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Assessing the impact of green finance on cereal crops production: A mediating role of climate change in major Asian crops producing countries

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Abstract

Climate change poses significant threats to agriculture sector in major Asian crops producing countries which resultantly, compromising global food security and economic growth. Therefore, this research paper investigates impact of green finance (GF) on the agriculture sector from 2015 to 2023 using causal mediation analysis approach. We examine the relationship among Green Finance using green bond financing (GBF), climate change variable, greenhouse gases emissions as a mediator, and for agricultural productivity taking cereal crop production as a proxy variable. The findings reveal a positive and significant impact of GBF while climate change negatively affects cereal crops production. The study also finds that GBF has potential to mitigate the adverse impacts of climate change on cereal crops production. The findings underscore the urgent need for climate adaptation and resilience measures to safeguard global food security and economic stability of these Asian countries. The study contributes to the existing literature by providing empirical evidence on the effectiveness of GBF in supporting climate-resilient agricultural practices.

Key words: Green Finance, Cereal Crop Production, Climate Change, Asian countries, Mediation role, Panel Regression, Causal Mediation

1. Introduction

some eighty-five thousand participants including heads of states and governments, businessmen, academicians, youth, international organizations and local civil society from 154 countries appeared in United Nations Climate Change Conference (COP28) held in December 2023 in Dubai and agreed upon to cut down the global greenhouse gasses emission by 43% until 2030. “We have found that path, said COP28 President, Dr. Sultan Al Jaber during his closing speech. We have worked very hard to secure a better future for our people and our planet. We should be proud of our historic achievement.” This conference ends with unanimous agreement to mitigate the

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impacts of climate change on the world in general and developing countries, which severely hit by daunting challenges (2023 UN Climate Change Conference (UNFCCC COP 28).

Climate change is one of the biggest challenges today facing by humanity, with far-reaching adverse ramifications in various aspects of life, including agriculture and food security. Rising temperature causing glaciers to melt, imbalance in rain precipitation and changes in weather patterns, which resultantly affected the crops production (Bedemo, 2022). It is forecasted in the last quarter of the 21st century that the average temperature of earth further rises because of rapid and massive emissions of greenhouse gases into the atmosphere. Global food insecurity also becomes a major threat for the increasingly populous world because of climate change, which consequently turns down the numbers of crops production.

In the agricultural sector, Cereal crops production is highly susceptible to climate change because of its reliance on climate-sensitive factors such as temperature, precipitation, and soil moisture. Cereal crops, including wheat, rice, maize, and barley, are staple foods for a large portion of the global population, making them crucial for food security and economic stability. Shockingly, environmental scientist predicts warmer earth in the forthcoming period of 30 years at the pace of roughly 0.2 Celsius per decade. Likewise, research also reveals that emission of greenhouse gases in the outer atmosphere causes global average earth temperatures rise from 2.5 to 4.5 Celsius by nearly the conclusion of the 21st century (Wang, 2018). Therefore, it is evident that the more presence of greenhouse gasses in environment results rise in average temperature which consequently effects the crop production of climate hit countries, Major Asian Crops producing countries particularly the members of Major Asian Crops producing Association for Regional Cooperation and China majorly responsible for global food supply. Moreover, the already weak economic growth of these counties is another concern, which can further be intensified due to low cereal crops production. Climate change affects Cereal crops production in multiple ways, including but not limited to temperature rise, uneven precipitation patterns, and frequently occurring of extreme weather events. Multiple weather prone factors causing low production yield such as rising temperature leads to heat stress in crops affecting their growth and development, droughts and floods result in reduced crop yields and quality. Additionally, increased occurrence and ferocity of extreme weather events become normal, like storms and hurricanes, which cause physical damage to crop that further endanger global food supply (Chandio & Jiang, 2022).

Several countries are major producers of cereal crops, accounting for a significant portion of global production. These countries also include major six countries of Southeast Asia: China, India, Pakistan, Bangladesh, Nepal, and Sri Lanka, among others. These countries play a very critical role in ensuring food supply across the world. So, it becomes important to study in the setting of climate change and agriculture production (Sahu, 2010).

Cereal crops production has a significant impact on the economic growth of countries, predominantly in evolving economies, which heavily rely on agriculture. Changes in Cereal crops production can affect the overall economic growth, employment, and income levels in these countries. Moreover, fluctuations in cereal crops production can also impact food prices, inflation, and trade balances, further affecting the economic stability of these countries. (Shafique, 2017).

Despite growing concerns about rapidly changing climate, there exists a significant knowledge gap regarding the specific effects of climate finance on cereal crop production and mediating role of climate change in major Asian crop producing countries which are specifically the most undesirably affected by climate change. This has become pertinent when a region is known as critical to global food supply chain. While existing literature has explored climate changes global and regional impacts on agriculture, few studies have explored relationship between climate finance, climate change and cereal crop production in major Asian crops producing countries and studied the potential of green bond financing as a mitigation strategy for climate-resilient agriculture practices. Furthermore, this highlights the vital need for mitigation and adaptation strategies to safeguard global food security food. The lack of empirical evidence on the efficacy of green bond financing in supporting climate-smart agricultural practices undermines efforts to scale up sustainable agriculture initiatives. The research has made an effort to examine impact of climate finance on cereal crop production in India, Pakistan, Bangladesh, Sri Lanka, and China. In addition, this has also found that how does climate change mediates the relationship between cereal crop productions and climate finance. Further, does climate finance support climate-resilient agricultural practices in South Asia? The findings of this research will not only contribute to the existing literature on climate change and agriculture but also provide policymakers and stakeholders with important information to develop effective strategies to mitigate the impacts of climate change on Cereal crops production and ensure food security and economic stability in the top crop producing countries.

2. Literature Review

Previous studies have extensively examined the impact of climate change on agriculture, including Cereal crops production. For example, (Lobell, 2012) found that rising temperatures have a negative effect on wheat, rice, and maize yields. Similarly, (Roberts, 2009) highlighted the detrimental impact of temperature increases on maize and soybean yields in the United States. In addition, (Raza, 2022) also highlighted that climate change is growing challenge for Pakistan's agriculture sector because 60 percent agriculture crops derived from rain-fed areas. Increasing earth temperature changing weather patterns drastically, particularly the precipitation patterns including a shift in our monsoon season. So, this changing situation directly effects crops production in Pakistan. Global warming has significant impact on agriculture sector in Pakistan, (Yaseen, 2017).

Similarly, the same phenomenon has been observed in Sri Lanaka and India as (Mendis, 2023) found that evidence proposed climate change will negatively impact agriculture sector in countries and small islands in South Asia particularly Sri Lanka. In the same way, climate change reduces 4.5 percent to 9 percent major crops output during 2010-2039 in the short run while in the long run this impact is even more drastic and could reduce crop production by 25 percent in absence of any adaptation (Guiteras, 2009). I continuity, the perceived negative impact from aforementioned studies has also been substantiated by (Prakash, 2024). The elements, which causes adversative effects on agricultural operations, such as planting, tending, and harvesting crops mainly are drought, storms, flooding, delayed monsoons, and variations in seasonal temperatures. Climate change impact the rain and temperature patterns, which adversely hit the

agricultural production (Charoenratana, 2024). Green finance helps in mitigation and adaptation of climate resilient or green agricultural practices, which resultantly enhance agricultural productivity. Whereas, in different Chinese region green finance reduce carbon emissions (Hao, 2025; Shi, 2025).

Few studies explore the connection between climate change and economic growth as (Dell, 2012) found that higher temperatures reduce economic growth in poor countries, with agriculture being most affected which is a major contributor in national economy. Similarly, (Burke, 2015) found that climate change could reduce global GDP by up to 23% by the end of the century, with agriculture being a major driver of this decline. Mendis (2023) disclosed that reduction in output of crop production may cause rise in inflation and less household consumption consequently rises food insecurity and negatively impact GDP thereon. Climate change has negative impact on Indian GDP (Prakash, 2024).

Anthropogenic (man-made) Global Warming (AGW), the question builds upon this theory which examines the effects of climate change on cereal crop production. This theory informs the research questions: How does climate change affect cereal crop production in Asia? Second, the Green Finance Theory explores financial mechanisms for climate change mitigation and adaptation, including green bond financing for climate-resilient agriculture. This theory examines that green finance considers environmental benefits to human beings (Razzaq, 2022). Research questions addressed include: Can green bond financing support climate-resilient agricultural practices in South Asia?

This research study is grounded in three theoretical frameworks: First, Anthropogenic Global Warming (AGW) theory, which states that people are familiar with this as climate change theory. This theory states that predominantly man-made greenhouse gasses (GHG) emissions are responsible for extreme weather conditions, floods, droughts and crops failures. It reveals that the disasters become regular if temperature constantly rises, however, the reductions in GHG emission can save the planet (Gore, 2006). AGW theory develops the hypothesis H1 which assumes that climate change negatively affects agricultural production. Whereas hypothesis H2 that primarily states that Green Financing (GF) positively influences agriculture sector in major Asian countries. This notion substantiates by GF theory that provides a basis for H2 and states that green finances are the funds which uses to support climate change mitigation and adaptation drives against adverse effects of climate change. GF investments in sustainable agricultural practices increases crops production and enhances climate resilient infrastructure. Furthermore, the relationship between agriculture sector and GF is mediated by climate change, as guided by H3; climate change mediates the relationship between GF and agricultural crops production. This hypothesis implies that green financing helps in mitigation of the undesirable impacts of climate change on crops production, highlighting the crucial role of climate finance in promoting sustainable agricultural practices and enhancing food security. Therefore, this study aims to bridge these research gaps by investigating the relationships between green finance, climate change, and agricultural produces, ultimately informing evidence-based strategies to promote climate-resilient agriculture in major Asian crops producing countries.

3. Methodology

This study employed quantitative research design, utilizing secondary data from 2015 to 2023 sourced from the World Bank Data Portal and Climate Bonds Initiative. Panel Causal mediation regression analysis is conducted using Statistical Analysis System (SAS) to examine the relationships between green financing, climate change, and agriculture sector. The variables included cereal crop production (CCP) in metric ton, green bond financing, (GBF) in billion US dollar and greenhouse gas emissions measured in Kilo Tons (KT) with the study estimating the direct and indirect impacts of green bond financing on cereal crop production using climate change as mediation.

[1] Direct Effect of Green Finance on Cereal Crop Production

$$CCP_{i,t} = \beta_O + \beta_1 GF_{i,t} + \varepsilon_{i,t} \qquad (1)$$

[2] Indirect Effect of Green Finance on Climate Change

$$CC_{i,t} = \beta_O + \beta_1 GF_{i,t} + \varepsilon_{i,t} \qquad (2)$$

[3] Effect of Climate Change on Cereal Crop Production

$$CCP_{i,t} = \beta_O + \beta_1 CC_{i,t} + \varepsilon_{i,t} \qquad (3)$$

[4] Combined Effect of Climate Change and Green Finance on Cereal Crop Production

$$CCP_{i,t} = \beta_O + \beta_1 CC_{i,t} + \beta_2 GF_{i,t} + \varepsilon_{i,t} \qquad (4)$$

3.1. Variables description

- $CCP_{i,t} = (DV)\ Cereal\ Crop\ Production\ (in\ metric\ tons)$
- $\beta_O = represents\ constant$
- $\beta_1 CC_{i,t} = (Mediator)$ Represents the variables estimate whereas CC Denotes climate change which is measured through Greenhouse Gas Emissions (in kilo tons)
- $GF_{i,t} = (IV)\ For\ Green\ Finance, Green\ Bond\ Financing\ (in\ billion\ USD)$
- $\varepsilon_{i,t}$ = Error term or unexplained variation in dependent variable
- $(i, t) =$ 'I' represents entity in this case major Asian crops producing countries, and 't' time period in years.

4. Results Discussion and Analysis

Table 1 presents the descriptive statics of the study variables include Greenhouse Gas (GHG) emissions measured in kilotons (KT), Cereal Crop Production (CCP) in metric tons (MT), and Green Bond Financing (GBF) in billion USD. The average GHG emissions of five major Asian crop-producing countries are 2,886,779.5 KT, high standard deviation of 4,296,505.21 KT with minimum (27033.5) and maximum (12942868.3) emissions indicates more variation. This variance signals that few among the selected countries are emitting more GHG and some contribute less.

Table 1: Study Descriptive Statistics

Variable	Mean	Median	Std Dev	Kurtosis	Skewness	Min	Max
GHG KT	2886779.5	400203.7	4296505.21	0.71	1.48	27033.5	12942868.3
CCP-MT	211122760.4	59185501	237496686.9	-0.89	0.86	2579086	633293471
GBF	2.58	0.15	4.47	2.83	1.94	0.01	16.3

Likewise, the mean CCP of 211,122,760.4 MT shows considerable production levels, but the high standard deviation and right skewness (0.86) suggest considerable differences among the countries production level which are primarily due to the size and amount of cultivable land area available in each country. Similarly, average GBF 2.58 billion USD with a huge CV 173.57%, specifies extreme variability in financing levels, indicating that while some countries invest heavily in green bonds, and others less.

Table 2: Correlation Matrix

Pearson Correlation Coefficients, N = 45			
Variables	GHG_KT	CCP_MT	GBF
GHG_KT	1		
CCP_MT	- 0.93876	1	
GBF	- 0.7866	0.83625	1

Table 2 shows correlation analysis, which indicates that (GHG_KT) and CCP_MT share a strong negative correlation with a coefficient of - 0.93. However, GBF reveals a strong positive relationship with CCP (0.83625) and on the contrary GHG_KT and GBF correlate negatively (-0.7866).

Table 3: The causal mediational analysis

Summary of Effects						
	Estimate	Standard Error	Wald 95% Confidence Limits		Z	Pr > |Z|
Total Effect	0.3888	0.07097	0.2497	0.5279	5.48	<.0001
Controlled Direct Effect (CDE)	0.1666	0.08807	-0.00602	0.3392	1.89	0.0585
Natural Direct Effect (NDE)	0.1779	0.0941	-0.00656	0.3623	1.89	0.0587
Natural Indirect Effect (NIE)	0.2109	0.0469	0.119	0.3028	4.5	<.0001
Percentage Mediated	54.2513	17.3672	20.2123	88.2904	3.12	0.0018
Percentage Due to Interaction	-2.9005	4.0534	-10.845	5.044	-0.72	0.4743
Percentage Eliminated	57.1518	16.5929	24.6303	89.6733	3.44	0.0006

After investigating correlations among variables shown in table 2 now**,** Table 3 consists of CAUSALMED procedure which is applied using SAS in order to explore the relationship between the treatment variable, independent, (GBF) and the outcome variable (CCP_MT_log), in presence of the mediator variable which is GHG_KT_log that playing a significant role. The findings in the similar table show significant Total Effect (TE) of GBF on CCP-MT as indicated by the ($p < 0.0001$) with an estimate of 0.3888. The control direct effect (CDE), while controlling the

influence of mediator variable, showing marginal significance at 10 % (p0.0585). Likewise, significance has been observed for Natural Direct Effect (NDE that also shows p value 0.0587, which is significant at similar significance level. However, the Natural Indirect Effect (NIE), impact of treatment on outcome variable through mediator, provides evidence of highly significant role of mediator with $p < 0.0001$ and coeffienciant 0.2109. Particularly, it is observed that nearly 55% of TE is mediated by the GHG_KT_log ($p = 0.0018$), this relationship triggers the importance of understanding climate change impacts in the sectoral ecosystem. Moreover, percentage eliminated shows that 57.15% of TE is eliminated in absence of mediation in finding the relationship between GF and agriculture sector produces of these major Asian countries, $p = 0.0006$) emphasizing extensive role of mediator in the model. At large, the result shows that climate change is a vital mediator in the modeling relationship between GF and agricultural cereal crops produce.

Table 3: The causal mediational analysis with four-way decomposition

Percentage Decompositions of Total Effect							
Decomposition	Effect	Percent	Std Error	Wald 95% Confidence Limits		Z	Pr > |Z|
NDE+NIE	Natural Direct	45.75	17.37	11.71	79.79	2.63	0.0084
	Natural Indirect	54.25	17.37	20.21	88.29	3.12	0.0018
CDE+PE	Controlled Direct	42.85	16.59	10.33	75.37	2.58	0.0098
	Portion Eliminated	57.15	16.59	24.63	89.67	3.44	0.0006
TDE+PIE	Total Direct	39.95	15.96	8.66	71.23	2.5	0.0123
	Pure Indirect	60.05	15.96	28.77	91.34	3.76	0.0002
NDE+PIE+IMD	Natural Direct	45.75	17.37	11.71	79.79	2.63	0.0084
	Pure Indirect	60.05	15.96	28.77	91.34	3.76	0.0002
	Mediated Interaction	-5.8	1.73	-9.18	-2.42	-3.36	0.0008
CDE+PIE+PAI	Controlled Direct	42.85	16.59	10.33	75.37	2.58	0.0098
	Pure Indirect	60.05	15.96	28.77	91.34	3.76	0.0002
	Portion Due to Interaction	-2.9	4.05	-10.84	5.04	-0.72	0.4743
Four-Way	Controlled Direct	42.85	16.59	10.33	75.37	2.58	0.0098
	Reference Interaction	2.9	3.84	-4.62	10.42	0.76	0.4495
	Mediated Interaction	-5.8	1.73	-9.18	-2.42	-3.36	0.0008
	Pure Indirect	60.05	15.96	28.77	91.34	3.76	0.0002

Four Way Decomposition in table 4 explores that merely 42.85% percent of the TE credited to CDE of treatment variable on outcome in absence of mediation of climate change, meaning that 42.85% impact on CCP is because of GBF even without interaction. This highlights the importance of direct relationships. On the other hand, reference interaction shares just 2.9% to the TE, which is statistically insignificant. Markedly, Pure Indirect that contributes maximum to the TE (60.05%), it infers that GBF largely influence agricultural production of Asian countries through the climate change. Therefore, the results conclude that mediation plays a crucial role in exploring the impact of GBF on CCP.

The results of this study have significant implications for policymakers and stakeholders in the agricultural sector. Firstly, the positive impact of green bond financing on cereal crop production suggests that investing in sustainable agricultural activities through green financing can lead to increased cereal crop production and the similar results are supported by (Hao, 2025) whose results showed that GF reduces carbon emissions and helps in adaption of green infrastructure which consequently, reduces climate change prone adverse events. It means climate finance can play a significant role in mitigating adverse impacts of climate change on the agricultural sector across the world in general and of Asian countries such as Pakistan, India, China, Bangladesh and Sri Lanka in particular. This way by adapting, climate resilient agricultural practices not only increase production levels but also ensure global food security. Secondly, as this study highlights that the more GHG emissions in the atmosphere, lessen the agricultural productivity. GHG emissions, which are both directly and indirectly linked with crops production. Therefore, the negative relationship between GHG emissions and CCP signifies the need to control this undesirable effect of changing climate particularly on agricultural products to ensure sustainable agricultural production, thereon, safeguard global food security. These results are also substantiated by the (Gore, 2006) AWG theory. Lastly, the mediation role of climate change highlights significance of green finance, which positively affects crops production by reducing GHG emissions. This means green finance has the potential to promote sustainable agricultural practices by adapting green practices, which consequently depletes GHG emissions footprints from the environment. Likewise, results have been reported by (Mendis, 2023).

5. Conclusion

In conclusion, the research has made an effort to examine the impact of green finance on agricultural production of major Asian crop producing countries, which are also severely hit by climate change elements, with attention on the interceding role of climate change. The results reveal that GBF has a significantly positive relationship with cereal crops production which further become prominent by inverse relation of GBF and climate change. Further, the research also concludes that GHG emissions shares a negative relationship with cereal crops production. Meaning, increasing GHG emissions decreases the cereal crop production and increases investment in GBF enhances crops yields, which signifies adaptation of climate resilient agricultural practices. As evident, it increases crops production by reducing adverse effects if climate change. The study contributes to the current literature on green finance and climate mitigation. The paper seeks the attention of all stakeholders and recommends the adaptation of green infrastructure. Like in the earlier section of research, which opens discussion with, COP28 conference ends with common promise to mitigate the impacts of climate change on the world in general and developing countries, which severely hit by daunting challenge. Hence, this study supports and substantiates the conference agreements and emphasizes promoting climate resilient infrastructure, which positive effects felt across the world by making earth planet a livable place. This research paper met with many limitations, which not limited to the inclusion of other factors, which influence cereal crops production in major Asian cereal crops producing countries, but also bears ones of limited data available of corresponding period for each country, condiment of

geographical scope and certainly the timer frame. Conversely, in future research can be built upon exploring sectoral comparison of these countries or countries specific that which sector is more prone to climate change impacts and green finance as a mitigation and adaptation strategy.

Conflict of Interest: The authors declare no conflict of interest.

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