

CLIMATE CHANGE, FOOD SECURITY, AND THE GEOPOLITICS OF AGRICULTURAL TRANSFORMATION: PROSPECTS FOR AFRICA IN AN ERA OF GLOBAL SUPPLY CHAIN DISRUPTIONS

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Abstract

Climate change has emerged as one of the defining challenges of the twenty-first century, profoundly reshaping agricultural systems, food production, and socio-economic development across the globe. Africa, despite contributing less than four percent of global greenhouse gas emissions, remains disproportionately vulnerable to climate-induced shocks. Concurrently, geopolitical tensions have intensified food insecurity by destabilizing agricultural input markets, increasing fertilizer prices, constraining food imports, and exposing the continent's dependence on external food systems. These overlapping crises have renewed global attention on agricultural transformation as a strategic pathway toward sustainable food security, economic resilience, and regional self-sufficiency. This study examines the intricate relationships among climate change, food security, geopolitical dynamics, and agricultural transformation in Africa. Drawing upon secondary qualitative data from international organizations, peer-reviewed literature, policy documents, and empirical reports, the study employs Political Ecology Theory, Food Regime Theory, and the Sustainable Livelihoods Framework to analyze how environmental change and geopolitical competition influence agricultural production systems and food governance across the continent. The paper argues that climate change and geopolitical disruptions should not be viewed merely as isolated threats but as interconnected drivers of structural transformation requiring integrated policy responses. The findings suggest that Africa possesses considerable opportunities to transform its agricultural sector through climate-smart agriculture, regional value chains, digital agriculture, biotechnology, renewable energy, irrigation expansion, and implementation of the African Continental Free Trade Area (AfCFTA). However, realizing these opportunities requires substantial investments in infrastructure, governance reforms, climate finance, technological innovation, and regional cooperation. The study concludes that Africa's long-term food security depends less on expanding cultivated land than

on building resilient agricultural systems capable of adapting to climatic uncertainties and geopolitical volatility. Strategic investments in agricultural transformation can reposition Africa from being a net food importer to becoming a globally competitive agricultural powerhouse.

Keywords: Climate Change, Food Security, Agricultural Transformation, Africa, Geopolitics, Global Supply Chains, Climate-Smart Agriculture, AfCFTA, Sustainable Development.

1. INTRODUCTION

The twenty-first century has witnessed an unprecedented convergence of environmental, economic, and geopolitical crises that collectively threaten global food systems. Among these, climate change represents perhaps the most pervasive challenge, affecting agricultural productivity, water availability, biodiversity, rural livelihoods, and national food security (Intergovernmental Panel on Climate Change [IPCC], 2023). Simultaneously, geopolitical tensions and disruptions to global supply chains have exposed the vulnerabilities of highly interconnected food systems, highlighting the strategic importance of domestic agricultural production and regional food resilience.

Food security remains one of humanity's most pressing development challenges. According to the Food and Agriculture Organization (FAO, 2024), more than 730 million people worldwide experience chronic hunger, while approximately 2.8 billion individuals cannot afford a healthy diet. Africa bears a disproportionate share of this burden, accounting for nearly one-third of the world's food-insecure population despite possessing approximately 60 percent of the world's uncultivated arable land (African Development Bank [AfDB], 2024).

Climate change has significantly altered rainfall patterns, increased the frequency and severity of droughts, floods, cyclones, heatwaves, and pest outbreaks across Africa. These climatic events have reduced agricultural productivity, degraded natural resources, increased livestock mortality, and intensified competition over land and water resources (IPCC, 2023). Smallholder farmers—who produce nearly 80 percent of Africa's food—remain particularly vulnerable because of limited access to irrigation, improved seed varieties, agricultural finance, insurance, and extension services (World Bank, 2024).

Recent geopolitical developments have compounded these vulnerabilities. The COVID-19 pandemic exposed weaknesses in global food logistics, disrupted labor markets, and constrained international trade. Shortly thereafter, the Russia–Ukraine conflict further destabilized global food systems because both countries are major exporters of wheat, maize, sunflower oil, and fertilizers. The resulting supply shortages, export restrictions, and price volatility significantly affected African countries that rely heavily on imported cereals and agricultural inputs (FAO, 2024).

These developments have fundamentally altered global conversations regarding agricultural development. Rather than viewing agriculture solely as a developmental sector, governments increasingly recognize agriculture as a strategic national security asset. Food self-sufficiency, supply chain resilience, agricultural industrialization, and climate adaptation have become central priorities in national development planning.

Africa occupies a unique position within this evolving global landscape. The continent possesses enormous agricultural potential, abundant natural resources, a youthful labor force, expanding digital connectivity, and growing regional markets through the African Continental Free Trade Area (AfCFTA). Yet agricultural productivity remains among the lowest globally due to inadequate infrastructure, limited mechanization,

poor access to technology, insecure land tenure, insufficient financing, and weak institutional governance (AfDB, 2024).

Agricultural transformation therefore represents not merely an economic imperative but also a strategic response to climate vulnerability, geopolitical uncertainty, and food insecurity. Transformation extends beyond increasing production to encompass modernization of value chains, technological innovation, sustainable resource management, agro-industrial development, digital agriculture, and regional market integration.

The convergence of climate change and geopolitical disruptions presents both risks and opportunities. While climate variability threatens agricultural systems, it also encourages innovation in climate-smart agriculture, renewable energy-powered irrigation, drought-resistant crop varieties, precision agriculture, digital advisory services, and sustainable land management. Likewise, disruptions in international supply chains have renewed interest in regional agricultural production, intra-African trade, and domestic food processing industries.

This paper explores these interrelated dynamics by examining how climate change and geopolitical developments influence Africa's agricultural transformation and food security prospects. It argues that Africa can transform current vulnerabilities into opportunities through strategic investments in climate resilience, agricultural modernization, technological innovation, and regional integration.

2. BACKGROUND TO THE STUDY

Climate change has become one of the most significant determinants of agricultural performance globally. Rising temperatures, changing precipitation patterns, increased frequency of extreme weather events, and ecosystem degradation continue to reshape food production systems. The IPCC (2023) identifies Africa as among the regions most vulnerable to climate impacts because of its geographic exposure, economic dependence on agriculture, and relatively low adaptive capacity. Agriculture contributes approximately 23 percent of Africa's gross domestic product and employs over 60 percent of the labor force, making climatic disruptions particularly consequential for economic development (AfDB, 2024). Unlike industrialized nations where agriculture relies extensively on mechanization and irrigation, over 95 percent of cultivated land in sub-Saharan Africa remains rain-fed. Consequently, variations in rainfall directly influence crop yields, household incomes, and national food supplies. Over the past two decades, Africa has experienced recurrent droughts in the Horn of Africa, devastating cyclones in Southern Africa, widespread flooding in West Africa, desertification across the Sahel, and increasing pest infestations such as the desert locust invasion. These climatic events have reduced cereal production, displaced millions of people, destroyed rural infrastructure, and increased humanitarian assistance requirements (United Nations Environment Programme [UNEP], 2023).

At the same time, global food systems have become increasingly interconnected through international trade. Many African countries depend heavily on imported wheat, rice, fertilizers, pesticides, and agricultural machinery. While globalization has improved market access, it has simultaneously increased exposure to external shocks. The COVID-19 pandemic demonstrated how disruptions in transportation, labor mobility, and international logistics could rapidly affect food availability. Border closures delayed agricultural imports, interrupted seasonal labor migration, and disrupted food distribution networks across the continent. Recovery remained incomplete when the Russia–Ukraine war generated further disruptions in fertilizer and grain markets.

Russia and Ukraine previously accounted for significant proportions of global wheat, maize, barley, sunflower oil, and fertilizer exports. African countries including Egypt, Sudan, Tunisia, Morocco, Nigeria,

Kenya, Ethiopia, and Somalia experienced substantial increases in food prices because of supply shortages and increased transportation costs (World Food Programme [WFP], 2024). These developments revealed structural weaknesses within African food systems, including excessive dependence on imported staples, limited storage infrastructure, underdeveloped agro-processing industries, fragmented regional markets, and inadequate strategic food reserves.

Meanwhile, geopolitical competition among major powers—including China, the United States, the European Union, Russia, India, Türkiye, and Gulf States—has intensified across Africa's agricultural sector. Foreign investments increasingly target agricultural land, mineral resources, fertilizer production, logistics infrastructure, digital agriculture, and food processing industries. Although such investments provide opportunities for technology transfer and capital inflows, they also raise concerns regarding land governance, food sovereignty, debt sustainability, and resource control.

Against this backdrop, agricultural transformation has become central to continental development strategies such as Agenda 2063, the Comprehensive Africa Agriculture Development Programme (CAADP), the Malabo Declaration, and AfCFTA. These initiatives seek to improve agricultural productivity, strengthen regional value chains, enhance food security, and increase competitiveness within global markets. Agricultural transformation differs fundamentally from agricultural expansion. While expansion focuses primarily on increasing cultivated land, transformation emphasizes productivity improvements, technological innovation, value addition, environmental sustainability, institutional reform, market integration, and resilience to external shocks. Climate-smart agriculture, digital technologies, biotechnology, renewable energy, precision farming, irrigation development, and sustainable soil management constitute key components of this transformation. The current era therefore represents both a challenge and an opportunity. Climate change and geopolitical instability threaten existing agricultural systems while simultaneously accelerating policy reforms, technological innovation, and investments that may fundamentally reshape Africa's agricultural future.

3. STATEMENT OF THE PROBLEM

Africa faces a paradoxical agricultural reality. The continent possesses approximately 60 percent of the world's remaining uncultivated arable land, abundant freshwater resources in several regions, favorable climatic diversity for multiple crops, and a rapidly expanding labor force. Yet it remains a net importer of food, spending an estimated US\$75 billion annually on food imports, with projections suggesting this figure could exceed US\$110 billion by 2030 if current trends persist (AfDB, 2024). Climate change has exacerbated this challenge by reducing crop productivity, increasing production risks, degrading soils, expanding desertification, and intensifying water scarcity. Rising temperatures and erratic rainfall continue to undermine the livelihoods of millions of smallholder farmers, who remain the backbone of African food production.

Simultaneously, geopolitical conflicts and global supply chain disruptions have exposed the vulnerability of African food systems to external shocks. Dependence on imported cereals, fertilizers, fuel, and agricultural technologies has heightened inflationary pressures and constrained agricultural production. The Russia–Ukraine conflict, export restrictions, and disruptions in maritime logistics have demonstrated the strategic risks associated with excessive reliance on global food markets. Despite numerous continental initiatives promoting agricultural modernization, implementation gaps persist. Limited investment in research and development, inadequate rural infrastructure, poor access to finance, weak extension services, fragmented markets, governance challenges, and policy inconsistencies continue to constrain agricultural transformation.

Existing scholarship has extensively examined climate change, food security, and agricultural development

independently. However, relatively few studies integrate these issues within a geopolitical framework that considers how global power competition, supply chain disruptions, and strategic resource politics collectively shape Africa's agricultural transformation. This study addresses this gap by examining the intersection of climate change, food security, geopolitics, and agricultural transformation, with particular emphasis on Africa's opportunities to build resilient, sustainable, and globally competitive agricultural systems.

4. CONCEPTUAL REVIEW

4.1 Climate Change

Climate change refers to long-term alterations in average weather patterns attributable primarily to anthropogenic greenhouse gas emissions, resulting in global warming, altered precipitation regimes, rising sea levels, and increased frequency of extreme weather events (IPCC, 2023). Although climate variability has always existed, contemporary climate change is characterized by unprecedented rates of environmental transformation driven by industrialization, deforestation, fossil fuel consumption, and unsustainable land-use practices. For Africa, climate change is not merely an environmental phenomenon but a multidimensional development challenge affecting agriculture, health, migration, conflict, biodiversity, energy systems, and macroeconomic stability (African Union Commission [AUC], 2023). The continent's vulnerability stems from a combination of geographical exposure, high dependence on climate-sensitive sectors, limited adaptive capacity, and persistent socio-economic inequalities.

The principal manifestations of climate change affecting African agriculture include:

- Increasing average temperatures;
- Erratic rainfall patterns;
- Prolonged droughts;
- Flooding;
- Desertification;
- Coastal erosion;
- Cyclones;
- Pest and disease outbreaks;
- Declining soil fertility;
- Water scarcity.

These factors collectively reduce agricultural productivity and increase food insecurity.

According to the IPCC (2023), global temperatures have already risen by approximately 1.1°C above pre-industrial levels. Africa is warming faster than the global average in several ecological zones, particularly the Sahel, North Africa, and Southern Africa. Without substantial mitigation efforts, average temperatures across much of Africa may increase between 2.5°C and 4°C by the end of the century. Climate change therefore represents not only an ecological crisis but also a governance and development challenge requiring integrated adaptation strategies.

4.2 Food Security

Food security is among the most widely discussed concepts in international development. The FAO (2024) defines food security as a condition in which:

"All people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

This definition encompasses four interconnected dimensions:

- **Food Availability**

Food availability concerns the physical presence of adequate food through domestic production, imports, food reserves, and humanitarian assistance.

- **Food Access**

Food access refers to the ability of households and individuals to obtain sufficient food through income, purchasing power, social protection, and functioning markets.

- **Food Utilization**

Food utilization concerns nutritional quality, food safety, healthcare, sanitation, and proper dietary practices that determine nutritional outcomes.

- **Food Stability**

Food stability requires consistent access to adequate food over time despite economic shocks, conflicts, climate events, or market disruptions.

Recent scholarship increasingly recognizes a fifth dimension:

- **Food Agency**

Food agency emphasizes individuals' and communities' ability to determine how food is produced, distributed, and consumed while maintaining cultural preferences and environmental sustainability (Clapp et al., 2022). Africa's food insecurity reflects deficiencies across all these dimensions. Climate shocks reduce food availability; poverty limits food access; weak healthcare systems undermine food utilization; conflicts disrupt food stability; and heavy dependence on imported staples constrains food sovereignty.

4.3 Agricultural Transformation

Agricultural transformation refers to the comprehensive modernization of agricultural systems beyond simple increases in production. It encompasses structural changes in productivity, technology adoption, value addition, market integration, institutional development, rural industrialization, and environmental sustainability (World Bank, 2024).

Agricultural transformation generally involves several interrelated processes:

- Mechanization
- Irrigation development
- Improved seed technologies
- Precision agriculture
- Digital agriculture
- Climate-smart agriculture
- Agricultural research and innovation
- Agro-processing
- Rural infrastructure
- Market integration
- Agricultural finance
- Extension services
- Export competitiveness

Unlike traditional agricultural development, transformation emphasizes increasing productivity per unit of land, labor, and water rather than merely expanding cultivated acreage.

The African Union's Comprehensive Africa Agriculture Development Programme (CAADP) views agricultural transformation as central to achieving Agenda 2063 and sustainable economic development.

4.4 Climate-Smart Agriculture

Climate-Smart Agriculture (CSA) has emerged as one of the leading paradigms for sustainable agricultural development.

According to the FAO (2023), CSA simultaneously seeks to achieve three objectives:

1. Increase agricultural productivity.
2. Enhance climate adaptation and resilience.
3. Reduce greenhouse gas emissions where feasible.

CSA includes practices such as:

- Conservation agriculture
- Agroforestry
- Integrated soil fertility management
- Water harvesting
- Precision irrigation
- Climate-resilient crop varieties
- Livestock management
- Renewable-energy-powered irrigation
- Digital climate advisory services

Climate-smart agriculture is particularly relevant for Africa because it addresses productivity and resilience simultaneously.

4.5 Geopolitics

Geopolitics traditionally examines how geography influences international power relations. Contemporary geopolitics extends beyond territorial competition to encompass energy security, food systems, technology, critical minerals, trade routes, supply chains, and strategic resources (Blackwill & Harris, 2016). Food has increasingly become a geopolitical instrument.

Governments employ:

- Export restrictions
- Food aid
- Strategic grain reserves
- Fertilizer diplomacy
- Agricultural investments
- Land acquisitions
- Maritime control
- Infrastructure financing to influence international relations.

The Russia–Ukraine conflict demonstrated how food exports can become geopolitical leverage affecting countries thousands of kilometers away.

Africa increasingly occupies a central position within global agricultural geopolitics due to its:

- Vast arable land
- Strategic minerals
- Growing consumer markets
- Water resources
- Renewable energy potential

4.6 Global Supply Chain Disruptions

Global supply chains refer to interconnected production, transportation, storage, and distribution networks linking producers and consumers worldwide.

Recent disruptions include:

- COVID-19 pandemic
- Russia–Ukraine war
- Red Sea shipping disruptions
- Rising protectionism
- Export bans
- Fertilizer shortages
- Energy price shocks
- Climate-induced transportation disruptions

These events revealed excessive dependence on concentrated suppliers for:

- Wheat
- Fertilizers
- Vegetable oils
- Animal feed
- Agricultural machinery

For Africa, disruptions increased production costs while reducing food affordability.

5. LITERATURE REVIEW

5.1 Climate Change and Agricultural Productivity

Extensive research demonstrates that climate change has significantly reduced agricultural productivity across Sub-Saharan Africa. Morton (2007) argued that agriculture remains the sector most vulnerable to climate variability because production depends heavily on rainfall and temperature. The IPCC (2023) estimates that climate change has already reduced yields of major African crops including maize, sorghum, millet, and wheat. Lobell et al. (2011) found that increasing temperatures significantly reduce maize yields across tropical regions. Schlenker and Lobell (2010) estimated that maize productivity in many African countries could decline between 20 and 30 percent by mid-century under high-emission scenarios. These impacts extend beyond crops.

Livestock systems experience:

- Heat stress
- Reduced pasture productivity
- Water shortages
- Increased disease prevalence

Similarly, fisheries face declining productivity because of ocean warming and acidification.

5.2 Climate Change and Food Security

Numerous scholars identify climate change as one of the principal drivers of contemporary food insecurity. According to Wheeler and von Braun (2013), climate change affects all four pillars of food security simultaneously.

- Availability declines because crop production falls.
- Access deteriorates as food prices increase.
- Utilization worsens because nutrition declines.
- Stability weakens because production becomes increasingly unpredictable.

The World Food Programme (2024) estimates that climate-related disasters now account for a growing proportion of humanitarian food emergencies globally. In Africa, recurrent droughts in Ethiopia, Somalia, Kenya, Malawi, Zambia, Zimbabwe, and Madagascar have displaced millions while increasing dependence on emergency food assistance.

5.3 Agricultural Transformation in Africa

African governments increasingly recognize agriculture as the foundation for structural transformation. The African Development Bank (2024) argues that agriculture possesses the greatest potential for poverty reduction because most poor households remain dependent on farming. However, agricultural productivity remains significantly below global averages. Average fertilizer application in Sub-Saharan Africa remains approximately one-tenth of levels observed in East Asia. Mechanization rates remain among the lowest globally. Less than six percent of cultivated land is irrigated.

Researchers therefore emphasize:

- mechanization;
- research and development;
- rural roads;
- irrigation;
- extension services;
- financial inclusion;
- agricultural industrialization.

These investments have transformed agriculture in countries such as Brazil, Vietnam, China, and India, providing lessons for Africa.

5.4 Global Supply Chains and Food Systems

The COVID-19 pandemic fundamentally altered scholarly understanding of global food systems. Before 2020, globalization was widely viewed as improving food security through trade efficiency. However, Clapp (2021) argues that excessive dependence on globalized supply chains created systemic vulnerabilities. Similarly, Laborde et al. (2020) demonstrated that export restrictions amplified food price volatility. The Russia–Ukraine conflict further reinforced these concerns. African countries dependent on imported wheat experienced dramatic price increases. Fertilizer prices nearly doubled in many markets because Russia and Belarus account for significant shares of global fertilizer exports.

5.5 Emerging Trends in Agricultural Innovation

Recent literature increasingly highlights technology as central to African agricultural transformation.

Emerging innovations include:

- Artificial Intelligence
- Machine learning
- Satellite monitoring
- Drone technology
- Internet of Things (IoT)
- Blockchain
- Digital marketplaces
- Mobile extension services
- Precision agriculture
- Biotechnology
- Climate forecasting
- Remote sensing
- Digital financial services

These technologies improve productivity while enhancing climate resilience. Countries including Kenya, Rwanda, Nigeria, Ghana, Morocco, and South Africa have become regional leaders in digital agriculture innovation.

6. RESEARCH GAP

Although extensive literature exists on climate change, food security, and agricultural development independently, relatively limited research integrates these themes within an international political economy framework.

Specifically, previous studies have paid insufficient attention to:

- interactions between geopolitical competition and agricultural transformation;
- implications of global supply chain disruptions for African food sovereignty;
- strategic role of AfCFTA in strengthening food resilience;
- climate-smart agriculture as a geopolitical adaptation strategy;
- implications of emerging technologies for food security under geopolitical uncertainty.

This study addresses these gaps by providing an integrated multidisciplinary analysis.

7. THEORETICAL FRAMEWORK

This study adopts an integrated theoretical approach combining Political Ecology Theory, Food Regime Theory, the Sustainable Livelihoods Framework, and Dependency Theory. Together, these perspectives explain how environmental change, global political economy, local livelihoods, and structural dependencies shape agricultural transformation and food security in Africa.

7.1 Political Ecology Theory

Political Ecology Theory examines the interaction between environmental change, political power, and economic structures (Robbins, 2020). It argues that environmental problems are not solely natural phenomena but are shaped by governance systems, unequal resource access, historical legacies, and policy choices. In the African context, climate impacts are intensified by weak institutions, unequal land distribution, and limited adaptive capacity, making this theory useful for analyzing the political dimensions of climate vulnerability.

7.2 Food Regime Theory

Food Regime Theory explains how global food systems are organized through international political and economic relations (McMichael, 2013). It highlights the influence of multinational corporations, trade agreements, and state policies on agricultural production and food distribution. The theory is particularly relevant for understanding Africa's dependence on imported food and agricultural inputs and the geopolitical implications of global supply chain disruptions.

7.3 Sustainable Livelihoods Framework

The Sustainable Livelihoods Framework focuses on the assets and capabilities households require to maintain resilient livelihoods (Scoones, 2015). It emphasizes five forms of capital—human, natural, physical, financial, and social—and examines how institutions and external shocks affect livelihood outcomes. This framework is valuable for assessing how climate change and agricultural transformation influence the resilience of African smallholder farmers.

7.4 Dependency Theory

Dependency Theory argues that historical patterns of unequal exchange have positioned many developing countries as suppliers of raw materials while creating dependence on industrialized economies for manufactured goods and technology (Frank, 1967). Applied to African agriculture, the theory helps explain persistent reliance on imported fertilizers, machinery, improved seeds, and food staples, as well as the continent's vulnerability to geopolitical disruptions in global markets.

7.5 Synthesis of the Theoretical Framework

The integration of these four theories provides a comprehensive lens for this study. Political Ecology explains the governance dimensions of climate change; Food Regime Theory illuminates the global organization of food systems; the Sustainable Livelihoods Framework highlights household resilience and adaptation; and Dependency Theory contextualizes Africa's structural vulnerabilities within the global economy. Together, they support a holistic analysis of climate change, food security, and the geopolitics of agricultural transformation.

8. RESEARCH METHODOLOGY

This study adopts a qualitative research design based on a comprehensive review and synthesis of secondary data. Secondary sources include peer-reviewed journal articles, books, reports from international organizations (such as the FAO, IPCC, World Bank, African Development Bank, United Nations Environment Programme, World Food Programme, and African Union), policy documents, and reputable statistical databases. A desk-based analytical approach is employed to examine the relationships among climate change, food security, geopolitical dynamics, and agricultural transformation in Africa. Data are analyzed using thematic content analysis, allowing recurring patterns, concepts, and policy trends to be identified and interpreted across multiple sources.

9. CLIMATE CHANGE AND AFRICAN AGRICULTURAL SYSTEMS

Climate change has become one of the most significant determinants of agricultural performance across Africa. Unlike many industrialized economies where agriculture depends heavily on controlled production systems, irrigation, mechanization, and advanced technologies, African agriculture remains predominantly rain-fed. Approximately 95% of cultivated land in Sub-Saharan Africa depends on rainfall, making

agricultural production exceptionally vulnerable to climatic variability (FAO, 2024). The effects of climate change extend beyond declining crop yields. They influence every component of the agricultural value chain, including land preparation, planting schedules, irrigation requirements, pest management, harvesting, storage, transportation, processing, and market access. Consequently, climate change is transforming agricultural production from a largely seasonal activity into an increasingly unpredictable enterprise. The Intergovernmental Panel on Climate Change (IPCC, 2023) identifies Africa as one of the world's climate "hotspots," where relatively small increases in global temperatures produce disproportionately severe socioeconomic consequences. Rising temperatures have shortened growing seasons, accelerated evapotranspiration, reduced soil moisture, and increased crop water requirements across much of the continent.

9.1 Changing Rainfall Patterns

Historically, African farmers relied on relatively predictable rainfall calendars. Climate change has disrupted these seasonal patterns, producing:

- delayed onset of rains;
- premature cessation of rainy seasons;
- prolonged dry spells;
- high-intensity rainfall events;
- frequent flooding.

The Sahel region provides an important example. Rainfall variability has increased substantially over the last four decades, making crop planning increasingly difficult. Farmers who traditionally planted according to historical rainfall calendars now face considerable uncertainty regarding planting dates, resulting in reduced productivity and increased production risks (World Bank, 2024).

East Africa presents a contrasting yet equally challenging pattern. Whereas some regions experience prolonged droughts, others experience excessive flooding within the same agricultural season. Such climatic instability complicates agricultural planning and increases production costs.

9.2 Temperature Rise and Crop Productivity

Temperature increases significantly influence plant physiology.

Higher temperatures:

- accelerate crop maturation;
- reduce grain-filling periods;
- increase evapotranspiration;
- reduce soil moisture;
- increase heat stress.

Major staple crops including maize, wheat, sorghum, millet, and rice demonstrate measurable yield reductions beyond optimal temperature thresholds.

Lobell et al. (2011) estimate that every 1°C increase above optimum growing temperatures can reduce maize yields by approximately 7–10% under tropical conditions.

Similarly, Schlenker and Lobell (2010) project substantial declines in cereal productivity across much of Sub-Saharan Africa under high-emission scenarios.

9.3 Water Resources and Irrigation

Water availability increasingly determines agricultural resilience.

Despite possessing major river systems—including the Nile, Niger, Congo, Zambezi, and Senegal Rivers—Africa irrigates less than 6% of cultivated land compared with approximately 37% in Asia (AfDB, 2024).

Climate change further complicates irrigation development through:

- declining groundwater recharge;
- reduced river discharge;
- increased evaporation;
- sedimentation of reservoirs;
- competing domestic and industrial water demands.

Countries investing in irrigation infrastructure, such as Morocco and Egypt, have generally demonstrated greater resilience than countries relying almost exclusively on rainfall.

9.4 Soil Degradation

Climate change accelerates multiple forms of land degradation:

- soil erosion;
- nutrient depletion;
- salinization;
- desertification;
- organic matter loss.

The United Nations Convention to Combat Desertification estimates that Africa loses millions of hectares of productive land annually because of unsustainable land management compounded by climatic pressures.

Declining soil fertility contributes directly to declining agricultural productivity despite increasing use of improved seed varieties.

9.5 Climate-Induced Pest and Disease Outbreaks

Changing climatic conditions have expanded the geographical range of numerous agricultural pests and diseases.

Notable examples include:

- Fall Armyworm
- Desert Locust
- Cassava Mosaic Disease
- Banana Bacterial Wilt
- Coffee Leaf Rust

The 2019–2021 desert locust invasion illustrated how climatic anomalies can generate transboundary agricultural crises affecting multiple countries simultaneously.

10. CLIMATE CHANGE AND FOOD SECURITY IN AFRICA

Food security remains one of Africa's greatest development challenges. Climate change intensifies existing structural vulnerabilities including poverty, conflict, weak infrastructure, limited market integration, and rapid population growth. The four pillars of food security are increasingly threatened.

Food Availability

Climate-induced yield reductions reduce domestic food production. Repeated droughts in Ethiopia, Somalia, Kenya, Zimbabwe, Zambia, Malawi, and Madagascar have significantly lowered cereal

production. Reduced production increases dependence on imports and humanitarian assistance.

Food Access

Food prices increase following production shocks. Poor households spend a large proportion of household income on food. Consequently, modest price increases significantly reduce food consumption. The World Food Programme (2024) estimates that climate shocks remain among the leading causes of acute food insecurity across Eastern and Southern Africa.

Food Utilization

- Nutrition outcomes deteriorate during climate-induced food shortages.
- Households often substitute nutritious diets with cheaper calorie-dense foods.
- Micronutrient deficiencies increase, particularly among women and children.
- Climate change also affects water quality and sanitation, indirectly increasing disease prevalence.

Food Stability

Perhaps the greatest threat concerns instability.

Increasing climatic variability creates repeated cycles of:

- drought;
- flooding;
- displacement;
- crop failure;
- livestock mortality;
- humanitarian emergencies.

Rather than isolated disasters, these events increasingly represent chronic conditions.

11. GEOPOLITICS AND AGRICULTURAL TRANSFORMATION

Agriculture has become increasingly intertwined with global geopolitics.

Food security now constitutes an important component of national security.

Governments increasingly use food systems as instruments of strategic influence.

The geopolitical dimensions affecting African agriculture include:

- fertilizer diplomacy;
- agricultural investment;
- export restrictions;
- strategic food reserves;
- infrastructure financing;
- technology transfer;
- maritime security.

11.1 The Russia–Ukraine Conflict

The Russia–Ukraine war fundamentally altered global food markets.

Before the conflict:

- Russia and Ukraine accounted for approximately 30% of global wheat exports.

- Significant shares of sunflower oil exports.
- Major fertilizer exports.

African countries heavily dependent upon imported wheat—including Egypt, Sudan, Tunisia, Morocco, Nigeria, Kenya, and Somalia—experienced dramatic food price increases. Fertilizer shortages further reduced domestic agricultural productivity. The conflict demonstrated how geographically distant geopolitical events directly affect African food security.

11.2 China's Agricultural Engagement

China has substantially expanded agricultural cooperation throughout Africa.

Areas include:

- irrigation projects;
- agricultural mechanization;
- demonstration farms;
- fertilizer production;
- research collaboration;
- rural infrastructure.

Chinese financing has supported numerous agricultural modernization projects. However, debates continue regarding debt sustainability and technology dependence.

11.3 European Union Green Policies

European sustainability standards increasingly influence African agricultural exports.

Carbon border adjustments, sustainability certification, and environmental regulations create both opportunities and compliance challenges for African exporters.

Countries capable of meeting environmental standards may benefit from premium export markets.

Others risk marginalization.

11.4 Gulf States and Agricultural Land Investments

Food-importing Gulf countries increasingly invest in African agriculture.

Investment target:

- Sudan;
- Ethiopia;
- Tanzania;
- Zambia;
- Mozambique.

While foreign investment provides capital, concerns remain regarding:

- land governance;
- local food security;
- displacement;
- environmental sustainability.

12. GLOBAL SUPPLY CHAIN DISRUPTIONS

The COVID-19 pandemic revealed unprecedented vulnerabilities within global food systems. Subsequent geopolitical crises reinforced these weaknesses.

Major disruptions included:

- transportation bottlenecks;
- container shortages;
- fertilizer shortages;
- export bans;
- labor shortages;
- rising fuel prices.

12.1 Fertilizer Markets

- Africa imports much of its fertilizer requirements.
- Russia and Belarus dominate several fertilizer markets.

Supply disruptions increased fertilizer prices by more than 80% in several African markets between 2021 and 2023 (FAO, 2024). Reduced fertilizer use subsequently lowered agricultural productivity.

12.2 Agricultural Machinery

Supply chain disruptions delayed imports of:

- tractors;
- irrigation equipment;
- harvesters;
- processing equipment;
- spare parts.

Mechanization programs experienced implementation delays.

12.3 Maritime Transport

- Global shipping costs increased substantially during the pandemic.
- Higher freight costs disproportionately affected African importers due to relatively smaller shipping volumes.
- Landlocked countries faced particularly severe challenges.

12.4 Food Inflation

Combined disruptions produced substantial food inflation.

Food inflation exceeded general inflation across many African economies.

Consequences included:

- declining purchasing power;
- increased poverty;
- reduced dietary diversity;
- greater humanitarian dependence.

13. COMPARATIVE CASE STUDIES

Nigeria

Nigeria possesses significant agricultural potential yet remains heavily dependent on food imports. Climate change has intensified flooding along the Niger and Benue River systems while desertification advances across northern states. The 2022 floods destroyed over 600,000 hectares of farmland, contributing to

substantial food inflation. Government initiatives promoting dry-season farming, irrigation, mechanization, and fertilizer production offer opportunities for greater resilience.

Ethiopia

Repeated droughts have severely affected livestock production. Pastoral communities continue experiencing declining herd sizes. Despite these challenges, Ethiopia has invested significantly in watershed restoration and climate-resilient agriculture. Large-scale tree planting initiatives have attracted international attention.

Kenya

Kenya has emerged as a continental leader in digital agriculture.

- Innovations include:
- mobile extension services;
- weather advisory applications;
- mobile agricultural finance;
- digital marketplaces.

These technologies improve resilience among smallholder farmers.

Morocco

Morocco demonstrates the importance of irrigation investment. Through the Green Morocco Plan and Generation Green Strategy, the country expanded efficient irrigation systems while promoting high-value agricultural exports. Water scarcity remains a challenge, yet productivity has improved relative to regional averages.

Egypt

Egypt's agriculture depends heavily upon Nile water resources. Climate change threatens water availability while sea-level rise affects the Nile Delta. Nevertheless, significant investments in desert agriculture, greenhouse production, and irrigation modernization illustrate adaptive capacity.

South Africa

South Africa possesses the continent's most industrialized agricultural sector. Climate change has increased drought frequency, particularly in the Western Cape. However, advanced research institutions, commercial farming, biotechnology adoption, and export-oriented agriculture provide comparatively strong adaptive capacity.

14. EMERGING OPPORTUNITIES FOR AGRICULTURAL TRANSFORMATION

Despite mounting challenges, climate change and geopolitical disruptions are accelerating innovation across African agriculture.

Key opportunities include:

Climate-Smart Agriculture

- Improved crop varieties, conservation agriculture, agroforestry, and precision irrigation enhance resilience while increasing productivity.

Digital Agriculture

- Artificial intelligence, satellite monitoring, remote sensing, blockchain, IoT, drones, and mobile advisory services improve decision-making and resource efficiency.

Renewable Energy

- Solar-powered irrigation and cold-chain infrastructure reduce dependence on expensive fossil fuels while improving productivity.

Regional Value Chains

- The African Continental Free Trade Area (AfCFTA) offers opportunities to strengthen intra-African trade, reduce dependence on overseas imports, and develop regional agro-processing industries.

Biotechnology

- Genome editing, improved seed breeding, biofertilizers, and disease-resistant crop varieties provide opportunities to enhance resilience and productivity.

Green Financing

- Climate finance, carbon markets, green bonds, blended finance, and agricultural insurance can mobilize resources for sustainable agricultural transformation.

15. DISCUSSION OF FINDINGS

This study demonstrates that climate change, food security, and geopolitics are no longer discrete policy domains but mutually reinforcing forces that are reshaping Africa's agricultural landscape. The evidence reviewed indicates that climate-induced environmental stress, geopolitical instability, and global supply chain disruptions collectively amplify vulnerabilities within African food systems while simultaneously creating incentives for structural transformation.

One of the principal findings is that climate change is fundamentally altering the ecological foundations of agricultural production. Increased temperatures, erratic rainfall, prolonged droughts, floods, pest outbreaks, and land degradation have reduced agricultural productivity across much of the continent. Because approximately 95% of agriculture in Sub-Saharan Africa remains rain-fed, climatic variability has immediate implications for rural livelihoods, national food supplies, and macroeconomic stability (IPCC, 2023). Smallholder farmers—who constitute the majority of agricultural producers—are disproportionately affected due to limited access to irrigation, finance, insurance, mechanization, and climate information services.

The study further reveals that contemporary food insecurity in Africa cannot be attributed solely to declining agricultural productivity. Rather, food insecurity results from the interaction of environmental pressures with structural weaknesses in governance, infrastructure, markets, and institutions. Climate shocks reduce food availability, while inflation, poverty, conflict, and market disruptions limit access to nutritious food. Consequently, millions of households experience chronic vulnerability despite adequate food production in some regions.

A second major finding concerns the increasing geopolitical significance of agriculture. Recent events—including the COVID-19 pandemic, the Russia-Ukraine conflict, Red Sea shipping disruptions, and the growing use of export restrictions—have demonstrated that food systems have become instruments of international power and strategic competition. African dependence on imported cereals, fertilizers, agricultural machinery, and fuel exposes the continent to geopolitical shocks originating far beyond its borders. The findings therefore support the argument that food security should be viewed not only as a development objective but also as a matter of national and regional security.

The analysis also highlights the strategic importance of supply chain resilience. The concentration of fertilizer production, grain exports, and maritime transport within a relatively small number of countries creates systemic risks for import-dependent economies. The sharp increases in fertilizer prices and food inflation following the Russia–Ukraine conflict illustrate how disruptions in one region can rapidly affect agricultural production across Africa. These developments underscore the need to diversify supply sources, strengthen regional production networks, and invest in domestic manufacturing capacity for key agricultural inputs.

Despite these challenges, the study identifies substantial opportunities for agricultural transformation. Advances in climate-smart agriculture, digital technologies, renewable energy, biotechnology, and precision farming offer new pathways for increasing productivity while improving resilience. Regional initiatives such as the African Continental Free Trade Area (AfCFTA) also provide opportunities to strengthen intra-African trade, develop regional value chains, and reduce dependence on external markets. These opportunities suggest that the current period of global uncertainty may serve as a catalyst for long-term structural transformation if supported by coherent policies and sustained investment.

The findings further indicate that governance remains a decisive factor in determining agricultural outcomes. Countries that have invested consistently in irrigation, agricultural research, extension services, rural infrastructure, and institutional reforms—such as Morocco and, in specific sectors, Egypt and South Africa—have generally demonstrated greater resilience to climatic and market shocks. This suggests that effective governance and policy coherence are as important as natural resource endowments in shaping agricultural performance.

Finally, the theoretical integration adopted in this study reinforces the multidimensional nature of the problem. Political Ecology Theory explains how environmental risks are mediated by institutions and power relations; Food Regime Theory illuminates the geopolitical organization of global food systems; the Sustainable Livelihoods Framework highlights household resilience and adaptive capacity; and Dependency Theory contextualizes Africa’s structural reliance on imported food and agricultural inputs. Together, these perspectives provide a comprehensive framework for understanding the interconnected challenges and opportunities facing African agriculture.

16. STRATEGIC FRAMEWORK FOR CLIMATE-RESILIENT AGRICULTURAL TRANSFORMATION IN AFRICA

Based on the findings, this study proposes a strategic framework comprising eight mutually reinforcing pillars.

16.1 Climate-Resilient Agricultural Production

Governments should prioritize climate-smart agricultural practices, including conservation agriculture, agroforestry, drought-tolerant crop varieties, integrated soil fertility management, efficient irrigation, and sustainable water harvesting. Scaling up these practices can enhance productivity while reducing vulnerability to climatic variability.

16.2 Agricultural Research, Innovation, and Technology

Increased investment in agricultural research and development is essential. National agricultural research systems should collaborate more closely with universities, regional research organizations, and international partners to develop locally adapted technologies. Priority areas include biotechnology, precision agriculture, artificial intelligence, digital advisory services, remote sensing, and climate

forecasting.

16.3 Regional Value Chains and Intra-African Trade

The implementation of AfCFTA should be leveraged to strengthen regional agricultural value chains. Reducing non-tariff barriers, harmonizing standards, improving transport infrastructure, and facilitating cross-border trade can enhance food availability while reducing dependence on extra-continental imports.

16.4 Fertilizer and Input Sovereignty

African countries should expand domestic production of fertilizers, seeds, and agricultural machinery through public-private partnerships and regional manufacturing initiatives. Greater local production would reduce exposure to international supply chain disruptions and improve input affordability.

16.5 Water Resource Development

Expanding irrigation infrastructure, improving water governance, rehabilitating watersheds, and promoting efficient irrigation technologies are critical for reducing dependence on rainfall. Investments in water storage and distribution systems should be prioritized, particularly in drought-prone regions.

16.6 Agricultural Finance and Risk Management

Governments and financial institutions should expand access to affordable credit, climate insurance, warehouse receipt systems, and digital financial services for farmers. Innovative financing mechanisms—including blended finance, green bonds, and climate adaptation funds—can mobilize additional resources for agricultural transformation.

16.7 Governance and Institutional Strengthening

Effective agricultural transformation requires transparent institutions, secure land tenure, coherent policy implementation, and strong extension systems. Governments should also strengthen early warning systems, disaster preparedness, and evidence-based policymaking.

16.8 Human Capital Development

Capacity-building initiatives targeting farmers, extension officers, researchers, and agribusiness entrepreneurs are essential. Expanding vocational education, digital literacy, and climate adaptation training will enhance the adoption of innovative agricultural practices.

17. CONCLUSION

Climate change, food insecurity, and geopolitical uncertainty represent three of the most significant challenges confronting Africa in the twenty-first century. Individually, each poses substantial risks to agricultural productivity, rural livelihoods, and economic development. Collectively, however, they constitute a systemic challenge that requires integrated, forward-looking, and transformative policy responses. The evidence reviewed in this study demonstrates that Africa's vulnerability is shaped not only by environmental conditions but also by structural dependence on imported food, agricultural inputs, and global supply chains. Recent geopolitical disruptions—including the COVID-19 pandemic, the Russia-Ukraine conflict, and disruptions to international shipping—have underscored the fragility of highly interconnected food systems and highlighted the strategic importance of domestic agricultural resilience.

At the same time, the continent possesses exceptional opportunities for agricultural transformation. Vast arable land, a youthful population, expanding digital connectivity, abundant renewable energy resources, and the establishment of AfCFTA provide a strong foundation for building more resilient and competitive

agricultural systems. Investments in climate-smart agriculture, research and innovation, irrigation, agro-processing, digital technologies, and regional value chains can substantially enhance food security while supporting broader economic development. Ultimately, Africa's agricultural future will depend less on the expansion of cultivated land than on the transformation of agricultural systems through innovation, effective governance, regional integration, and sustainable resource management. By adopting integrated strategies that address environmental, economic, and geopolitical dimensions simultaneously, African countries can strengthen food sovereignty, enhance resilience to external shocks, and position agriculture as a cornerstone of inclusive and sustainable development.

18. POLICY RECOMMENDATIONS

Drawing on the analysis, the following policy recommendations are proposed:

1. Increase public expenditure on agriculture to meet or exceed the 10% target established under the Malabo Declaration.
2. Accelerate the implementation of climate-smart agriculture through targeted subsidies, technical assistance, and farmer training.
3. Expand irrigation infrastructure and improve integrated water resource management to reduce dependence on rain-fed agriculture.
4. Strengthen national agricultural research systems and promote partnerships with universities, international research institutes, and the private sector.
5. Invest in digital agriculture, including mobile advisory services, precision agriculture, artificial intelligence, remote sensing, and digital marketplaces.
6. Develop regional fertilizer production facilities and improve access to quality agricultural inputs.
7. Promote agro-processing and value addition to reduce post-harvest losses and increase rural employment.
8. Enhance the implementation of AfCFTA by improving transport corridors, customs procedures, and regional market integration.
9. Establish strategic food reserves and strengthen early warning systems to improve preparedness for climate and market shocks.
10. Increase access to agricultural finance through innovative credit mechanisms, crop insurance, and blended finance instruments.
11. Strengthen land governance and tenure security to encourage long-term investments in sustainable agriculture.
12. Integrate climate adaptation into national agricultural development plans and budgeting processes.
13. Promote renewable energy technologies, particularly solar-powered irrigation and cold-chain infrastructure, to enhance productivity and reduce emissions.
14. Foster inclusive governance by engaging farmers' organizations, women's groups, youth, and the private sector in agricultural policymaking.
15. Strengthen continental cooperation through the African Union, regional economic communities, and development partners to coordinate responses to transboundary climate and food security challenges.

19. IMPLICATIONS FOR THEORY, POLICY, AND PRACTICE

Theoretical Implications

This study contributes to the literature by integrating environmental, geopolitical, and development perspectives into a unified analytical framework. The combination of Political Ecology Theory, Food Regime Theory, the Sustainable Livelihoods Framework, and Dependency Theory offers a more

comprehensive understanding of the complex interactions among climate change, food security, and agricultural transformation.

Policy Implications

The findings highlight the need for integrated policies that simultaneously address climate adaptation, agricultural modernization, trade, infrastructure, and governance. Sector-specific interventions are unlikely to produce sustainable outcomes without broader institutional reforms and regional cooperation.

Practical Implications

For governments, development agencies, and private investors, the study underscores the importance of investing in resilient agricultural systems, digital technologies, renewable energy, and regional value chains. These investments can improve food security while generating employment, reducing poverty, and enhancing economic competitiveness.

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