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CLIMATE CHANGE AND AGRICULTURE IN REGIONAL ECONOMICS OF BRICS COUNTRIES

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Abstract. *Climate change has emerged as one of the most significant systemic shocks to regional and global economies in the 21st century, with particularly severe implications for agricultural production, food security, and economic stability. This study presents a comprehensive analysis of climate change impacts on the regional economies of BRICS nations—Brazil, Russia, India, China, and South Africa—and their neighboring countries through computer integrated statistical techniques and multidimensional economic parameter analysis. The research employed programming methods, comparative methods, analysis and synthesis methods, induction and deduction methods, as well as desk research methods. The research program utilized extensive code written by the author in the R programming language for the analysis of the BRICS Climate-Economy relations.The significance of BRICS lies in the fact that it represents a new economic, global, trade, and financial power, uniting countries with rapid economic and demographic growth in synergy with high investments, market liberalization, mutual cooperation, and the transfer of knowledge and technology. The analyzed indicators show a critical correlation between climate change and global warming and agriculture. The study concludes that coordinated action among BRICS nations is essential, emphasizing the development of technological transfer mechanisms for climate-adaptive agriculture, implementation of new technologies, financial instruments promoting agricultural resilience, supply chain coordination within the bloc, and comprehensive rural development strategies to protect food security and economic stability across regions.*

ВЛИЯНИЕ ИЗМЕНЕНИЯ КЛИМАТА НА СЕЛЬСКОЕ ХОЗЯЙСТВО В РЕГИОНАЛЬНОЙ ЭКОНОМИКЕ СТРАН БРИКС

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Аннотация. *Изменение климата стало одним из наиболее значительных системных потрясений для региональной и глобальной экономики в XXI веке, имеющим особенно серьезные последствия для сельскохозяйственного производства, продовольственной безопасности и экономической стабильности. В данном исследовании представлен всесторонний анализ воздействия изменения климата на региональную экономику стран БРИКС — Бразилии, России, Индии, Китая и Южной Африки — с помощью компьютерных статистических методов и многомерного анализа экономических параметров. В исследовании использовались методы программирования, сравнительные методы, методы анализа и синтеза, методы индукции и дедукции, а также методы кабинетного исследования. В исследовательской программе использовался обширный код, написанный автором на языке программирования R, для анализа взаимосвязи климата и экономики стран БРИКС. Значение БРИКС заключается в том, что он представляет собой новое экономическое, глобальное, торговое и финансовое содружество, объединяющее страны с быстрым экономическим и демографическим ростом в синергии с высокими инвестициями, либерализацией рынка, взаимным сотрудничеством и передачей знаний и технологий. Проанализированные показатели демонстрируют критическую взаимосвязь между изменением климата, глобальным потеплением и ситуации в сельском хозяйстве. Исследование приходит к выводу о необходимости скоординированных действий между странами БРИКС, подчеркивая важность развития механизмов передачи технологий для адаптации сельского хозяйства к изменению климата, внедрения новых технологий, финансовых инструментов, способствующих повышению устойчивости сельского хозяйства, координации цепочек поставок внутри блока и комплексных стратегий развития сельских районов для защиты продовольственной безопасности и экономической стабильности в регионах.*

Introduction

The significance of BRICS (Brazil, Russia, India, China, South Africa) lies in the fact that it represents a new economic, global, trade, and financial power acting as an alternative to globalization and the prevailing economic, financial, and geopolitical polarization and unification of the world. It introduces a new perspective on economics, finance, and even agriculture by uniting countries with rapid economic and demographic growth, in synergy with high investments, market liberalization, mutual cooperation, and the transfer of knowledge and technology. In this way, by uniting at a global rather than a regional level, priority is given to cooperation over subordination, profitability over unilateral interest, and diversification, balance, and optimality in business operations globally, as opposed to centralization through soft power.

However, climate change is rapidly becoming a dominant reality in past few decades affecting numerous economic indicators and national business operations at local, regional, and global levels, particularly affecting agriculture and the agro-industry as a whole [1], [2].

Agricultural yields in certain countries have been devastated by climate change, threatening both their food and economic stability. To analyze the complete and comprehensive impact of climate change on society as a whole, it is necessary to examine how climate change and global warming—based on variables measured over the past few decades—affect the economic indicators of given countries, as well as agriculture and agro-industry indicators collected in datasets over the same period.

Agriculture, in fact, represents an exceptionally important aspect in assessing the negative impact of climate change and global warming on the economies of numerous countries facing these effects with increasing intensity over the years and decades. Namely, agriculture is one of the key sectors of every country's economy because it not only enables profitability for farmers but also plays a crucial role in maintaining food stability, security, self-sufficiency, and, in the full sense of the word, the food independence and autonomy of a country.

In this analysis, data were used from numerous online platforms with open datasets, retrieved via Application Programming Interfaces (APIs). Based on this data, through various analyses, Venn diagrams, calculations, and the determination of causal links between the impacts of climate change and global warming, an attempt was made to answer the question regarding the long-term stability and sustainability of BRICS as an entity and community in light of the global economic crisis, and especially the increasingly negative impacts of climate change and global warming.

Literature Review

The research paper “Climatic change and agricultural production” emphasise that the most important global debate of this century is on climate change [3]. The paper states that by 2050 there will be significant impacts of climate changes especially on agriculture, including rising temperature, increasing drought due to higher evaporation and changing rainfall distribution, and increased levels of CO2 due to greenhouse effect and agriculture gas emissions [3].

Food and Agriculture Organization of the United Nations’ report “The state of food and agriculture 2024” states that the slow rate of progress on the Sustainable Development Goals (SDGs) and the accelerating pace of climate change are fuelling the discourse on global agrifood systems transformation in an attempt to identify feasible transformation pathways and to take decisive action [7].

Research paper “Temperature increase reduces global yields of major crops in four independent estimates” emphasises the magnitude of a temperature impact on yields of the four crops at the global scale [11]. For instance, the impact estimates are consistently negative for four major maize producers, together responsible for two-thirds of global maize production [11]. This is namely the case in the United States (−10.3 ± 5.4% per degree Celsius), China (−8.0 ± 6.1% per degree Celsius), Brazil (−5.5 ± 4.5% per degree Celsius), and India (−5.2 ± 4.5% per degree Celsius) [11].

The reference [12] states that together, Brasil, Russia, India, China, South Africa, Egypt, Ethiopia, Indonesia, Iran, Saudi Arabia, and the United Arab Emirates are responsible for 42% of global food production; own 33% of agricultural land; and hold 39% of the planet's water resources. Consequently, the BRICS countries have greater responsibility in mitigating climate change and global warming and promoting sustainable agriculture. In regards, BRICS countries are leaders in promoting food security and sovereignty, nutrition and sustainable global agriculture [12]. Moreover, the cooperation and negotiations between BRICS member countries provide an opportunity to share successful experiences. For instance, that is the case with India’s National Food Security Act (NFSA), Ethiopia’s National Wheat Harvest Programme, and Brasil’s National System for Food Security and Nutrition [12].

There is an academic literature gap of integrated data and non-linear models correlating climate variables, economic indicators and regional spill-over effects concerning BRICS countries and regional economies. This research paper relatively covers the literature gap by implementing research, providing and highlighting data concerning previously named topics.

Limitations of the Study

The implemented research and analysis is based on the open access data (World Bank WDI - World Development Indicators, Open-Meteo, United Nations, WIPO - World Intellectual Property Organization) which have certain limitations regarding time scope, frequency of data gathering, as well as consistency of certain data values.

Additionally, the availability of certain indicators is limited. This is the case for certain series of data regarding some countries and its’ agricultural performance metrics.

Although the model uses non-linear realtions and PCA (Principal Component Analysis) it can not capture the scope and impact of all political, geo-strategic, technological and institutional aspects of climate shock adaptation of different countries.

The 2071–2100 research projections are nearly one of the scenarios based on current climate conditions and trends. Relatively different climate trends in the future could potentially yield alternative scenarios and quantitative results.

In addition to this, the research is focused on BRICS countries and selected number of regional countries, making transference of research conclusions to other regions relatively limited.

Materials and Methods

The research employed programming methods, comparative methods, analysis and synthesis methods, induction and deduction methods, as well as desk research methods. The research program utilized extensive code written by the author in the R programming language for the analysis of the BRICS Climate-Economy Nexus. The program code was designed to be maximally comprehensive regarding both economic indicators, including agriculture and agro-industry, as well as climate change and global warming.

The aforementioned program created by the author encompasses analyses and mathematical calculations aimed at obtaining patterns and cause-and-effect relationships through the combination of data and their processing, utilizing numerous methods and mathematical algorithms optimal for this purpose and topic. To fully understand the complexity of such research and the comprehensive analysis that emerged from it—related to BRICS countries, the region, agriculture, and the impact of climate change and global warming—which represents a multidisciplinary topic, it is necessary to consider it not only from the perspective of combining natural sciences (informatics, programming, electrical engineering, software engineering, computer science, climatology) and social sciences (agroeconomics, economics, agriculture, macroeconomics, econometrics, quantitative methods), but also in the application of the given conclusions in numerous and diverse practical fields of the economy and society of the given countries.

Research Design

The program written in R code, for the efficiency and simplicity of processing large datasets, represents the automation of data collection from numerous reputable open-type online platform sources.

The numerous functionalities of the mentioned R code and program include multiple databases, multiple models and techniques for processing collected data, statistical analyses, regional analyses, as well as the generation of data tables and visually appealing charts using the suitable R programming language.

Results

Data Collection

Data collection consisted of the following open databases, which were largely retrieved through automated API protocols:

• World Bank WDI Data – Economic indicators were retrieved (GDP - Gross Domestic Product growth, renewable energy, CO_2 emissions, patents, migration, trade, etc.);

• Open-Meteo Climate Data – Daily temperatures and precipitation were retrieved for central points of countries, both BRICS countries and selected countries in their surroundings (1990–2024);

• UN Comtrade Trade Data – SITC (Standard International Trade Classification) trade series were retrieved (agricultural exports, food imports, technology imports);

• WIPO Patents – Loaded from a manually downloaded CSV (Comma Separated Value) file from the WIPO online platform;

• Data Caching – Local storage of retrieved data for faster repeated analyses with additional countries, parameters, or indicators.

Data Processing

Data processing consisted of the following methods:

• Interpolation of Missing Values – Linear interpolation + carry forward/backward + median by country;

• Calculation of Temperature Anomalies – Deviation from the base period (1990–2000);

• Calculation of Precipitation Changes – Deviation from the base period;

• Counting Extreme Weather Events – Days with T ≥ 35°C or precipitation ≥ 50 mm;

• Creation of Total Trade in USD – Sum of exports and imports in USD.

Statistical Analyses

Statistical analyses used to process the cleaned and stabilized data include:

• PCA Analysis – Dimension reduction to 3 main components: ECT (Extended Concordia Transform), CMC (Canonical Measure of Correlation), MCR (Multivariate Curve Resolution);

• Venn Intersections – 8 economic indicators (Knowledge Transfer, Technology Transfer, Finance, Trade, Migration, Workforce Exchange, Sustainability, Integrated Resilience);

• Econometric Validation – Panel regression and climate impact on the economy (GDP);

• Correlation Matrix – Indicators versus temperature variability.

Regional aspects

Regional results were obtained through the analysis of regional spillover effects, i.e., testing the impact of BRICS countries on neighboring economies. Five BRICS countries were tested with neighbors from each region:

• Brazil Region – Argentina, Chile, Colombia, Peru, Mexico;

• India Region – Pakistan, Bangladesh, Sri Lanka, Nepal, Indonesia;

• China Region – Japan, Korea, Vietnam, Thailand, Malaysia;

• Russia Region – Kazakhstan, Belarus, Azerbaijan, Uzbekistan;

• South Africa Region – Nigeria, Egypt, Kenya, Ethiopia, Angola.

Therefore, the program retrieves real data from 3 sources, performs statistical analysis of the climate-economy relationship, generates 8 composite indicators, and exports all results as CSV tables and PNG graphics.

This paper presents a comprehensive analysis of climate change impacts on the regional economies of

BRICS nations and their neighboring countries through integrated machine learning and multidimensional economic parameter analysis. Using Venn diagram analysis to identify intersections of knowledge transfer, technology transfer, financial integration, trade, workforce exchange, sustainability, and population migration, we establish nonlinear causal relationships between climate variables and macroeconomic indicators, including agriculture. Climate and economic datasets, combined with our analysis, reveal that climate change will reduce regional performance, with heterogeneous impacts across regions. The intersection of multiple economic dimensions—particularly technology transfer paired with trade liberalization and workforce mobility—emerges as a critical leverage point for climate-resilient development.

This paper employs R programming language code and a custom-made program to identify nonlinear relationships between climate variables and regional economic indicators (GDP growth, agricultural imports, agricultural exports, sectoral productivity, trade flows, FDI - Foreign Direct Investment, labor market outcomes).

The Venn framework quantifies overlaps among seven economic dimensions (Knowledge Transfer, Technology Transfer, Finance, Trade, Workforce Exchange, Sustainability, Population Migration), identifying critical policy leverage points in 2-way and 3-way intersections.

The X-axis shows the temp_lag1 Coefficient, which represents how temperature from the previous year affects economic performance. Negative coefficients are displayed on the left side of the axis. These can be interpreted as indicating that warming reduces economic activity after a period of one year. The vertical line represents the zero effect, i.e., the area where there is no climate impact on economic indicators. Countries on the right side of the vertical axis record positive economic performance following temperature impacts. To understand this fact, it is necessary to examine the aspect of climate impact on the economy, especially agriculture, for each country individually. These are predominantly countries where tropical agriculture dominates, with longer growing seasons and higher yields, albeit in the short term. Additionally, these are countries whose economies do not depend solely on agriculture but primarily on tourism and mining. Short-term adaptability dominates here; however, with significantly more pronounced risks in the future.

For countries marked as Low Signal, the impact of climate change on the country's GDP is either small, inconsistent, or statistically unreliable. The reason for this at the statistical and macroeconomic level, which is particularly relevant for India, may be the fact that the effects of losses accumulate in rural communities but are not visible in the overall national GDP.

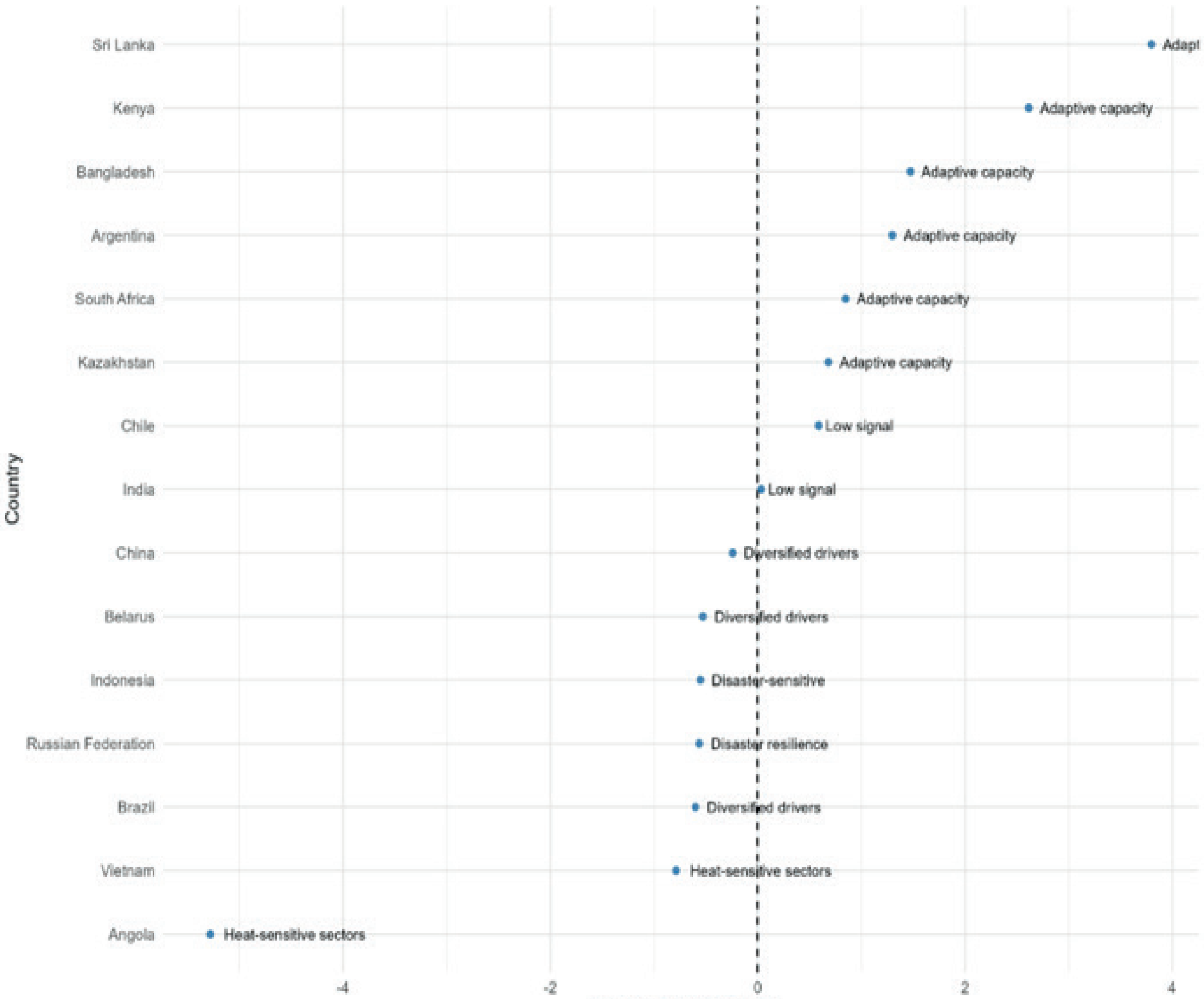

Fig. 1. Climate Impact on Economy (Temp lag) by Country; Source: Authors

The Diversified Drivers category denotes countries in which the economy does not depend solely on temperature. Therefore, the negative impacts of climate change on the economy are very close to the zero effect.

The categories named Disaster-sensitive, Heat-sensitive sectors, and Disaster resilience are extremely sensitive to climate and temperature shocks, representing potentially extremely vulnerable economic policies that depend significantly on agriculture, with the exception of the Russian Federation, which is a significant oil producer and thus has a sustainable economic policy based on energy trade, regardless of potential losses in agriculture caused by climate shocks.

Among the indicators, Integrated Resilience should be particularly highlighted. Namely, resilience denotes the potential, ability, or capacity of a system to recover from a shock, in this case, a climate shock.

A low resilience index indicates a potential disaster either in the recent past or in the future due to the increasingly severe effects of climate change and global warming.

A high resilience index value indicates pronounced flexibility in response to climate change impacts. For example, Brazil demonstrates resilience in that if a drought potentially occurs in the south, it is strategically oriented to shift production to the north. Likewise, if a drought occurs in the European part of the Russian Federation's territory, there is a strategic possibility of shifting production to Siberia, which, with increasing temperatures and melting permafrost, may represent fertile ground for cereal and soybean growing, as well as opportunity for Russian Federation's food reserves and food security.

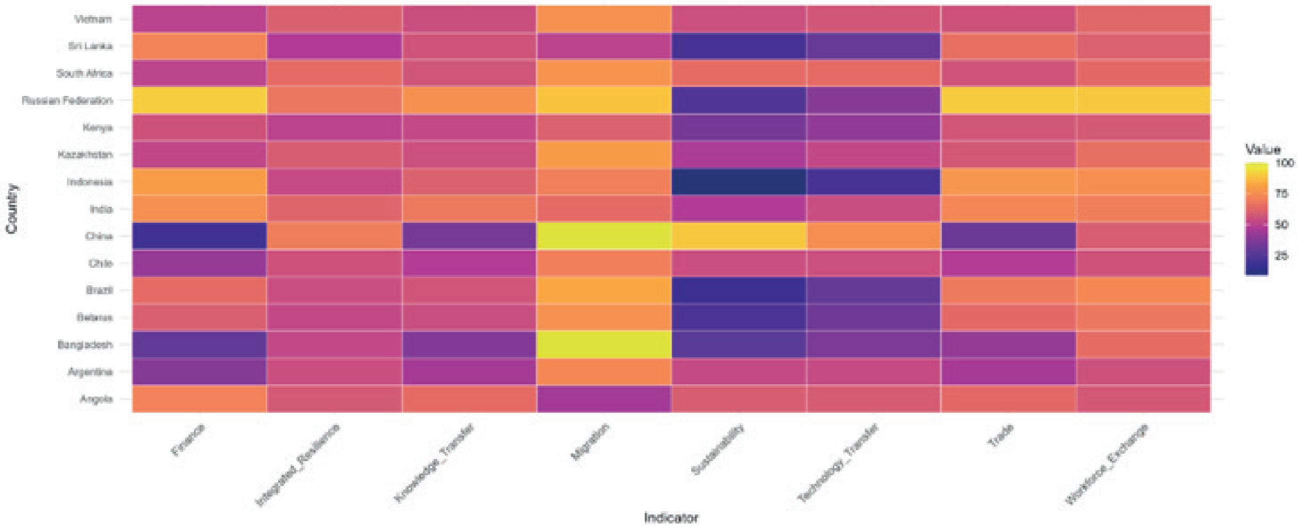

Fig. 2. Indiciators Heatmap by country in 2024; Source: Authors

The heatmap visualizes 8 economic indicators (Finance, Integrated Resilience, Knowledge Transfer, Migration, Sustainability, Technology Transfer, Trade, Workforce Exchange) for BRICS countries and their neighboring economies. Dark blue (25) represents a low indicator value and/or risk and/or vulnerability. Yellow (100) represents the highest value, indicating strength and/or resilience for each of the economic indicators.

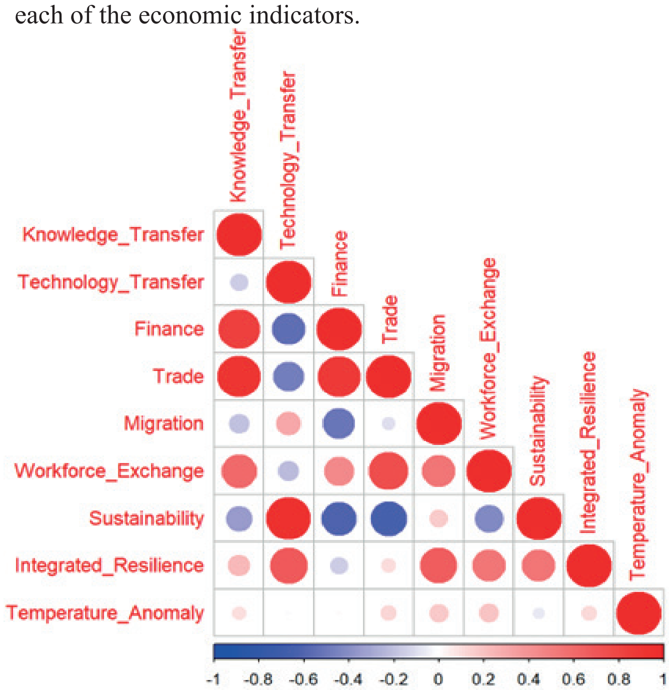

Fig. 3. Inter-relations between different indicators; Source: Authors

The key agricultural relationships shown in Fig. 3 are as follows:

Warming degrades the ecological sustainability of agriculture (-0.55), which means that increasingly higher temperatures cause more damage to soil, water scarcity as a resource, increased pesticide use, etc.

Additionally, Fig. 3 shows that temperature affects integrated resilience (+0.65). Based on this indicator, it can be concluded that BRICS countries and their regions are compelled to adapt to climate shocks and the consequent economic and agricultural damage.

Furthermore, one of the dangers from the perspective of agricultural production and the agri-industry is represented by the relationship between workforce exchange and migration (+0.72). This indicator represents a critical correlation for agriculture, as warming affects yield losses, and consequently, there is less money for agriculture and farmers, which can potentially cause migrations and depopulation of rural areas, as well as de-agrarianization of the agricultural sector.

Conclusion

Climate change represents a systemic shock to regional economies within the BRICS bloc and in countries gravitating toward it, challenging the integration frameworks that have driven growth over the past two decades. While global climate research establishes physical impacts (temperature rise, precipitation variability, extreme weather events), macroeconomic transmission mechanisms, particularly through trade, financial flows, technology access, labor mobility, and knowledge networks, remain inadequately modeled for policy-relevant analysis at regional scales.

Climate change represents a systemic shock to regional economies within BRICS countries. This shock is particularly impactful in the area of agricultural production., i.e. agricultural sector which adds pressure on global agricultural and food systems [3].

While physical impacts (temperature, precipitation) are known, macroeconomic transmission mechanisms, trade, finance, technology, labor, knowledge, and especially agriculture, which is extremely sensitive to climate change, remain inadequately modeled for policy-relevant analysis. This is particularly the case with agriculture and agro-industry, which in many countries, due to climate change and global warming, as well as inadequate or nonexistent mitigation policies and strategies at the state, regional, or BRICS bloc level, are suffering severe damages and losses.

Since the 1980s, the annual temperature departure from the average has been consistently positive. In 2024, the global land and ocean surface temperature anomaly stood at 1.29 °C above the 20th-century average, the largest recorded across the displayed period [4-7]. Earth's average surface temperature in 2024 was the warmest on record, according to an analysis led by NASA scientists [4-7].

Global temperatures in 2024 were 1.28 °C above the 20th-century baseline (1951-1980), which is higher than the record set in 2023 [4-7]. The new record comes after 15 consecutive months (June 2023 through August 2024) of monthly temperature records [4-7].

NASA scientists estimate Earth in 2024 was about 1.47 °C warmer than the mid-19th century average (1850-1900) [4-7]. For more than half of 2024, average temperatures were more than 1.5 °C above the baseline, and the annual average, with mathematical uncertainties, may have exceeded the level for the first time [4-7].

Global temperatures exceeded 1.5°C above pre-industrial levels in 2024, with India recording its second-highest January temperature since 1901 [4-7]. Extreme rainfall events (>150mm/day) increased by 75% in central India (1950-2015). Dry spells during monsoon increased by 27% (1981-2011 vs 1951-1980) [4-7]. Nearly half of seasonal rainfall now falls within just 20-30 hours, creating dangerous dry gaps [4-7].

The Paris Agreement limit of 1.5 °C was surpassed in all regions in 2024, except in Oceania (1.4 °C) [4-7]. Europe and the America recorded the largest temperature increases (2.4 °C), followed by Asia (2.1 °C), Africa (1.8 °C) and Oceania [4-7].

Severe rainfall deficits gripped wide regions of India, parts of Ladakh, Arunachal Pradesh, Bihar, UP, Punjab, and the Northeast suffered 30-70% below-normal rainfall and dwindling soil moisture, triggering crop stress and water shortages [6]. This crisis from record rainfall to exceptional drought within the same season is virtually unprecedented in the meteorological records [6].

According to publicly available datasets, India recorded over 271 extreme weather events in 2023 alone, with an estimated 45% increase in frequency compared to the 1990s [8]. Meanwhile, economic losses attributed to climate-linked disasters reached nearly USD 87 billion in 2022, and India is expected to lose up to 2.8% of its GDP annually by 2050 if current warming trends continue [8]. In this context, the Supreme Court of India delivered a landmark judgment in M.K. Ranjitsinh v. Union of India (2024), declaring, for the first time, the existence of a constitutional "right to be protected from the adverse effects of climate change" under Articles 14 and 21 [8]. This judicial recognition of climate rights represents a transformative moment in Indian jurisprudence [8]. It shifts climate policy from a discretionary domain of the executive to a constitutionally enforceable obligation [8].

In 2024, Brazilian agriculture faced significant challenges, from declining global demand and high input costs to extreme weather events linked to El Niño [9]. Global demand slowed, reducing prices for key crops like soy and corn (especially demand for corn from China declined) [9]. El Niño-related droughts and floods in critical production areas disrupted harvests [9].

Despite these crisis, overall agricultural production and soy exports experienced only a modest decline [9]. Soy exports to China even increased [9]. The vulnerability of Brazilian agriculture to climate change became evident in 2024 [9]. Specifically, Rio Grande do Sul experienced the wettest April and May on record, impacting over 206,000 rural properties [9]. Concurrent droughts in other regions, particularly impacting the Amazon and the coffee production in Minas Gerais [9]. Brazil recorded a 150% increase in burned land compared to 2023, with 22.38 million hectares affected between January and September [9].

In Brazil in 2023, in the state of Mato Grosso, during October and November, 53% less precipitation was recorded compared to the thirty-year average [10]. The combination of hot and dry weather has caused significant crop stress, leading some farmers in Mato Grosso to shift acreage into cotton rather than soybeans [10]. November 2023 represents the warmest and driest month in the last 30 years in Mato Grosso [10].

All of this, as well as numerous other climate disasters, negatively affects economic indicators and the macroeconomy of countries, especially agricultural production and supply chains in the agro-industry.

Table 1 shows future predictions of specific negative effects on agriculture in individual BRICS bloc countries, with a special focus on 2071–2100, compared to the base period 1981–2010.

These data represent an extremely negative effect on the global food market and supply chains in the agro-industry, given that 42% of the world's food is produced within BRICS countries [12].

In 2021, BRICS nations attracted 22.45% of the global FDI [13]. In 2021, China attracted the highest amount of FDI inflow of $181 billion, followed by Brazil ($50 billion), India ($45 billion), South Africa ($41 billion) and Russia ($38 billion) [13]. BRICS nations contributed 16% of global trade, 41% of the global population [13].

Table 1

Future projections of the impact of climate change; Source: [11]

Country	Crop	Effect per 1°C Temperature Increase
China	Wheat	2.6 ± 3.1%
Brazil	Maize	−5.5 ± 4.5%
India	Rice	-6.6%
China	Maize	−8.0 ± 6.1%

Additionally, given that BRICS countries are producing more than one-third of the world's agricultural output, the impacts of climate change on economy, especially agriculture sector, have far-reaching consequences [13].

Furthermore, the impacts of climate change are reflected not only in large countries but also in countries within their regions. Thus, there is cooperation among BRICS countries, such as the Russian Federation, China, Brazil, South Africa, and India, which generate a so-called "spillover effect" of economic well-being and benefits to countries in the region, thereby making the entire region financially and nutritionally more robust and sustainable. However, climate change affects both large and small countries with its negative effects. The spillover of negative effects of climate change and global warming from large BRICS nations to their regional neighbors also occurs, which is the subject of this research.

This analysis of BRICS countries and countries in their immediate surroundings, as well as the analysis of cooperation between BRICS countries and surrounding countries, points to the following aspects: First of all, technological transfer mechanisms for climate-adaptive agriculture are of exceptional importance for the robustness and adaptability of each country. New technologies, mechanization must be implemented and legacy ones should be upgraded, retrofitted and eventually replaced [14], [15].

The risk that exists if adaptive climate policies or new technologies are not developed is extremely high for both agriculture and the population of the given country. Reducing unemployment and implementing climate mitigation strategies in rural areas must be a priority in the development of villages and agricultural regions, as well as agricultural production. This includes the preservation of resources for self-sufficiency and food security of a country's agriculture, as well as a tradition and agricultural knowledge. It is necessary to develop financial instruments that encourage the resilience and resistance of agriculture to climate change. Unfortunately with the rise of negative effects of climate change and global warming insurance companies are losing their interest for agriculture insurance and farmers are left on their own. In a situation where agriculture insurance has limited scope, alternative solutions must be sought [16].

Coordination of supply chains within the bloc of countries is also necessary to prevent, avert, or anticipate potential regional collapses related to food security, food stability, and food supply.

Therefore, coordinated action by all BRICS countries is necessary, especially the largest and the most developed ones, to protect agriculture from the negative impacts of climate change and global warming. From this research analysis, the devastating impact of worsening negative effects of climate change and global warming can clearly be seen. This is not only the case for agriculture but also the economy as a whole within BRICS countries and their regional partners.

To implement this, state support, regional cooperation, and coordination among BRICS countries are necessary, as well digitalization of agriculture and adoption of new technologies. Industry 4.0 and Industry 5.0 that include smart and precise agriculture, based on sensors, microprocessors, microcontrollers, robotics, Artificial Intelligence and Machine Learning algorithms, Industrial Internet of Things, are just a few examples and potentials of available new technologies and concepts that can potentially mitigate negative effects of climate change and global warming in agriculture [14].

The necessity of these measures and actions lies in the conclusions of this research, which show that there are indications of cumulative agricultural systemic collapse in Sub-Saharan Africa and South Asia, close in the region economics of the BRICS countries, potentially in the future decades. With crisis spillovers, economic and food security instability could be affecting the global food supply chain and agro-industry system.

References

1. Pejanović R. Ogledi iz agrarne i ruralne ekonomije [Essays in agrarian and rural economics]. Novi Sad: Poljoprivredni fakultet; 2013.

2. Simunic I, Spalevic V, Vukelic-Shutoska M, Tanaskovic V, Moteva M, Uzen N. Climate changes and water requirements in field crop production. In: Proceedings of the 24th International Scientific-Expert Conference on Agriculture and Food Industry; 2013; Sarajevo, Bosnia and Herzegovina.

3. Popović V, Jovović Z, Marjanović-Jeromela A, Sikora V, Mikić S, Bojović R, et al. Climatic change and agricultural production. In: Book of Proceedings, GEA (Geo Eco-Eco Agro) International Conference; 2020 May 28-31; Podgorica, Montenegro. p. 160-6.

4. National Oceanic and Atmospheric Administration. Land and ocean temperature anomalies based on temperature departure [Internet]. Statista; 2024 [cited 2025 Feb 1]. Available from: https://www.statista.com/statistics/224893/land-and-ocean-temperature-anomalies-based-on-temperature-departure/.

5. NASA Scientific Visualization Studio. Global temperature anomalies 2024 [Internet]. NASA; 2025 [cited 2025 Feb 1]. Available from: https://svs.gsfc.nasa.gov/5450/.

6. From floods to drought: the 2025 climate story of India [Internet]. CEED India; 2025 [cited 2025 Feb 1]. Available from: https://ceedindia.org/from-floods-to-drought-the-2025-climate-story-of-india/.

7. Food and Agriculture Organization of the United Nations. The state of food and agriculture 2024 [Internet]. Rome: FAO; 2024 [cited 2025 Feb 1]. Available from: https://openknowledge.fao.org/bitstreams/0f606eca-3ca8-4535-8013-f3f4467badf7/download.

8. India's climate crisis: analysing extreme weather events [Internet]. Int J Financ Manag Res; 2024 [cited 2025 Feb 1]. Available from: https://www.ijfmr.com/research-paper.php?id=63229.

9. Brazil agriculture - looking back 2024 [Internet]. Agroberichten Buitenland; 2025 Feb 6 [cited 2025 Feb 1]. Available from: https://www.agroberichtenbuitenland.nl/actueel/nieuws/2025/02/06/brazil-agriculture---looking-back-2024.

10. Brazil cuts its soybean and corn production projections for 2024 [Internet]. farmdoc daily, University of Illinois; 2023 Dec [cited 2025 Feb 1]. Available from: https://farmdocdaily.illinois.edu/2023/12/brazil-cuts-its-soybean-and-corn-production-projections-for-2024.html.

11. Zhao C, Liu B, Piao S, Wang X, Lobell DB, Huang Y, et al. Temperature increase reduces global yields of major crops in four independent estimates. Proc Natl Acad Sci U S A. 2017;114(35):9326-31. doi: 10.1073/pnas.1701762114.

12. BRICS shares solutions to promote global food security [Internet]. BRICS Brazil; 2024 [cited 2025 Feb 1]. Available from: https://brics.br/en/news/brics-shares-solutions-to-promote-global-food-security.

13. BRICS economic indicators and global trade analysis [Internet]. Int J Energy Econ Policy; 2024 [cited 2025 Feb 1]. Available from: https://econjournals.com/index.php/ijeep/article/download/15808/7862/36858.

14. Pejanović V, Urekar M. Retrofitting legacy photo-sensor infrastructure for hybrid smart agriculture and Industry 4.0. In: 2025 12th International Conference on Electrical, Electronic and Computing Engineering (IcETRAN); 2025; Serbia. p. 1-6. doi: 10.1109/IcETRAN66854.2025.11114313.

15. Radović G, Subić J, Pejanović V. Analysis of implementation of the IPARD II Program in Serbia. Ekonomika poljoprivrede. 2024;71(3):1017-31.

16. Radović G. Insured risks in plant production in Serbia and climate changes. Evropska Revija Za Pravo Osiguranja. 2025;XXIV(2):61. doi: 10.46793/ERPO2402.61R.