J. Agr. Sci. Tech. (2022) Vol. 24(6): 1519-1531

Impact of Climate Change and Technological Advancement on Cotton Production: Evidence from Xinjiang Region, China

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ABSTRACT

China is the largest producer of cotton crop, followed by the United States of America. China's 52% cotton is produced in Xinjiang Region. The agricultural sector depends on the climate, and it is substantially susceptible to future climate changes. Climate factors directly affect cotton production and, therefore, assessing the influence of these factors on the cotton output is imperative. This study empirically investigated the relationship between climate and non-climate variables on Xinjiang Region's cotton production over the last three decades. To this end, an econometric technique was employed and the "Autoregressive Distributed Lag Model" (ARDL) was used to analyze the long-run and short-run relation between the selected variables. Empirical results revealed that a 1% decrease in average temperature, labor force, and rainfall could decrease cotton production by 0.18, 1.94, and 0.18%, respectively, due to the significant negative relation. However, this study depicted 1% rise in average temperature, technological changes, and the cultivated area will increase cotton production by 0.07, 0.05, and 0.23%, respectively. In conclusion, the regional climate changes significantly affect cotton crop. Although the study analyzed the data from XUAR Region, this model can be applied to all developing countries. This research helps the policymakers and the respective government department to introduce, promote, and subsidize environment-friendly production inputs and make the long-term plan for farmers and stakeholders to educate, spread awareness, and help to adopt new skills to gain sustainable regional cotton productivity.

Keywords: Autoregressive Distributed Lag model, Regional cotton production, Xinjiang cotton.

INTRODUCTION

Climate change, especially global warming, is one key to the dilemma that negatively impacts agriculture and society. Intergovernmental Panel on Climate Change (IPCC) has revealed that average global land temperature increased by 0.78% from 2003 to 2013 (Yang, 2003; Li *et al.*, 2011; Luo *et al.*, 2019). Furthermore, the sixth report of IPCC revealed that atmospheric temperature is anticipated to alarmingly rise by 5.7°C by 2100 (Masson-Delmotte, 2021). Over the past years in China, land surface temperature has grown by 0.5-0.8 °C and these climate changes affect the global agricultural economy (Luo *et al.*, 2019). The agriculture sector is severely affected by climate variations (Abbas, 2021; Ali *et al.*, 2021). The increasing temperature has been destroying the productivity of agriculture and causing food insecurity. Over the last decades, many studies have been conducted on the impact of climate changes on the productivity, yield, and growth/development of crops, including cotton crops. Different studies obtained variable conclusions and results subject to types of the crops.

Cotton crop is the most widely grown fiber

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and cash crop worldwide and portrays a dominant role in developing countries' economies. China ranks second in the production of cotton worldwide. Approximately 52% of the total cotton in China is produced in XUAR Region (Wu and Chen, 2015; Bai *et al.*, 2017). In XUAR, cotton crop has been a cash crop for the people. Cotton industry in XUAR supports millions of people including cotton growers, cotton textile workers, labor, and their family members by improving lives and promoting their economic and social rights. Cotton industry provides quality raw material, which benefits hundreds of millions of people directly or indirectly. In recent years, many studies from other regions have explored the impact of climate variations on the cotton crop by using combinations of statistical, regional, and crop modeling.

Several studies concluded that climate warming, change in air, sunshine, and precipitation significantly increased cotton production (Zhenyong *et al.*, 2008; Xiang-ling and Xin, 2011; Chen *et al.*, 2015; Huang and Ji, 2015). It could be inferred that an increasing trend in temperature, which helps plants in receiving more heat for photosynthesis and sunlight, accelerates the growth rate of thermophilic crops. Increasing temperature could positively affect the cotton crop at the beginning and the end of the growing season. Abbas (2020) depicted that cotton crop was more resilient to the temperature because of its vertical tap root. Schlenker and Roberts (2008) found that the threshold temperature level for the cotton crop was 33 °C and concluded that cotton crop output could fall if the temperature increased above this level. The rapid growth of the textile sector (cotton planting area) into areas with unsuitable climate in XUAR Province has reduced the yield and quality of cotton. In addition, average surface temperature in Xinjiang has increased 0.5-0.8°C per decade, affecting the growth of cotton and threatening the stability of cotton yield (Li *et al*., 2011 ; Lu *et al.*, 2018).

Moreover, global warming alters the growth cycle of the cotton crop and decreases the period of flowering-boll opening and retention stage (Boyer, 1982 ; Reddy *et al.*, 1995 ; Wang *et al*., 2017), consequently, shortening the growing period of cotton. Similarly, some studies in the countries situated in tropical areas are under alarming threat due to increased climate temperature. The agriculture sector has been negatively impacted by climate changes such as drought, floods, temperature increase, erratic rainfalls, and newly borne illnesses, all of which distort agricultural productivity. Increasing temperature and less frequent rains are depleting the water resources. Furthermore, water pollution, worse air quality, soil erosion, and low soil fertility are the main risk factors to the environment in Pakistan (Bank, 2006; Blok *et al.*, 2015).

Agricultural technologies include biological inventions and engineering that have opened a new era, and mechanization has increased the output in the agriculture sector. In the modern agriculture system, adopting new technology transforms new knowledge and technologies that could significantly enhance cotton production (Hedenus *et al.*, 2014). Therefore, conventional machinery has been replaced with automation devices to increase per hectare yield (Pan *et al.*, 2020). Additionally, technological innovation, automatic machinery, connected analytical sensors, advanced technology, and improved irrigation system have expanded the cotton crop's scale, speed, and productivity (Latifmanesh *et al*., 2020). Advancements in technologies have altered the U.S. agriculture system and increased per hectare yield (Mumm *et al.*, 2014). Selective seed and molecular techniques address the biological shortcoming and overcome environmental limitations (Gurr and You, 2016). Similarly, conversation systems, consequently, reduce the negative impact on water and soil, which improves environmental sustainability (Hajer *et al.*, 2016).

Different studies have documented that adopting new agriculture machinery, a better quality of fertilizers, and better quality of seeds would increase productivity and reduce the climate impact. All these elements are related to modern science and technology. Additionally, advancement and innovation in agricultural technology mitigate the effects of climate change on the growth of agriculture production (Zewdie *et al.*, 2021). The progress in agricultural technologies, inventions, innovations, and diffusion indicates a breakthrough in the agriculture system, which will increase agriculture production, processing, marketing and reduce the per-unit cost (Lybbert and Sumner, 2012). All these factors would integrate advanced production and labor methods that would transform the labor image and boost the non-agriculture sector, such as communication, transportation, and infrastructure. Consequently, the TFP, social wealth, ecological environment, and economic benefit would be improved (Saliou *et al.*, 2020) and would benefit the whole society, which is an important driving force for the cotton and agriculture sector.

A plethora of literature review revealed that substantial research on climate-changing factors had been conducted on different crops worldwide. Although some researchers investigated the impact of climate changes on cotton production, available studies were based on a single site and few studies considered the impact of technological changes. Therefore, in XUAR, limited information is known about the effect of climate change and technological advancement on Xinjiang's cotton. Consequently, it is imperative to explore how climate changes and technological advancement affects cotton production. It is essential to alleviate such adverse situations to enhance cotton yield. Therefore, the present study was designed to fill the gap in available literature by exploring the robust short and long-run relation between cotton production, climate variables, and other non-climate factors in XUAR over the last three decades (1990-2020) by utilizing the time series data. We aimed to employ different econometric approaches such as the unit root test, ordinary least square approach, Autoregressive Distributed Lag (ARDL), and Johansen cointegration approach. Additionally, the stability of the model was to be tested through numerous diagnostic tests.

MATERIALS AND METHODS

Xinjiang Uygur Autonomous Region (XUAR) is an arid and semi-arid region situated in the northwest of China, and it covers one-sixth area of the country. The unique weather conditions are favorable for producing cotton. This study analyzes the relationship between climate, non-climate variables, and cotton production. For this purpose, the latest secondary data of selected variables are retrieved from the most authentic national sources, and an econometric model, ARDL, is applied to analyze and estimate these variables.

Study Area and Selection

This study analyzed the relationship between climate and non-climate variables with cotton production. The climate variables consisted of temperature, rainfall, and sunshine, while the non-climate variables were cotton output, cotton cultivated area, number of laborers, fertilizer consumption, and number of agricultural machinery. The time-series data of selected variables was taken from 1990-2020 from different national databases. The non-climate variable data was collected from XUAR statistical yearbooks, while climate variables data was collected from China's meteorological data-sharing service network. The description of selected variables is mentioned in Table 1. The primary purpose of this study was to incorporate all variables which can influence cotton production.

Table 1. Description, unit, and source of selected variables.

Variables	Unit	Data source
Cotton production	Ten Thousand tons	Xinjiang Statistical yearbooks
Cultivated area under cotton	Thousand Hectares	Xinjiang Statistical yearbooks
Fertilizer consumption	Tons	Xinjiang Statistical yearbooks
No. of labor used in agriculture	Numbers	China Statistical yearbooks
Technological development	Numbers	Xinjiang Statistical yearbooks
Average minimum temperature	°C	China's meteorological data-sharing
Average Maximum temperature	°C	service network
Average Precipitation	Millimeter	Meteorological Department

Model Description

It is conceivable to examine the relationship between the climate variables, non-climate variables, and cotton production after an extensive literature review on cotton production and regional climate change. The relationship between the selected variables can be expressed as follows,

$$C.P._t = \beta_0 + \beta_1 Ar_t + \beta_2 Fer_t + \beta_3 lab_t + \beta_4 Tech_t + \beta_5 S.S._t + \beta_6 Mint_t + \beta_7 Mtemp_t + \beta_8 Rf_t + \mu_t \quad (1)$$

Where, CP represents Cotton Production, Ar is the cultivated Area under cotton, Fer is the Fertilizer consumption for the cotton, the lab is the agriculture taken as a proxy of the variable, tech is available tractors, and agriculture machinery represents proxy of technological development, SS represents the Sunshine, Mint, and Mtemp represents the average Minimum and Maximum temperature, and Rf represents the average rainfall in the selected period.

Estimation Technique

There are many techniques used to analyze the time-series data. This study used the Autoregressive Distributed Lag (ARDL) model to determine the impact of regional climate and non-climate variables on cotton production. The ARDL approach was initially introduced by Pesaran and Shin (1995) and later extend by Pesaran *et al.* (2001). This approach has many advantages over other cointegration approaches like Engle and Granger (1987) and Johansen and Juselius (1990). First, this technique gives valid results whether all the variables are mixed order of integrations like I(0) or I(I). Second, this technique uses a general modeling framework for data generation by taking sufficient number of lags (Laurenceson and Chai, 1998). Third, it uses the linear transformation technique to calculate both short-run and long-run estimates of all the variables by presuming them endogenous at once. Finally, it is suitable for a smaller sample size. Considering all these advantages, the ARDL model is the most appropriate technique for estimating and analyzing the selected variables.

Applying the unit root (stationarity) test is necessary for the ARDL method. It verifies none of the variables is integrated at I (2) or beyond because the Pesaran *et al.* (2001) technique becomes invalid in the presence of I(2). The study employed the Augmented Dickey-Fuller (ADF) and Phillips-Perron unit root techniques to test the null hypothesis against the alternative hypothesis of stationarity (Dickey and Fuller, 1979).

The ARDL bound cointegration technique is used to check whether all the variables are cointegrated or not. For this purpose, the null hypothesis (H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = \alpha_9 = 0$) is tested against the alternative hypothesis (H_1: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = \alpha_9 \neq 0$) to check the cointegration among the variables. The decision criteria are the value of F-statistics. The variables are cointegrated if the calculated test statistic is greater than the upper bound value. The variables are not cointegrated if the calculated test statistic is less than the lower bounds value. And the result is inconclusive if the F-statistics is greater or equal to lower bound and less or equal to upper bound.

$$\Delta C.P._{i,j} = \beta_0 + \sum_{i.j}^{t} \emptyset \Delta C.P._{t-i,j} + \sum_{i.j}^{t} \theta ar_{t-i,j} + \sum_{i.j}^{t} \delta Fer_{t-i,j} + \sum_{i.j}^{t} \gamma lab_{t-i,j} + \sum_{i.j}^{t} \partial tech_{t-i,j} + \sum_{i.j}^{t} \propto S.S._{t-i,j} + \sum_{i.j}^{t} \forall Mint_{t-i,j} + \sum_{i.j}^{t} Maxt_{t-i,j} + \sum_{i.j}^{t} \tau Rf_{t-i,j} + \varepsilon_t \ldots\ldots \quad (2)$$

The diagnostic and stability tests are performed to analyze the adequacy of the model's specification. The diagnostic test examines the problem of non-normality, functional form, serial correlation, and heteroscedasticity. The stability of long and short-run coefficients is measured by the Cumulative Sum (CUSUM) and Cumulative Sum of Squares (CUSUMSQ) tests (Brown *et al.*, 1975). The plots of these two tests can check the model's stability within the critical bounds of a 5% level of significance.

RESULTS

Climate changes and technological advancement are considered the critical factors that affect cotton production, and the impact of climate changes on cotton production is expected to be severe. Figure 1 shows the box plots of the climate variables, which are illustrated as a horizontal line, median, box-boundaries, 25^{th} and 75^{th} percentiles during the cotton growing season of 1990-2020 at different sites in XUAR. Table 2 shows the result of descriptive analysis, which reveals that the minimum average temperature in XUAR is 12°C, while, in the peak summer, the maximum temperature is about 24.7°C. During the selected time, the minimum rainfall was 108.6 mm, the maximum was 295 mm, and the average sunshine was 2775 hours. (Table 2)

ARDL Lag Selection

The estimation results indicate the lowest value of AIC is (1, 0, 1, 2, 1, 0, 2, 0). However, in the selected model, cotton production and the dependent variable will appear with lag 2, while the independent variable has different lags. (Tables 3 and 4)

The unit root test is applied to analyze the non-stationarity of the selected variables. The result suggests that variables including fertilizer, sunshine, average minimum, average maximum temperature, and average rainfall are non-stationary at the level, while at 1^{st} difference, all variables are non-stationary. Additionally, the Phillips-Perron unit root test is used to check the stationarity of all variables included in the model. The unit root test results suggest using the ARDL bounds testing approach to establish the long-run and the short-run relationship between the cotton productivity and selected variables in the model.

Table 5 indicates the result of the ARDL cointegration test, and it reveals that the computed F-statistics value is greater than the upper and lower bound critical values. Therefore, it is evident that cointegration is present in all selected variables.

Long Run and Short-Run Evidence

Long run and short run estimation results of the selected variables in the study are illustrated in Table 6. The coefficient of cultivation area under cotton crop reveals that a 1% increase in the area could increase cotton production in the long run by 0.23%, and in the short run by 0.22%. Additionally, the coefficient of the area is positively associated with cotton production. While fertilizer and labor's coefficient are negatively associated with production, which means that 1% increase in fertilizer and labor will decrease production by 0.0005 and 1.79% in the long run, and 0.005 and 1.57% in the short run, respectively. The result indicates that agriculture machinery is positively associated with cotton production, which means that a 1% increase in agricultural machinery will increase cotton production by 0.005% in the long run, while 1.46% in the short run. Rashid *et al.* (2020)

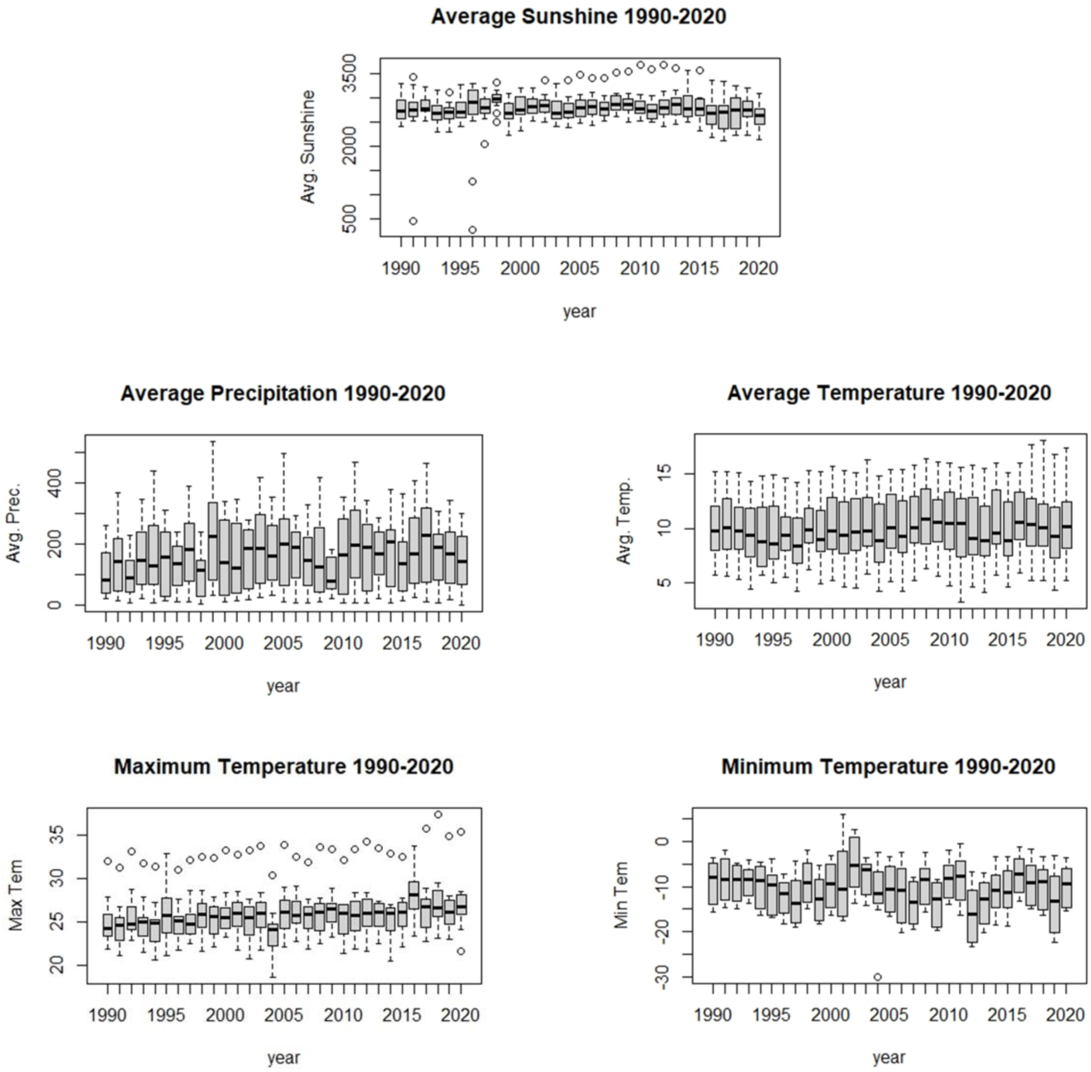

Figure 1. Box plots of the climate variables during the cotton growth season over 1990-2020 at the Xinjiang Uygur Autonomous Region (XUAR).

Table 2. Descriptive statistics of the variable used in the ARDL under different combinations of distributional assumptions.

Abbreviation	Variable name	Mean	Min	Max	J. B. stat
CP	Production	238.6	46.88	516.1	2.61
Ar	Area	1353.3	435.2	2540.5	1.88
Fer	Fertilizer	174782.1	79055.2	311527.3	0.93
Lab	Labor	3351464	2448163	4929119	2.84
Tech	Technological development	13397085	5607600	28556089	3.89
SS	Sunshine	2775	2045.3	3136.6	38.74
Mint	Avg. Min Temp	15.6	12.722.50	18.7	1.2
Maxt	Avg Max Temp	24.7	22.5	27.9	4.4
Rf	Rainfall	175.8	108.6	295.9	12.01

Table 3. Result of Autoregressive Distributed Lag (ARDL) lag selection.

Lag	AIC	SC	HQ
0	-8.165007	-7.846982	-8.045873
1	-20.38733*	-17.52511*	-19.31512*
2	-20.39807	-15.12165	-18.50279

* Indicated lag order selected by criterion; Hannan-Quinn information criteria (HQIC), Akaike Information Criterion (AIC), Bayesian Information Criterion (SBIC).

Table 4. Result of Unit root analysis of selected variables in the study.

	Augmented Dickey-Fuller (ADF) test				Phillips-Perron test			
	I(0)		I(I)		I(0)		I(I)	
	C	C & T	C	C & T	C	C & T	C	C & T
Production	1.72	-2.09	-5.78***	-3.73**	2.78	-1.81*	-5.2***	-9.6***
Area	0.957	-3.32	-6.20***	-6.41***	0.62	-2.72	-8.07***	-11.4***
Fertilizer	-2.73*	-3.83***	-7.72***	-7.58***	-2.61	-3.83***	-12.28***	-11.8***
Labor	-1.56	-4.14***	-3.75***	-3.18*	-1.56	-0.83	-4.57***	-4.35***
Technology	3.65	0.065	-1.20	-3.89**	3.04	-1.17	-2.40*	-3.49**
Avg. Sunshine	-6.16***	-6.40***	-4.66***	-4.85**	-6.2***	-8.14***	-28.9***	-26.96***
Avg. Min temp	-3.562*	-5.83***	-4.89***	-4.75***	-3.45*	-12.62***	-26.48***	-25.78
Avg. Max temp	-4.40***	-5.73***	-4.66***	-4.66***	-4.44***	-12.14***	-24.63***	-26.59***
Avg rainfall	-4.79***	-4.92***	-8.79***	-8.77***	-4.94***	-4.78***	-13.95***	-14.81***

***, ** and *: Denote significance at 1, 5, and 10 percent, respectively.

Table 5. ARDL bound cointegration test.

Variable	F-Stats	Cointegration
Production	10.96	Exist
Area	6.61	Exist
Fertilizer	14.38	Exist
Labor	47.16	Exist
Technology	7.94	Exist
Sunshine	15.60	Exist
Avg min temp	6.75	Exist
Avg max temp	10.92	Exist
Avg rainfall	12.04	Exist
Significance level	Critical values	
	Lower bounds	Upper bounds
10%	1.85	2.85
5%	2.11	3.15
2.5%	2.33	3.42
1%	2.62	3.77

argued that agricultural machinery had made agriculture practices more efficient and effective. The average minimum temperature coefficient is negatively associated with cotton production, which is in line with results of Abbas (2020) and Rashid *et al*. (2020), giving clear evidence that a higher temperature is better for the cotton crop. In comparison, previous literature concluded that the threshold temperature for cotton crop was around 32ºC, which could enhance cotton output (Raza, 2009; Schlenker and Roberts, 2009; Malik and Ahsan, 2016). Additionally, the average higher temperature coefficient indicates that a 1% increase in temperature will increase cotton production by 0.07% in the long run. An increase in rainfall is also

Table 6. Result of long and short-run dependent variables.

Dependent variable: Productivity			
Long run result			
Variable	Coefficient	St. Error	t-stat
Area	0.23***	0.04	5.06
Fertilizer	-0.0005**	0.00	-3.69
Labor	-1.94*	2.56	-1.92
Technological adv	0.005***	0.0003	-0.060
Sunshine hours	0.016**	0.02	0.061
Avg min temp	-0.189*	3.13	-0.06
Avg max temp	0.070**	2.75	0.25
Avg rainfall	-0.18*	3.13	-0.61
Short Run			
Coin Eq (-1)	-1.07	0.05	18.87
Area	0.22***	0.037	5.93
Fertilizer	-0.0005*	0.0002	-2.28
Labor	-1.57**	3.07	-1.48
Technological adv	1.46	3.73	3.91
Sunshine hours	0.015*	0.026	0.56
Avg min temp	-0.175*	2.88	-0.06
Avg max temp	-1.59*	0.096	-1.03
Avg rainfall	-0.100	180.4	0.78
Diagnostic test			
Diagnostic test	F-Stat		P-value
LM test	0.15		0.69
X^2 Breusch-Pagan-Godfrey	1.40		0.51
X^2 Remsay	0.035		0.85

***, **, and *: Denote significance at 1, 5, and 10 percent, respectively.

negatively associated with cotton production. A possible cause for this inverse relationship could be that rainfall decreased temperature.

Model's Consistency

After estimating ARDL long and short run, the model's consistency is checked by the cumsum and cumsum square test. The result of the consistency model is mentioned below in Figures 2 and 3. The model is perfectly aligned and plotted within the 5% significance.

DISCUSSION

This study assessed the impact of climate variation using the ARDL model and concluded that increasing temperature positively affects cotton production. A similar finding was also analyzed by Abbas (2020) and Rashid *et al*. (2020). Our study found that, in the case of XUAR, an increase in the average temperature positively affects overall cotton production. A decrease in average temperature negatively influences the XUAR region. Similarly, Li *et al.*(2020) found that cotton crop is more vulnerable to the minimum temperature in the Xinjiang region. And Prabnakorn *et al.* (2018) predicted that an increase in minimum temperature on rice yield responded negatively. Similarly, Chandio *et al.* (2020) analyzed relationship of climate variables, CO_2, and rice production. They revealed that all variables, including temperature change and CO_2 emission, show a significant and positive relationship with rice production. Abbas and Rashid investigated the relationship between cotton production and climate change. They revealed that

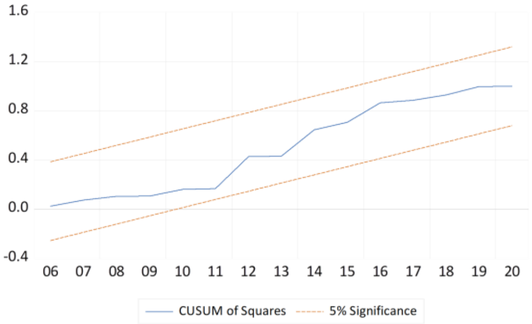

Figure 2. Result of CUSUM squares test to analyze structural change.

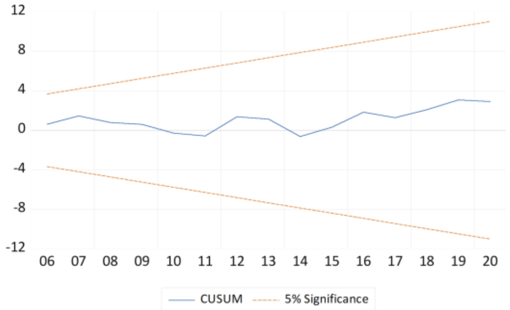

Figure 3. Result of CUSUM test to analyze structural change.

maximum rainfall and maximum temperature significantly affected cotton production, while minimum temperature negatively affected cotton production. Furthermore, both studies urge that it is necessary to focus on strategies to mitigate climate change factors, adopt environment-friendly production techniques, improve the water conservations to produce sustainable cotton in the area (Abbas, 2020 ; Rashid *et al.*, 2020).

In this study, the empirical results explained that there could be a complex nonlinear relationship or linear relationship between cotton production and climate change variables in the XUAR Region. It indicates that the response of cotton growth to climate variations is more complex. Xinjiang is an arid and semi-arid zone and, given the critical role of rainfall in agriculture, the impact of rain on cotton growth was negative. Different studies show that the ideal temperature for the cotton crop is 32ºC, while, during the growing season of cotton crop in XUAR, the maximum temperature rises to 28ºC. This study results show that an increase in average rainfall negatively correlates with cotton production in the long and short run. The possible cause could be the rainfall that decreases the temperature during the cotton-growing season. First, the selected variables themselves may exert significant control on cotton production during the study. Second, there may be the combined influence of climate changes. Thirdly, these variables may be associated with other variables that play a vital role in cotton production. Previously published results explained that the Autoregressive Distributed Lag (ARDL) cointegration technique had a role in obtaining a good relationship between cotton production and climate change variables. However, due to the regional differences in different climate factors, different crops, different study periods, etc., the crop response to the climate has also varied accordingly. Production of the cotton crop, its growth, and its development process is complex. Therefore, climate variations makes it challenging for the cotton crops growth and yield.

CONCLUSIONS

This study empirically investigates the impact of technological advancement like overall agricultural machinery, combine harvesters, ploughs, seeders, planters, transplanters, and climate variables on the cotton production of Xinjiang Uygur Autonomous Region (XUAR), China, from 1990 to 2020. Additionally, this study includes non-climate variables such as the cultivated area under cotton crop, labor force as a proxy variable for the cotton labor force, fertilizer consumption, and infrastructure. This study reveals that climate variables' average change in maximum temperature is positively associated with cotton yield. However, moderate rainfall and average minimum temperature have a significant negative relationship with cotton crop production. In contrast, a previous literature review in the Asian region shows the adverse effect of increasing maximum temperature on cotton productivity. An increase in the maximum temperature above 32°C can decrease cotton productivity, which provides enough reason for reducing the emission of CO_2. Reduction in CO_2 will help to reduce the maximum temperature and increase the average rainfall. However, in XUAR, as the climate is cold, an increase in average precipitation negatively affected cotton production. The findings suggest that the government should make policies that attract investment to automate and adopt new technology in the agriculture sector.

Moreover, the respective departments should play their role in facilitating the farmers' knowledge, awareness regarding new technology, and relevant agriculture skills to select the appropriate input and quantity to cope with the rapidly changing climate and weather and get the optimum cotton yield. This research had some limitations since it analyzed only the relationship between climate changes, technological advancement, and cotton production over the past three decades. However, there is certainly room for improvement by considering other inflectional factors that were not considered due to limited data availability. Future studies should focus on investigating the impact of CO_2, sunshine, and airflow on micro-level crop production.

ACKNOWLEDGEMENTS

The first authors are very grateful to the Chinese Government Scholarship Council for their support during this research tenure. We also acknowledge the support of China Meteorology Department, and China and Xinjiang Bureau of Statistics. This research work was supported by the Major Social Science Projects of Inner Mongolia Autonomous Region, China (Grant No.: 2018ZGH006 and 2018ZDA004).

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تاثیر تغییرات آب‌وهوایی و پیشرفتهای فناوری بر تولید پنبه: شواهدی از منطقه Xinjiang در چین

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چکیده

چین بزرگترین تولید کننده محصول پنبه است و پس از آن ایالات متحده آمریکا قرار دارد. ۵۲% پنبه چین در منطقه سین جیانگ(Xinjiang) تولید می شود. به طورکلی، بخش کشاورزی به آب‌وهوا بستگی دارد و به طور چشمگیری در برابر تغییرات آب‌وهوایی آینده حساس است. عوامل آب‌وهوایی مستقیماً بر تولید پنبه تأثیر می گذارد و بنابراین ارزیابی تأثیر این عوامل بر تولید پنبه ضروری است. این مطالعه به طور تجربی رابطه بین

متغیرهای آب‌وهوایی و غیر آب‌وهوایی را با تولید پنبه منطقه سین جیانگ طی سه دهه گذشته بررسی کرد. برای این منظور، از یک تکنیک اقتصادسنجی استفاده شد و از "مدل تاخیر توزیع شده خود رگرسیون" (ARDL "autoregressive distributed lag model":) برای تحلیل رابطه بلندمدت و کوتاه مدت بین متغیرهای انتخابی استفاده شد. نتایج تجربی نشان داد که کاهش ۱ درصدی در میانگین دما، نیروی کار، و بارندگی می‌تواند تولید پنبه را به دلیل رابطه منفی معنی‌دار به ترتیب ۰/۱۸%، ۱/۹۴% و ۰/۱۸% کاهش دهد. با این حال، نتایج این پژوهش نشان داد که ۱% افزایش متوسط دما، تغییرات تکنولوژیکی، و سطح زیر کشت، تولید پنبه را به ترتیب ۰.۰۷% ، ۰.۰۵ % و ۰.۲۳ % افزایش می دهد. نتیجه‌گیری اینکه، تغییرات آب‌وهوایی منطقه ای به طور معناداری بر محصول پنبه تأثیر می گذارد. اگرچه این مطالعه داده‌های منطقه XUAR را تجزیه و تحلیل کرد، اما این مدل می‌تواند برای همه کشورهای در حال توسعه اعمال شود. این پژوهش به سیاستگذاران و نهادهای دولتی مربوطه کمک می‌کند تا نهاده‌های تولید سازگار با محیط زیست را معرفی، ترویج و یارانه بدهند و برنامه‌ای بلندمدت برای کشاورزان و ذی‌نفعان برای آموزش، گسترش آگاهی و کمک به کاربرد مهارت‌های جدید برای دستیابی به بهره‌وری پایدار منطقه‌ای برای پنبه تهیه کنند.