrated at I(1),

Table 2: Unit root tests of Dependent and Independent Variables

	ADF				PP				
	Level		I Difference		Level		I Difference		
Crop	t-Statistic	P value	t-Statistic	P value	t-Statistic	P value	t-Statistic	P value	Decision
LNSP	-0.37	-0.9	-5.7	0	-0.03	0.94	-5.88	0	I(I)
LNNIRR	-1.34	-0.59	-7.75	0	-1.81	0.36	-8.91	0	I(I)
LNFR	-0.82	-0.79	-7.14	0	-0.72	0.82	-7.02	0	I(I)
LNARF	-3.85	0	-7.4	0	-3.85	0	-15.42	0	I(0)
LNTEMP	-3.43	-0.01	-7.22	0	-3.38	0.01	-9.95	0	I(0)
LNAGC	-1.87	-0.38	-3.23	-0.03	4.25	1	-2.02	0	I(I)

Sources; Auther calculation E-view 10

Co-integration Test

The co-integration test determines whether the variables have in long-term equilibrium. F statistic value is larger than the upper bound I(1) under the significance threshold, the variables have a long-term co-integration connection—table 3 lists ARDL bounds testing results. The best lag structure is (1, 0, 0, 0, 0, 1, 1) since the F statistic value is larger than the upper boundary value at the significance level of 1%. Thus, LNIRR, LNFR, LNTEMP, LNARF, and LNAGC are long-term co-integrated with LNSP at the 1% significant level. After reaching these results, we may investigate the ARDL model's long-term and short-term relationships.

Table 3: ARDL bound test

	Bounds Critical Value		F-Statistic Value
Significance levels	**Lower Bound I(0)**	**Upper Bound I(1)**	
10%	2.26	3.35	
5%	2.62	3.79	3.85
1%	3.41	4.68	

Sources; Authors calculation E-view 10

Table 4: Long-term regression results of Dependent and Independent Variables in the ARDL

variable	Coefficient	Standard Error	t-Statistics	Probability
LNNIRR	2.65	0.80	3.29	0.00
LNFR	-0.91	0.24	-3.81	0.00
LNARF	0.25	0.19	1.31	0.20
LNTEMP	-0.51	2.75	-0.18	0.85
LNAGC	0.08	0.03	2.09	0.05

Sources; Authors calculation E-view 10

As shown in Table 4, agricultural credit has a very significant positive impact on sugarcane production in the long term. Specifically, when the number of agricultural credits increases by 1 percent, it will increase sugarcane production by 0.08 percent in the long term, which is consistent with the previous research[20] when rainfall goes up by 1 percent, the unit production of sugarcane goes up by 0.25 percent. This is in line with the drought area being larger than the flood area, and sugarcane production in Uttar Pradesh is more affected by drought. At the same time, the warming trend has been clear in recent years, and an increase in rainfall can easily offset the risk of drought to sugarcane production. The model looks at how climate change affects India's overall sugarcane production and how it varies by region. The temperature has a bad effect on sugarcane production, but it's not a big deal. This coefficient shows that the sugarcane yield will decrease when the temperature increases. The long-term coefficient may not be important because farmers have gotten agricultural loans and bought new equipment and more advanced technology. This has lessened the effect that high temperatures have on sugarcane production. This finding backs up our previous evidence.[21,06] Due to the lack of data, this study doesn't include any other agricultural technology progress variables besides F.R. This is also an area where more research could be done. Long-term irrigation is also a big part of why the unit yield of sugarcane goes up. Table 5 shows that when irrigation goes up by 1%, the unit yield of sugarcane goes up by 2.65%. This is also how things work in the real world. Most

people agree that making sugarcane requires a lot of work, and most of the arable land in East Uttar Pradesh is in hilly areas where big farming machines can't be used. With more irrigation, planting, farming, and harvesting can all be made better. This rise in unit yield will last for a long time. In the long run, land that has been worked is a valuable asset for a family. Agriculture Credit has a direct effect on sugarcane output, partly because farmers can take advantage of economies of scale and partly because farmland can be used as collateral for bank credit, which can be used to improve planting techniques or buy farm equipment to increase sugarcane yield.

Table 5: Short-term regressionsDependent and Independent Variable

Variable	Coefficient	Standard Error	t-Statistics	Probability
LNNIRR	3.52	0.97	3.59	0.00
LNFR	0.24	0.16	1.51	0.15
LNARF	0.13	0.05	2.17	0.04
LNTEMP	-1.98	0.64	-3.06	0.00
ECM(-1)	-0.85	0.15	-5.55	0.00
C	-1.62	0.29	-5.49	0.00

Sources; Authors calculation E-view 10

Table 6 Summary model

R-squared	0.682507	Mean dependent var	0.01619
Adjusted R-squared	0.55551	S.D. dependent var	0.073272
F-statistic	5.374189	Durbin-Watson stat	2.555115
Prob(F-statistic)	0.001076		

Sources; Authors calculation E-view 10

By setting up ARDL-ECM, this study looks at the short-term relationships between different variables. Table 5 shows that the coefficient of, E.C.M. (1), is -0.85, which is a negative number. This means that the next period will correct 85 percent of the system's deviation from the long-term trend in year. Temperature and rainfall are two other important factors that can explain why sugarcane production goes up or down in the short term. The research can show that this is true.[22,23,24] In particular, when the temperature increases by 1%, sugarcane production decreases by 1.98% in the short term.

On the other hand, when rainfall increases by 1%, sugarcane production goes up by 0.13% in the short term, which is also what happens in Uttar Pradesh. Uttar Pradesh has been getting warmer in the last few decades. In the short term, irrigation is a big part of how sugarcane production is helped. When irrigation goes up by 1%, the amount of sugarcane grown goes up by 3.25 percent.

In the same way, the fertilizer also positively helps sugarcane production in the short term. When F.R. increases by 1 percent, sugarcane production will increase by 0.24 percent. It also gives us more confidence to give farmers more technical help in the future. This study fits with what we know from real life.[25,26]

Table 6 model summaries is given; it shows the value of r-square is 0.6825, which reveals that all the explanatory variables taken in the model explain 68.25 percent variation in sugarcane production

Diagnostic Test

This study uses the CUSUM and CUSUM of squares to test the stability of the ARDL model. Figures 1 and 2 show testing results.

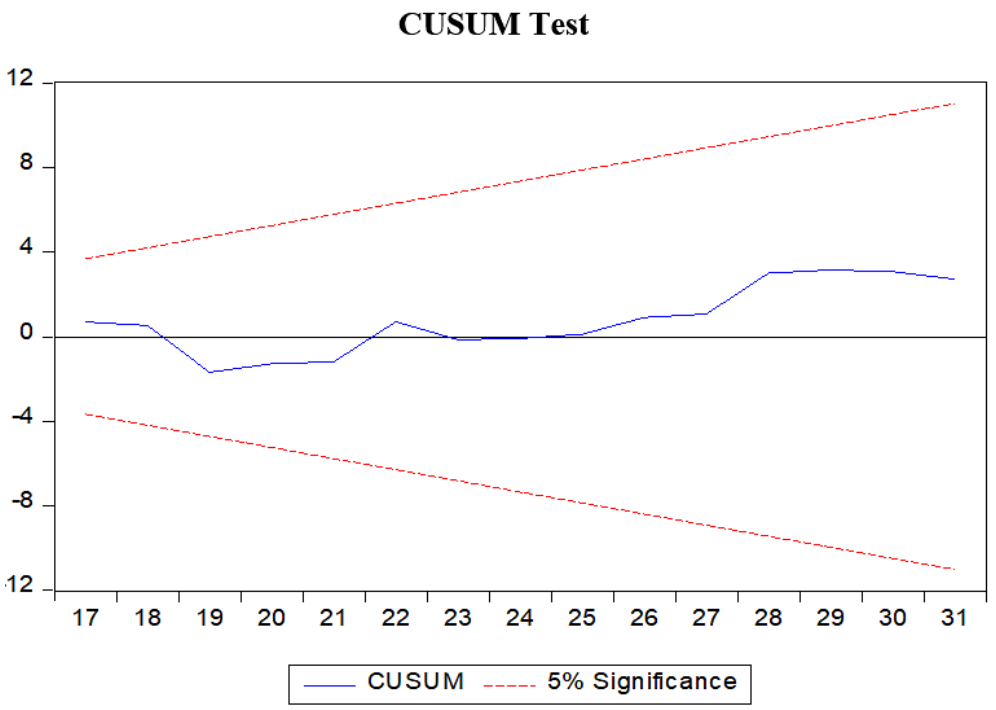


Fig. 1: Dependent and Independent Variables

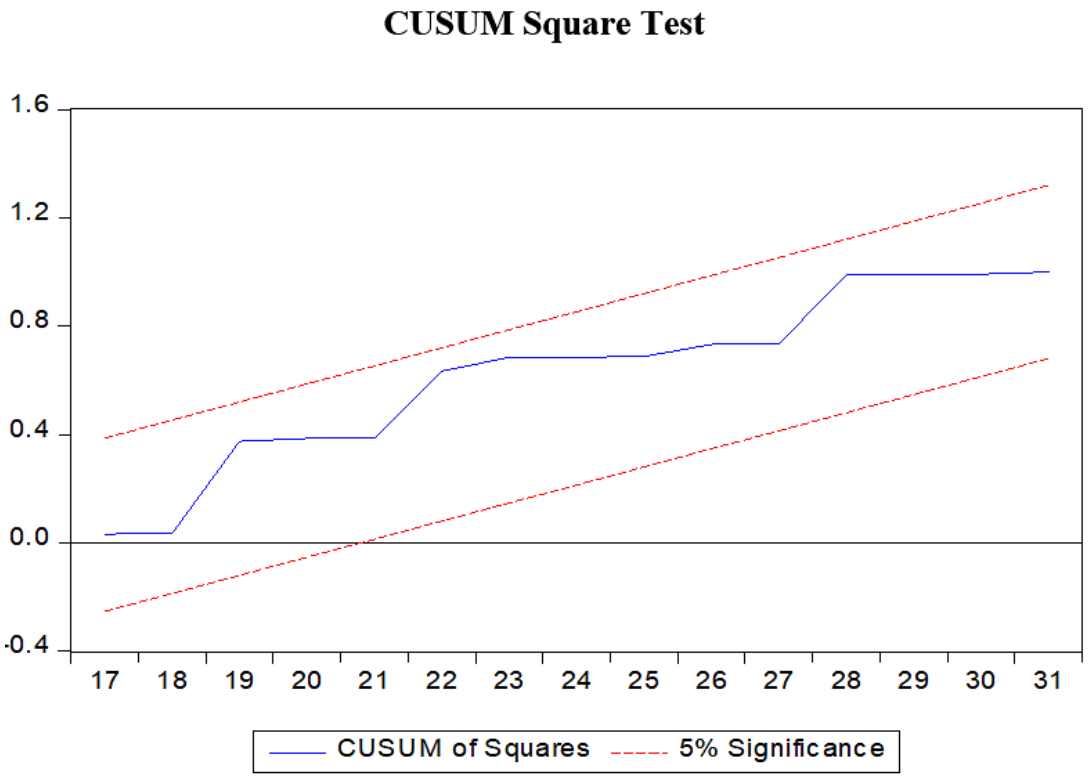


Fig. 2: Dependent and Independent Variables

Conclusions and Policy

The ARDL bounds test results showed a long-term co-integration relationship between sugarcane production, agricultural credit, climate change (through temperature and rainfall), irrigation, and fertilizer. The ARDL model examined the explanatory variables' long-term and short-term effects on sugarcane production. Here's what the results showed.

1. In the short and long term, climate change significantly affects how much sugarcane is grown in Uttar Pradesh. In particular, the temperature has a significant, short-term negative effect on sugarcane production. The temperature hurts sugarcane production in the long term, but it's not a big deal. It could be because farmers have gotten agricultural loans and bought new tools and modern farming methods. This has lessened the effect that high temperatures have on sugarcane production.

2. Rainfall boosts sugarcane production, but the long-term impact is greater. This suggests that Uttar Pradesh's drought response is inadequate and that weather risk on agricultural output should be better managed.

3. Due to agricultural credit, Uttar Pradesh's sugarcane output has recovered from climate change. Agricultural credit boosts sugarcane output both short-term and long-term. Long-term effects outweigh short-term effects . Thus, agricultural credit can mitigate the negative effects of climate change on agricultural output, and the government should promote its supply, especially long-term loans that can be used to improve technology and mitigate climate change.

4. Irrigation shows how far agricultural technology has come, and it also helps sugarcane production in Uttar Pradesh, both in the short and long term. So, based on what we've learned so far, we should continue to make agricultural technology more popular and work harder to get the word out about agricultural machinery.

5. In the long run, fertilizer has a big negative effect on sugarcane production, but in the short run, it has almost no effect, and the short-run effect is stronger than the long-run effect. So, the departments in charge should develop policies to stop fertilizer loss and keep sugarcane production in Uttar Pradesh stable and growing. They insinuated that farmers can get close to economies of scale over time.

But fertilizer has a small but positive effect on sugarcane production in the short term. This is something that needs to be looked into more in the future. Based on the above conclusions, this study thinks that agricultural credit, especially long-term credit, should be encouraged in Uttar Pradesh so that farmers have more money to buy technologies that help them adapt to or reduce the effects of climate change. Even though the amount of agricultural credit in Uttar Pradesh has been growing steadily over the past few years, it needs to grow even more to keep improving sugarcane production and boosting farmers' incomes. This is especially true for long-term credit. At the same time, we need to pay more attention to how drought affects sugarcane growth. Even though the average amount of rain in Uttar Pradesh from June to September has been going up, so has the temperature. Check frequently to see if there isn't enough water in the sugarcane field. The best time to grow sugarcane is from October to November. Especially at the stage of flowering and setting seeds, when the plant needs a lot of water and minerals.

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conflict of Interests

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