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Climate Change and Agro-based Food Competitiveness: Panel Data Analysis for Developing Countries

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Abstract--Climate change and agricultural development are interconnected and are a fundamental challenge for developing countries. Many developing countries are highly affected by climate change, particularly the rise in temperature that significantly affects the agriculture sector, economic prosperity, and exports. This study aims to examine the relationship between climate change and the agriculture sector and the impact of climate change on agro-based food competitiveness of 80 developing countries for the period 1975 to 2023. The study utilizes 3 SLS method and confirms that an increase in temperature affects agricultural production and further deteriorates the agro-based food competitiveness of developing countries. Initially, developing countries increase agricultural production by utilizing pests and chemicals without taking safety measures that would enhance the temperature of developing countries. Similarly, industrialization, natural resources rent, and forest conversion affect the climate and increase temperature, which affects agricultural development and hence deteriorates competitiveness. On the contrary, inflation, globalization, urbanization, human capital or employment, and a rise in exchange rate directly affect agricultural competitiveness. The study suggests utilization of technology, water conservation, climate-smart agriculture practices like crop diversification, conservation and drought-resistant crop varieties can reduce vulnerability to climate changes.

Keywords--Climate Change, temperature, Agriculture, Competitiveness, Developing Countries.

1. Introduction

Climate change and agricultural development interconnect in nature. The variability in climate generally changes the agriculture climate resources like precipitation, temperature, sunlight etc. that influences arable/livestock sector and hydrological sector. Globally, many countries are facing climate change due to an increase in global temperatures that causes irregular patterns of rain, frequent occurrence of cyclones/ droughts, and a rise in sea level. Unfortunately, Climate change has affected the socioeconomic environment of many developing countries in terms of declining agriculture production, creating food insecurity, affecting human health, ecosystems, biodiversity; etc., and subsequently deteriorates economic growth and prosperity. In recent era, many developing countries are susceptible to the adverse effect of climate change despite the fact that their contribution in global warming and climate change is minimal. The World Bank (2023), indicating that the contribution of developing countries in climate change is the least, but they are facing landscape that affects livelihood, stressed natural resources and increased extreme weathers. Without contribution in climate changes, more than 130 million peoples live in most vulnerable countries that will pushed into extreme poverty by 2030. The reliance of developing countries on agriculture and nature resources is higher than developed countries; not only for domestic livelihood but also for exports largely comprise agro-based commodities.

Agriculture plays a crucial role in the national income and employment generation of developing economies and is highly vulnerable to climate variations. According to World Bank indicators (2022), 50 percent to 90 percent of the population of developing countries relied on the agriculture sector for livelihood, substantially foreign exchange earnings in Africa, Latin America, and Asia. According to FAO (2023), there are crop and livestock production losses with climate change or disasters that valued were US\$3.8 trillion during the period 1991 and 2021, as compared to average losses of US\$123 billion per annum, or 5 percent of annual global agricultural GDP. The climate change losses are higher in developing countries compared to developed countries, which subsequently affects the exports to other countries. The Centre for Global Development (2024) stated that the average per capita income of developed countries is nine times higher than that of developing countries, but their per capita greenhouse gas emissions are more than twice those of developing countries. These inequalities have driven much of the current debate about climate change and agricultural development.

The effects of climate change on agriculture will depend upon the rate and severity of the change, as well as the degree to which farmers can adapt. According to some estimates of Hickey (2023), the number of agricultural farms has been declining since 1930, which affects many industries, including agro-based exports such as food services, food manufacturing, etc., that depend entirely on agriculture. According to estimates, the number of farms will globally decline to 272 million by 2100, compared to 616 million in 2020, which can affect agriculture. The reason behind the decline of farms may be climate change, water scarcity, cost of business, global warming etc. The United Nations Framework Convention on Climate Change (UNFCCC) indicated that the Paris Agreement

accepted the essential priorities, including safeguarding food security, ending hunger, and addressing the particular vulnerabilities related to food production systems to the adverse effects of climate change (UNFCCC, 2015).

The US Global Leadership Coalition (2021) stated that climate change disproportionately affects the food, health, water security, and economic development of developing countries. Developing countries are often involved in deforestation due to resource exploitation and agriculture. These countries often have limited capacity to adapt to the negative impact of climate change on food security, agriculture, health, etc. The decline in agricultural production not only creates food insecurity but also a decrease in exports. Climate adaptation measures can protect rural communities better, become familiar with climate change unpredictability, mitigate potential damages, and help them cope with the adverse consequences, significantly reducing vulnerability to climate change [Cline (2008)].

Technically, many scholars, policy advocates, and researchers have observed the climate change impact on different economies and are considering mechanisms that need to be implemented to minimize the risk and losses. According to the World Bank (2016), the economic cost of climate change is approx. 6 percent of GDP, while in developing countries, the average cost is 3-4 percent of GDP. Developing countries have limited financial resources, access to technology and information, institutional capacity, and underdeveloped infrastructure; hence, they face a lack of effective planning and implementation of climate resilience measures, including creating awareness for mitigating measures.

Given the above, this study investigates the impact of climate change on agro-based food competitiveness of developing countries for the period 1975 to 2023 by utilizing the Three-Stage Least Squares (3 SLS) method. The study contributes to setting up a medium-term climate-change adaptation mechanism for developing countries that are facing the negative impact of climate change on their agricultural production and agro-based exports, thus suffering from food insecurity. The study advocates that policymaker formulates policies related to combating climate change and improving agricultural development.

The paper includes five sections. Following the introduction, Section 2 discusses a review of the literature; Section 3 presents the methodological framework and data collection procedures. Section 4 presents estimations of the model and empirical outcomes, and the last section presents the conclusion, policy implications, and sets directions for further research.

2. Review of Literature

The Environmental Kuznets Curve (EKC) explained the theoretical relationship between different factors of environmental degradation and economic development (per capita income). According to EKC, at the early stage of development, greenhouse gas emissions may deteriorate the environmental quality, which ultimately creates global warming and changes the climate. While during the later years, the trend may reverse with the development of the country, economic

growth may lead to environmental improvement due to mitigation or safety measures [Stern (2004)].

Abildtrup et. al. (2006) investigated the impact of climate change on European agricultural land use by utilizing an integrated approach through socio-economic scenarios. Differences in the socio-economic condition also had significant impacts on land use.¹ The study stated that it is not possible to design policies that anticipate certain climate-induced land use changes, but that policies should be adjusted to adapt to climate change. The land use is sensitive to markets for agricultural inputs and outputs, technology and policies, and these modifications may have significant impact on land use than climate change. The study suggested that the vulnerability assessment in combination with the scenario analysis might help the future formulation of agricultural policies, gathering concerns that are more public with less transition cost. The inclusion of climate change impact in the design and implementation of European national and local development initiatives can reduce the vulnerability of the farm sector and rural economy. The World Bank (2008) also indicated that Climate change would affect agriculture and forestry systems through higher temperatures, elevated CO2 concentration, precipitation changes, increased weeds, pests, and disease pressure, and increased vulnerability of organic carbon pools. This can enhance the gap between the developed and developing countries and would be more severe climate change impacts in already vulnerable developing regions, exacerbated due to lower technical and economic capacity to respond to new threats.

Brenton and Chemutai (2021) indicated that there is an interconnection between trade and climate change. The trade has the potential to enhance mitigation and adaptation. Generally, the trade contributes to the carbon emissions that cause global warming and further change the climate, and leads the country to deviate from its comparative advantages. They stated that climate change generates immense challenges for developing countries, and provides new opportunities to promote trade diversification in the evolution to a low-carbon world. Suitable trade and environmental policies can deal effective economic incentives to accomplish both sustainable growth and poverty reduction. International trade can assist countries in adapting to higher average temperatures and extreme weather events by offering consumers lower-emissions goods and services and facilitating the use of climate-friendly technology. On the other side, climate change may also negatively affect trade as extreme weather events increase the cost of trade, by destroying or degrading transport infrastructure and reducing agricultural production.

WTO (2022) report also discussed the greenhouse gas emissions that are essential to limit the consequences of climate change, as this has a major impact on human beings, the environment, and the global economy. This study concluded that Climate change increases trade costs and disrupts production and supply chains. Nevertheless, trade and trade policies, in conjunction with relevant policies and international cooperation, can assist countries to alleviate some of

¹ The scenarios interpreted from the narratives described in the IPCC Special Report on Emission Scenarios (SRES), which safeguards internal consistency between the evolution of socio-economics and climate change.

the impacts of climate change on agriculture and food security by contributing to enhancing economic resilience.

In time series studies, Wreford et al (2010) studied the impact of climate change on the agriculture sector and forecasted effects on food production, water stress, and security. The study utilized data from 1900 to 2000 to project climate change scenarios up to 2100 globally. The authors stated that extreme events like droughts, heatwaves, and floods became common in the 20th century and in the 1990s; the temperature was warmer than average. The study found that higher temperatures linked to climate change would be dangerous for the production of many crops and livestock. If there is water and heat stress or a combination of both stresses, then the global cereal production will be vulnerable to minor changes in temperature. The authors concluded that temperature, precipitation, and CO₂ can affect crop production, and by the implementation of adaptation measures, the yield of crops can be increased.

Lee et al. (2012) studied climate change impacts on the agricultural production of Asian Countries from 1998 and 2007.² The authors estimated each country-level fixed effect panel model for agricultural production by using seasonal climate variables and other input variables. The outcomes indicated that high temperatures and large precipitation in summer increase the agricultural production, while higher temperatures in the fall period are harmful in South and Southeast Asian countries. The study determined that an overall increase in annual temperature decrease the agricultural production in Asian countries.

Beach and Cai (2013) assessed the impact of climate change on agriculture production and trade globally by utilizing the Computable General Equilibrium Model within a consistent framework for Applied Dynamic Analysis of the Global Economy.³ The broad-based economic framework focused on agricultural production, including the Forest and Greenhouse Gases. The authors created baseline projections for 2010 to 2050 and found that different crops have different impacts of climate change depending on temperature sensitivity.⁴ The temperate regions experience less negative productivity shocks than the tropical, leading to shifts in production and trade patterns. The authors found potential of agriculture commodities for substantial alterations in the agriculture market and global trade and expected some important distributional effects on different regions.

Javed et al. (2014) examined the impact of climate change and weather shocks on agriculture of Pakistan by employing the Generalized Method of Moment, Fixed Effect, and Instrumental Variable estimations on district-level panel data for the years 1980 to 2010. The study confirmed the significant effects of climate change on agriculture and concluded that a warming climate affects negative on

² The study utilized panel data of 13 Asian countries.

³ The author utilized GTAP v7.1 database and introduce a detailed breakdown of agricultural crops. The model has capability to examine impact of climate variation on global economy by including domestic and global changes may feed the U.S. economy.

⁴ The dynamics in model arises from growth in GDP, population, capital accumulation, labor productivity, natural resource stocks and technological changes in the energy intensive and agricultural sectors.

agriculture and rain-fed regions while rising precipitation impacts positive on the agriculture sector.⁵

Birthal et al. (2014) investigated the effects of climate change (temperature and rainfall) on the yield of important food crops for the period 1969 to 2005 of 200 districts of India.⁶ The authors utilized the panel data approach (fixed effect) as suggested by Deschenes and Greenstone (2007) to capture the effects of time-invariant variables and farmers' autonomous adaptation in response to year-to-year fluctuation in weather variables. The authors observed a significant rise in mean monthly temperature during the post-rainy season, which did not significantly affect the food crop. An increase in maximum temperature harms crop yields, while an increase in minimum temperature has a favorable effect on the yields of most crops. The study forecasted climate change and crops production for 2100 century and has suggested that significant changes in temperature and rainfall can lower the rice yield by 15 percent and wheat yield by 22 percent.

Alam et. al. (2015) identified the climatic factors that are responsible for affecting the productivity of the cotton crop in Aligarh district (Uttar Pradesh).⁷ The authors found that factors like average rainfall, humidity, and maximum temperature have negative impact on the productivity of the crop. The authors concluded that in the absence of technological advancement and change in consumption pattern of inputs, climatic condition plays a gambling role in determining the agricultural productivity.

Awan and Yaseen (2017) studied the impact of global warming on the agriculture of Pakistan for 1974 to 2013 by utilizing the ARDL model.⁸ The study confirmed the existence of short-run and long run relationships. They found significant impact of carbon oxide emission, agriculture methane emission, agriculture nitrous oxide emission, greenhouse gas emission, and population density on agriculture value added. The author suggested various policy measures to reduce the global warming by controlling the carbon emission and various other agriculture emission during industrialization.

Dumrul and Kilicarslan (2017) analyzed the economic impact of climate change on agriculture of Turkiye by applying the ARDL technique for the period 1961 to 2013. The authors found that an increase in precipitation affects the agricultural GDP positively, while an increase in temperature has negative effect on agricultural GDP. The study emphasized on the need of formulation of policies, strategies, plans, and programs to combat climate change in Turkiye in order to minimize the adverse effects of climate change.

⁵ The study also stated that the previous year production also influence the current year output of agriculture.

⁶ The study used cereals (rice, wheat, sorghum, maize, and barley), two pulse crops (chickpea and pigeon pea) and two oilseed crops (groundnut and rapeseed- mustard).

⁷ Nine indicators like maximum temperature, minimum temperature, average temperature, variation in maximum and minimum temperature, morning humidity, evening humidity, and average humidity, variation in morning and evening humidity and rainfall have utilized for analysis.

⁸ The study used agriculture value added annual growth rate as dependent variable and carbon oxide emission, agriculture methane emission, agriculture nitrous oxide emission, greenhouse gas emission and population density as explanatory variables.

Chandio et al. (2019) examined the impact of global climate change on the agricultural output of China for the period of 1982 to 2014 by using ARDL bounds testing approach. The outcomes indicated that CO₂ emissions have a significant effect on agricultural output in both long run and short-run analyses, while temperature and rainfall have negative effects on agricultural output in the long run. The other determinants, like the land area under cereal crops, fertilizer consumption, and energy consumption, have positive and significant relations with agricultural output in both long run and short-run analyses.

Gupta et al. (2020) investigated the effects of climate change on the agricultural production of India by analyzing data trends. The study discussed that an increase in temperature, precipitation, and CO₂ concentration directly affects crop production.⁹ The authors indicated that the crop residue burns in the field after harvesting helps in increasing the level of CO₂ and kills the microorganisms in the field. The authors also found that changes in climate increase the incidence of pests and diseases, which causes a huge loss in crop production, affects soil fertility, promotes salinity, and creates resistance to many pesticides and herbicides, and deterioration of irrigation water quality.

Nassr et.al (2021) analyzed the potential economic and social impacts induced by the deterioration of weather conditions on economic growth and food security of Egypt by utilizing IMPACT model. The outcomes of the model showed that climate change will decline aggregate food production between (-3%) by 2030 and (-3.8%) by 2050. Furthermore, this will lead to a rise in the general level of prices, decrease in per capita food consumption and increase in hunger (millions of people at risk) by 2030 to 2050. The study suggested that Egyptian policymakers need to develop adaptive measures to address the potential impacts of climate change that induced agricultural productivity losses, improve agricultural practices and educating farmers to shift from crops that are profoundly impacted by climate change to those that are not impacted.

Luh and Chang (2021) investigated the effects of climate change on staple food production by utilizing structural Ricardian model to accommodate for spatial clustering of the climate variables.¹⁰ The study utilized farm household data of Taiwan and anticipated that seasonal temperature/precipitation variations are the major determinants of staple food production after controlling for farm households' socio-economic characteristics. The study found that the impacts of seasonal climate variations are location-dependent, which also vary significantly across the staple food commodities. The Climate change impact assessment, under four Representative Concentration Pathways (RCPs) scenarios, indicated the detrimental effect of climate change on rice production during 2021–2100. The study showed a negative impact of climate change on rice and vegetables, while positive on fruit production.

Khan et. Al (2021) investigated the causal relationship between Pakistan's agricultural products export, industrialization, urbanization, transportation, energy consumption, and carbon emissions for the period 1976 to 2017 by

⁹ As the production of Agriculture sector is dependent on climatic and weather conditions.

¹⁰ The author used three commodities for analysis i.e. rice, fruit and vegetables.

employing the ARDL technique. The study found that an increase in energy consumption would increase the export of agricultural products, while an increase in urbanization, transportation, and carbon emissions would result in a decrease in agricultural exports of Pakistan in the long run. The study recommended sustainable agricultural production, renewable energy consumption, low-carbon emission technologies, and a green portfolio for sustainable agricultural product export.

Nugroho et al. (2023) studied the effects of climate change on agricultural competitiveness of developing and developed countries. The study utilized data from 71 developing countries and 24 developed countries from 1990 to 2020. The authors found that agricultural competitiveness raises temperatures in developing countries while decreasing temperatures in developed countries, which ultimately reduces agricultural competitiveness. The authors recommended the use of technology in agricultural business management, as well as to increase agricultural competitiveness by dealing with the rise in temperatures.

Reinsch et. al (2023) studied the impact of climate change on US agriculture exports by analyzing the time series trend.¹¹ The study observed that climate change has affected the agricultural landscape of certain crops like wheat, soybeans, corn, and cotton because of severe weather events like extreme heat waves and floods that affect agriculture negatively. Climate change also affects the dairy and meat industries due to heat stress.¹² The study concluded that maintaining or increasing output will become more expensive as weather patterns grow more unstable. To maintain US primacy on the global agricultural stage, there is a need to take more proactive steps to encourage the sustainability of the agriculture sector in the face of climate change.

3. Methodological Framework

According to Ricardian (1821), competitiveness is a country's ability to produce a particular good or service at a lower cost compared to trading partners. Balassa (1965) presented the Revealed Comparative Advantage (RCA) index that reflects competitiveness based on relative export performances.¹³ In this study, Agro-based Food Competitiveness Advantage (ABFCA) can be measured by RCA, which is commonly used to estimate export competitiveness in the international market. The index estimated whether that product has a comparative advantage in international trade or not.

¹¹ Historically, US had surplus in agriculture trade, which has now converted in to deficit in last two years.

¹² The study found that macroeconomic factors like the persistent strength of the U.S. dollar, poor economic performance in many parts of the world, and tighter monetary policy to combat rising inflation also affect agriculture exports of US.

¹³ The RCA along with its variants such as revealed export advantage (RXA) and Revealed Symmetric comparative advantage (RSCA) has been extensively used in the literature to explore the competitiveness of any country over given exports concerning the world or trading partners.

The formula for ABFCA is as follows;

$$ABFCA = \frac{\left(\frac{X_{ij}}{X_{it}}\right)}{\left(\frac{X_{ej}}{X_{et}}\right)} \dots\dots\dots (3.1)$$

where:

- X_{ij} = Current year's total value of Agro-based Food exports of developing countries (US Dollars)
- X_{it} = Current year's total value of exports of all commodities of developing countries (US Dollars)
- X_{ej} = Current year's total value of Agro-based Food exports of all countries (US Dollars)
- X_{et} = Current year's total value of exports of all countries (US Dollars)

The formula produces the following outcomes:

- a) A country has a comparative advantage if the index calculated by the ABFCA is greater than 1; otherwise
- b) A country has a comparative disadvantage if the ABFCA index value is less than 1.

3.1 Econometric Model

The study investigates the impact of climate change on the agricultural competitiveness of 80 developing Countries for the period of 1975 to 2023.¹⁴ The study presented climate change with temperature changes. According to the literature, climate change (temperature changes) may depend on agro-based food competitiveness (ABFCA), industrial growth (IND), population (POP), consumption of renewable energy (RENEW), natural resource rents (RENT), and forest conversion (CONV).

$$TEMP = \beta_0 + \beta_1 ABFCA + \beta_2 IND + \beta_3 POP + \beta_4 RENEW + \beta_5 RENT + \beta_6 CONV + \mu \quad (3.2)$$

The EKC theory indicated that an increase in economic activities, including agriculture, without mitigation measures, could deteriorate the environment and increase the temperature. In the above equation, the other factors that drive economic activities are industrial growth and population; both affect the temperature and settlements.¹⁵ The rise in economic activities encourages people to explore nature, including forests, and use or rent natural resources. Moreover, human populations also started the use of environmentally friendly energy, i.e., renewable energy, to preserve their economic existence and reducing environmental damage [Batmunkh et al., (2022)].

The model may perceive an endogeneity problem as temperature changes are supposed to influence agricultural competitiveness and vice versa. In order to obtain the effects of climate change on Agro-based Food Competitiveness

¹⁴ The study used United National classification of developing countries.

¹⁵ Industry and agriculture are dominant activities in developing countries that can increase income and affect the environment.

Advantage (ABFCA), the model given in 3.3 is used. According to the hypothesis, Agro-Based Food Competitiveness is affected by temperature (TEMP), consumer prices (CPI), exchange rates (EXC), economic globalization (EGI)¹⁶, agriculture employment (AEMP), human capital index (HCI), and Urbanization (URB).

$$ABFCA = \gamma_0 + \gamma_1 TEMP + \gamma_2 CPI + \gamma_3 EXC + \gamma_4 EGI + \gamma_5 AEMP + \gamma_6 HCI + \gamma_7 URB + \nu \quad (3.3)$$

An increase in average annual temperature affects the export competitiveness of the agriculture sector (Abbas, 2022). Moreover, food and livestock yield may decline with an increase in extreme temperatures, permitting countries to accomplish domestic requirements instead of exporting to other countries [Adhikari et al. (2022)]. On the other hand, the cost of production, including the cost of raw material, can be increased with an increase in demand for agricultural products and subsequently reduce export competitiveness [Huo (2014), Dua and Gaur (2010)]. The exchange rate is an important factor in international trade that can affect competitiveness [Kargbo, (2006)]. The depreciation of currency generally has a positive effect on exports. International relations or openness of countries, i.e., globalization, has a substantial positive impact on the competitiveness of the agricultural sector. Trade liberalization will equalize the income of agricultural labor in developing countries with the higher-wage labor in developed countries. Trade Liberalization allows countries to trade agricultural products and increase incomes from the agricultural sector [Abbas (2022)]. The competitiveness generally lowers the cost of labor [Sarker and Ratnasena (2014)]. Human Capital has a positive effect on agricultural competitiveness. Training and Education will empower farmers to get expertise in a wide range of technology options and other decision-support tools [Rodenburg et al., (2011)]. Urbanization also reduces agricultural competitiveness as this leads to decline in agricultural land and reduces food production [Beckers et al (2020)].

Due to endogeneity problems, the study uses three three-stage least squares method.¹⁷ According to Greene (2003), 3 SLS is appropriate when an endogeneity problem is detected in a simultaneous equation. The utilization of the 3 SLS method is fulfilling the assumption that the model's instrument variables correlate with endogenous regressors [Choi et al. (2018)]. The 3 SLS method has several post-estimation tests, like an endogeneity test using the Hausman method, a weak instrument test using the Stock & Yogo method, and an identification restriction test using the Sargan method. Prior to the 3 SLS, the stationarity of variables was checked by using the Levin, Lin & Chu test to assess the spurious regression caused by the use of nonstationary panel data throughout the period. The study collected data from the World Bank (World Development Indicator), Food and Agriculture Organization Statistics, International Labor Organization publication, and KoF Globalization Index.

¹⁶ Economic Globalization Index used as calculated by KOF.

¹⁷ Endogenous variables correlate the error terms of one equation with another, making the least squares estimates biased.

4. Estimation Results

The outcomes of the Levin, Lin & Chu (with and without trend) test is reported in Table 4.1. The results show that most of the variables are stationary with a time trend or without a time trend at the level and are integrated of order zero, i.e., I (0).

Table 4.1: Panel Unit Root Test Results

Levin, Lin & Chu test					
Variables	Without trend	With trend	Variables	Without trend	With trend
TEMP	-9.2061 (0.000)	-9.6249 (0.000)	CPI	-31.3621 (0.000)	-33.0881 (0.000)
ABFCA	-4.06621 (0.000)	-6.0703 (0.000)	EXC	-12.6041 (0.000)	-11.4343 (0.000)
IND	-3.7964 (0.000)	-2.0060 (0.022)	EGI	-3.2924 (0.000)	-3.7361 (0.000)
POP	-3.3762 (0.000)	-3.9143 (0.000)	AEMP	-3.1540 (0.000)	-3.8278 (0.000)
RENEW	-2.3538 (0.009)	-1.6298 (0.984)	HCI	-1.8549 (0.057)	-1.8712 (0.030)
RENT	-9.0667 (0.000)	-7.4406 (0.000)	URB	-1.0055 (0.157)	-3.5935 (0.000)
CONV	-11.4384 (0.000)	-10.2253 (0.000)			

Source: Authors' estimation. Probability value is given in parenthesis.

The outcomes of the endogeneity test indicate are significance at lower than 1 percent level with the Hausman statistic indicating that both models have endogeneity problems in their structural equations. The over-identification test and the weak instrument test show a significant value at the 5% alpha level, meaning that the structural model is included in the over-identified category, and each equation has a strong instrument variable. Moreover, the final stage of regression shows Adj. R² value and F-statistic value are significant at a 1 percent level. All post-estimated statistical tests [Sargen test, Hausman, and Stock & Yogo method] confirm the utilization of 3 SLS regression in the study.

4.1 Determinant of Temperature

The empirical outcomes of Equation 3.2 are given in Table 4.2. The outcomes indicated that an agro-based food competitiveness significantly increases the temperature of developing countries because over-utilization of chemicals and pests just for an increase in production and lower average cost that directly affects the environment [Lynch and Garnett (2021)]. Due to a lack of technological advancement and other bottlenecks, developing Countries do not take safety measures. There is a negative relationship between industrial growth and temperature. A rise in industrial activities without safety measures can deteriorate the environment and significantly increase the temperature, which will

negatively affect agricultural production. In this study, the effect of population on climate change is positive but insignificant.

Table 4.2: Three-Stage Least Squares Regression Results

Dependent Variable: TEMP		Dependent Variable: ABFCA	
Variables	Coefficient (Stand. Error)	Variables	Coefficient (Stand. Error)
C	-0.2241* (0.0904)	C	-2.0561* (0.4520)
ABFCA	0.1949* (0.0152)	TEMP	-13.3837* (1.2022)
IND	0.0125* (0.0015)	CPI	-0.0056* (0.0012)
POP	2.84E-11 (3.69E-11)	EXC	-0.0001* (2.16E-05)
RENEW	-0.0026* (0.0002)	EGI	-0.1375* (0.0245)
RENT	-4.39E-05 (0.0012)	AEMP	-0.0214* (0.0048)
CONV	-0.0085* (0.0018)	HCI	6.9118* (1.2873)
		URB	-0.0087** (0.0036)
Adj R ²	0.60	Adj R ²	0.91
F-test	1741.47*(0.00)	F-test	6592.44*(0.00)
Over-identification	744.42	Over-identification	430.98
Weak identification	821.48	Weak identification	624.55
Endogeneity	99.71 (0.00)	Endogeneity	100.52 (0.00)
No. of Observations 3918			

Note: Standard errors of the coefficient are given in parentheses: * is 1%, and ** is 5% level of significance.

Source: Authors' estimation.

There is a negative effect of a rise in the consumption of renewable energy on an increase in temperature. Renewable energy reduces temperature significantly in developing countries. Our findings are consistent with that study, which indicates that renewable energy has a negative and significant relationship with CO₂ and temperature over a long period [Abbas et al. (2021)]. The potentials of renewable energy is enormous in developing countries because of the availability of wind, sun, water, and biomass, and a large area of land for the cultivation of biofuel crops. The study found that there is a significant negative relationship between natural resource rent and climate change. Overutilization and overreliance on natural resources can create economic dependence, reduce diversification of natural resources, social inequalities that making countries vulnerable to climate change. Agboola et al. (2021) and Adedoyin et al. (2020) also found the same phenomenon in Saudi Arabia and Sub-Saharan African countries, where natural

resource rents increase CO₂ emissions. The study also indicates there is a negative relationship between forest conversion and climate change. Forest conversion increases CO₂, which contributes to global warming, and temperature rise, which leads to more extreme weather, drought, heat stroke, etc.

4.2 Determinant of Agriculture Competitiveness

The empirical outcomes of equation 3.3 are given in Table 4.2. The results indicated that an increase in temperature significantly declines agro-based food competitiveness by decreasing production and yield. The high temperatures can increase drought periods and pathogens, less water availability, decrease the agricultural area and forage quality, and negatively affect reproduction [Srbinovska et al., (2015); Debaeke et al., (2017)]. As a result, agricultural production and competitiveness have plunged dramatically, which may discourage farmers from increasing production and subsequently affect the exports of country. The study found that inflation (consumer price index) negatively affects the agro-based food competitiveness of developing countries. Inflation may increase the cost of production (input prices) and discourage farmers from increasing the production of agriculture, and affect competitiveness.

The exchange rate is an important driver of the international competitiveness of the agro-based food. The rise in exchange can deteriorate the competitiveness of the developing countries' agriculture [The World Bank (2024)]. The outcomes also found a negative effect of globalization on agricultural competitiveness. Globalization generally affects competitiveness and stimulates countries to implement structural changes. This should encourage the modification of land tenure, improvement in human resources, and allow social and financial capital openness to intervene in the market of the agriculture sector [Neglo et al., (2021)]. Unfortunately, many developed countries are providing subsidies and other assistance to the agricultural sector and also impose tariff and non-tariff barriers on developing countries that also affects the competitiveness as agricultural sector has limited innovation and technological advancement that is not confirmed the business sustainability.

The study indicates negative relations between the agricultural labor force and agro-based food competitiveness. The agriculture sector is generally a labor-intensive sector, and a large share of agricultural employment reflects a lower level of economic development that raises the risk of failure of agro-food revealed comparative advantage [Bojnec and Fertő (2017)]. Moreover, a higher number of workers in the agriculture sector increases the cost and subsequently diminishes the agricultural competitiveness [Huo (2014)]. In the agriculture sector, mostly unskilled labor is utilized, and the utilization of skilled labor in agriculture sector increases the cost of production and hence affects competitiveness. The study also found negative effects of urbanization on agricultural competitiveness in developing countries. There is a general perception that an improvement in human capital increases competitiveness, while skilled and educated labor migration toward urban areas has an impact on competitiveness. Generally, the agricultural laborers migrated to the non-agricultural sector when they improved their education and skills [Wegren (2014)].

5. Concluding Observations and Policy Implications

During the last three decades, the agro-based food cooperativeness has been of great concern in developing countries due to the decline of exports. According to experts, climate change and global warming are the main factors that affect the agricultural production and exports of developing countries. The study investigates the effects of climate change on the agro-based food competitiveness of developing countries. The study confirms that there are negative effects of climate change, particularly a rise in temperature, on agricultural production and agro-based food competitiveness. Initially, developing countries increase agricultural productivity by utilizing chemicals, pests, etc., which increase CO₂, which enhances temperature. Thereafter, an increase in temperature reduces agricultural production and subsequently affects agricultural competitiveness.

The study believes that precision in agricultural practices can boost competitiveness while maintaining environmental sustainability. The study suggests the utilization of technology for minimizing the risk of temperature and maximizing agro-based food competitiveness. The study also recommended that developing countries should enhance institutional capacity for enhancing research & development and innovation for minimizing the risk of climate change. Moreover, the study also underscores the need for comprehensive coastal management strategies, improvement in forecasting systems, and robust infrastructure to minimize the risk of climate change.

Technological innovations in agriculture, such as precision farming, hydroponic systems, and genetically modified crops that can withstand extreme weather conditions, and is vital for food security in developing countries. Other adaptation strategies, like the implementation of climate-smart agriculture practices like crop diversification, conservation agriculture, and drought-resistant crop varieties, can significantly reduce vulnerability to climate variability. Developing countries can encourage the advanced economies to take preemptive measures to rebuild confidence in international cooperation for climate change. Integrating climate action with development goals that involve aligning climate change mitigation and adaptation strategies with the United Nations SDGs is required to ensure that efforts to combat climate change address poverty, health, education, and inequality. The developing countries should navigate the path toward a resilient and sustainable future through technology, sustainable development strategies, international cooperation, and local empowerment.

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