Effectiveness of Global Partnerships for Climate Change Mitigation in Sub-Saharan Africa's Agricultural Sector: A Sustainable Development Perspective

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Abstract
This study investigates the effectiveness of global partnerships in mitigating climate change impacts within Sub-Saharan Africa's agricultural sector. Anchored in globalization, interdependency, and public policy theories, it evaluates partnership outcomes, identifies best practices, and analyzes challenges related to power asymmetries and African agency. Using a qualitative desk review of literature from 2010–2024, the study focuses on five country cases and highlights the lived experiences of smallholder farmers. Findings reveal that while partnerships have advanced climate resilience and resource mobilization, they often lack contextual sensitivity and equitable governance. The study recommends inclusive, locally adapted strategies to enhance stakeholder ownership and promote sustainable agricultural transformation.

Keywords: Agriculture, Climate Change, Food Security, Global Partnerships, Globalization, Interdependency, Mitigation, Multi-stakeholder Initiatives, Sub-Saharan Africa, Sustainable Development

1. Introduction
Climate change presents a profound threat to global agricultural systems, with Sub-Saharan Africa expected to bear disproportionate impacts due to its reliance on rain-fed agriculture and limited adaptive capacity. Projections suggest up to a 30% decline in agricultural productivity by 2050 (Schlenker & Lobell, 2010), compounded by a rapidly growing population projected to double within the same timeframe (United Nations, 2019). These pressures exacerbated by erratic rainfall, rising temperatures, and institutional vulnerabilities intensify risks to food security, economic stability, and sustainable development across the region (Omweri, 2024).

In response, global partnerships comprising international organizations, national governments, non-governmental organizations (NGOs), and private-sector actors have emerged as critical mechanisms for climate change mitigation and adaptation in agriculture. These collaborative efforts aim to facilitate resource mobilization, knowledge transfer, technology deployment, and capacity building to enhance agricultural resilience (Newell & Touni, 2018).

This study examines the effectiveness of such global partnerships in addressing climate challenges in Sub-Saharan Africa's agricultural sector through the lens of sustainable development. Drawing on globalization and interdependency theories (Mittelman, 2000; Keohane & Nye, 1977), the research explores how these partnerships operate within power-laden global structures and reciprocal relationships, potentially shaping or constraining local agency and climate-smart agricultural strategies.

Employing a qualitative desk review methodology, the study analyzes literature, policy documents, and program reports published between 2010 and 2024. The analysis focuses on cases from Rwanda, Ethiopia, Mali, Zambia, and Malawi. It critically evaluates partnership outcomes, identifies best practices, and interrogates challenges, particularly those affecting smallholder farmers and vulnerable communities.

Ultimately, the research contributes to the evolving discourse on climate mitigation, sustainable agriculture, and the United Nations Sustainable Development Goals (SDGs). Its findings offer actionable insights for improving partnership models, strengthening African stakeholder agency, and promoting equitable, responsive, and context-sensitive agricultural transformation under a changing climate

Objectives of the Study

To guide the analysis, the study pursues the following objectives:

1. To evaluate the outcomes of global partnerships aimed at climate change mitigation in agriculture across Sub-Saharan Africa.
2. To identify best practices that improve the responsiveness, adequacy, and sustainability of climate-smart agriculture interventions.
3. To analyze the challenges and power dynamics that influence the agency of African stakeholders in shaping climate mitigation strategies.
4. To assess the adequacy of climate change responses in Sub-Saharan Africa's agricultural sector, focusing on their relevance, coverage, inclusivity, and effectiveness for smallholder farmers.

2. Literature Review

While globalization theory explains the structural dominance of Global North actors in shaping climate interventions, interdependency theory introduces a counterbalance, highlighting the potential for reciprocal agency and negotiated outcomes. This tension is critical: partnerships may simultaneously empower and constrain African stakeholders. Public policy theory adds evaluative depth, distinguishing between procedural legitimacy (input validity) and tangible results (output validity). Together, these lenses expose the complex interplay between power, participation, and performance in climate-smart agriculture.

Globalization Theory

Globalization, understood as both a process and a form of governance (Wulff, 2021), has significantly shaped climate intervention structures in Sub-Saharan Africa's agricultural sector. It influences resource flows, technological norms, and policy priorities, often reinforcing Global North dominance over local agricultural systems (Parjanadze, 2009; Muna et al., 2020). This dynamic raises concerns about the marginalization of traditional agricultural knowledge and the contextual relevance of imported climate-smart technologies.

Interdependency Theory

Interdependency theory offers a valuable lens for analyzing the relational dynamics between international actors and African stakeholders in climate mitigation partnerships (Keohane & Nye, 1977; Van Lange & Balliet, 2015). Key concepts such as level of dependence and co-variation of interests help explain tensions between dominance and agency in decision-making processes. For instance, the degree to which African nations rely on external partners can influence whether mitigation strategies reflect joint control or external imposition. This tension may manifest as assertiveness versus passivity in policy negotiations (Rusbult & Van Lange, 2008; Balliet et al., 2016).

Public Policy Validity

Drawing on Marsh and McConnell's framework (2010), the success of climate partnerships can be assessed through input validity and output validity. Input validity refers to the extent to which partnerships incorporate the voices, priorities, and lived experiences of local stakeholders, particularly smallholder farmers and cooperatives. Output validity evaluates whether partnerships achieve tangible outcomes such as increased agricultural productivity, enhanced climate resilience, and reduced greenhouse gas emissions. However, as McConnell (2010) cautions, policy success often resides in grey zones. In the context of Sub-Saharan Africa, additional

dimensions such as timing, adequacy, and agency are critical for evaluating the real-world effectiveness of climate mitigation efforts.

2.1. Global Climate Partnerships on Agriculture in Sub-Saharan Africa

Climate change, driven by anthropogenic activity, continues to reshape weather patterns, increase climate extremes, and disrupt agricultural livelihoods in Sub-Saharan Africa (Omweri, 2024; Intergovernmental Panel on Climate Change [IPCC], 2021). In response, global partnerships have emerged as transnational multi-stakeholder platforms (Knutsson & Lindberg, 2019), enabling diverse actors including governments, international organizations, non-governmental organizations (NGOs), civil society groups, and philanthropic foundations to pursue climate-smart agriculture (CSA) and resilient food systems (Lipper et al., 2014). These partnerships reflect evolving governance structures that balance public-private collaboration and align with aid effectiveness principles (Menashy & Dryden-Peterson, 2015; Ogbuoji & Yamey, 2019).

Rwanda: Strategic Plan for Agricultural Transformation (PSTA IV under CAADP)

Under the Comprehensive Africa Agriculture Development Programme (CAADP), Rwanda's Strategic Plan for Agricultural Transformation Phase IV (PSTA IV) was launched for the 2018–2024 period to modernize agriculture and enhance climate resilience. One of its most notable achievements has been the integration of climate-smart agriculture (CSA) practices, particularly among smallholder farmers. The plan prioritized the promotion of drought-resistant crop varieties such as improved maize, beans, and cassava, which have demonstrated higher yields under erratic rainfall conditions. These varieties were developed and disseminated through partnerships with research institutions including the Rwanda Agriculture and Animal Resources Development Board (RAB) and the Consultative Group on International Agricultural Research (CGIAR) centers, contributing to increased food security and reduced vulnerability to climate shocks (RAB, 2023; CGIAR, 2022).

In addition to crop diversification, PSTA IV emphasized sustainable land management techniques. The expansion of radical and progressive terraces, covering over 143,000 hectares by 2024 and helped reduce soil erosion and improve water retention in hilly terrains (Ministry of Agriculture and Animal Resources [MINAGRI], 2023; Abbott & Malunda, 2014). Small-scale irrigation systems were also scaled up, with irrigated land increasing by nearly 50% from 2017 levels, enabling year-round vegetable production and mitigating the effects of seasonal droughts (Alliance for a Green Revolution in Africa [AGRA], 2025; World Bank, 2023). Farmers in districts such as Bugesera and Gatsibo reported yield increases of

up to 60% due to greenhouse farming and irrigation support, as documented in Rwanda's National Agriculture Investment Plan and United Nations Development Programme (UNDP) monitoring reports (UNDP, 2024; Federal Ministry of Agriculture, 2022).

Moreover, the plan supported the development of early warning systems and climate information services, enabled farmers to make informed decisions about planting and harvesting. These systems, backed by the UNDP and other partners, reached over 100,000 farmers and significantly reduced crop losses during extreme weather events (UNDP, 2024; International Fund for Agricultural Development [IFAD], 2024a; World Bank, 2023). The fisheries and poultry sectors also experienced notable growth. Aquaculture production rose from approximately 31,000 tonnes in 2018 to over 46,000 tonnes by 2023 (Commercial Agriculture for Smallholders and Agribusiness [CASA], 2023a; African Union Inter-African Bureau for Animal Resources [AU-IBAR], 2024). During the same period, poultry numbers increased from 5.4 million to over 6 million birds, diversifying protein sources and improving household nutrition (Commercial Agriculture for Smallholders and Agribusiness [CASA], 2023b; Cocchini & ter Steeg, 2019).

Collectively, these outcomes reflect Rwanda's commitment to transforming its agricultural sector into a resilient, market-oriented, and inclusive engine for sustainable development. The Strategic Plan for Agricultural Transformation Phase IV (PSTA IV) not only advanced productivity but also laid the groundwork for long-term adaptation to climate change through institutional reforms, farmer training, and public-private partnerships (Ministry of Agriculture and Animal Resources [MINAGRI], 2018; World Bank, 2023; Network of Excellence on Land Governance in Africa [NELGA], 2017).

Ethiopia: Agricultural Growth and Watershed Management Program

Ethiopia's Agricultural Growth and Watershed Management Program, implemented under the Comprehensive Africa Agriculture Development Programme (CAADP), has significantly advanced climate resilience and sustainable land use across vulnerable regions. Through flagship initiatives such as the Agricultural Growth Program (AGP) and the Sustainable Land Management Program (SLMP), the country rehabilitated degraded landscapes in over 400 woredas, integrating soil conservation, agroforestry, and water harvesting techniques (Federal Ministry of Agriculture, 2022). These interventions have improved soil fertility, reduced erosion, and enhanced moisture retention, enabling farmers to cultivate previously unproductive land. In regions like Amhara and Tigray, agroforestry systems combining fruit trees with staple crops have diversified household incomes and stabilized food supplies

during drought seasons (World Bank, 2011). Water harvesting structures including check dams, percolation ponds, and rooftop rainwater systems have expanded access to irrigation, reducing dependence on erratic rainfall and boosting crop yields. Notably, Ethiopia's irrigated wheat program reduced national wheat import dependency by 35%, with some farmers doubling their yields within two seasons (AGRA, 2025). These outcomes reflect Ethiopia's strategic alignment with CAADP's goals of productivity, resilience, and poverty reduction. However, challenges persist in scaling technologies to remote areas and ensuring equitable access to irrigation and extension services, underscoring the need for inclusive and context-sensitive implementation strategies.

Mali: International Fund for Agricultural Development (IFAD) Fostering Agricultural Productivity Project

Mali's *Fostering Agricultural Productivity Project* (Projet d'Amélioration de la Productivité Agricole au Mali, PAPAM), co-financed by the International Fund for Agricultural Development (IFAD), the World Bank, and other development partners, was designed to enhance the productivity and climate resilience of smallholder farmers through a combination of technology transfer, irrigation infrastructure, and institutional reform. Implemented between 2011 and 2018, the project introduced drought-tolerant millet and sorghum varieties, alongside water-efficient irrigation systems tailored to semi-arid zones. These interventions enabled over 100,000 smallholder farmers to maintain crop yields despite increasingly erratic rainfall patterns and prolonged dry spells (IFAD, 2022). The project also developed over 2,200 hectares of irrigated land, including small-scale village schemes and lowland perimeters, which significantly expanded the area under cultivation and reduced seasonal vulnerability (World Bank, 2015). In partnership with Mali's National Research Institute and technical services, PAPAM facilitated the dissemination of improved agricultural technologies such as the biogas digesters and organic slurry systems that reduced reliance on chemical fertilizers and improved soil health (IFAD, 2024b). These innovations not only boosted productivity but also contributed to environmental sustainability and gender equity by alleviating labor burdens on women and promoting equitable access to farming inputs. Despite implementation delays and political instability, PAPAM's outcomes underscore the potential of integrated climate-smart strategies to transform smallholder agriculture in fragile contexts.

Zambia: UNDP Climate Information and Early Warning Systems

The Climate Information and Early Warning Systems (CIEWS) Project in Zambia, implemented by UNDP in collaboration with the Government of Zambia and funded by the Global Environment Facility (GEF), exemplifies how the localized climate data can enhance adaptive capacity among vulnerable populations. By installing and rehabilitating over 30 meteorological and hydrological stations in flood-prone districts such as Kasaya in Kazungula and Mbeta Island in Western Province, the initiative provided real-time weather forecasts and seasonal climate data to over 100,000 smallholder farmers (UNDP, 2019; UNDP, 2022a). Dissemination through radio, mobile alerts, and community bulletins translated into local languages enabled farmers to adjust planting schedules, select climate-resilient crop varieties, and mitigate exposure to climate-related risks. Notably, in Southern Province, women farmers reported "bumper" harvests after using forecast data to avoid planting during dry spells, thereby improving food security and household income (UNDP, 2022b). The project also strengthened institutional capacity by training forecasters and district officers to interpret and communicate climate data, contributing to long-term agricultural planning and disaster preparedness (UNDP, 2024). Despite logistical challenges in reaching remote communities, the CIEWS initiative demonstrates the transformative potential of climate-informed decision-making in fostering resilience and inclusive development.

2.2. Regional & Alliance-Based Initiatives

Africa Climate-Smart Agriculture Alliance (ACSAA)

Launched in 2014 under the leadership of NEPAD and five international NGOs, ACSAA was designed to accelerate the adoption of climate-smart agriculture (CSA) across Africa. The alliance aimed to reach at least 6 million farming households by 2021**,** contributing to the African Union's Vision 25x25 goal (ACSAA, 2022). ACSAA mobilized funding through CAADP-aligned National Agriculture Investment Plans (NAIPs), promoted CSA innovation through farmer-led approaches, and supported the development of national CSA strategies. It facilitated peer learning, policy engagement, and technical backstopping across 10 core member organizations, including CGIAR, Food and Agriculture Organization of the United Nations (FAO), and Forum for Agricultural Research in Africa (FARA). The alliance emphasized inclusive programming by targeting women, youth, and marginalized groups, and helped build enabling environments for CSA through evidence-based advocacy and institutional capacity strengthening (Steiner et al., 2020).

Global Alliance for Climate-Smart Agriculture (GACSA)

Established in 2014 and hosted by FAO, GACSA is a voluntary, multi-stakeholder platform that fosters global cooperation on CSA. It operates through three action

groups: Knowledge, Investment, and Enabling Environment. GACSA catalyzed transformational partnerships, facilitated policy dialogue, and disseminated CSA knowledge across the African contexts. It supported national CSA strategies, aligned CSA with NDCs and SDGs, and promoted integrated approaches to productivity, adaptation, and mitigation. GACSA's clearinghouse mechanism enabled evidence-based decision-making and cross-sectoral collaboration, while its facilitation unit provided technical support and convened annual forums for knowledge exchange (Lipper et al., 2014; GACSA, 2022).

Consultative Group on International Agricultural Research (CGIAR) & International Crops Research Institute for the Semi-Arid Tropics (ICRISAT): Research-Based Interventions

CGIAR centers, particularly ICRISAT, have led the development of drought-tolerant crop varieties tailored to the semi-arid agroecologies in Africa. These include improved strains of the sorghum, pearl millet, pigeon pea, and green gram. Demonstration farms in Kenya's drylands showed yield increases of up to 55% compared to traditional varieties, even under below-average rainfall (ICRISAT, 2018). The integration of conservation agriculture and climate information services further enhanced adaptive capacity. Over 1,500 farmers participated in scaling trials, with 75% being women, reflecting strong gender inclusion (Neufeldt et al., 2015).

African Risk Capacity (ARC): Insurance-Integrated Early Warning Systems

ARC, a specialized agency of the African Union, provides parametric insurance and early warning systems to help member states respond to climate disasters. It uses Africa RiskView, a satellite-based tool to trigger payouts based on rainfall thresholds. ARC enabled early recovery planning and rapid disbursement of funds within 2–4 weeks of drought events, reducing humanitarian response delays. Countries like Senegal and Malawi received payouts that supported food distribution and livestock protection. ARC Replica and ARC Ltd. expanded coverage through donor-supported premium subsidies and technical assistance. The initiative also strengthened national contingency planning and risk modeling capacities (Greatrex et al., 2015; ARC, 2022; UNDP, 2024).

2.3. Best Practices in Global Climate Partnerships on Agriculture in Sub-Saharan African

Climate-smart agriculture (CSA) has emerged as a best practice in global climate partnerships focusing on Sub-Saharan Africa. CSA aims to simultaneously increase agricultural productivity, enhance resilience to climate change, and reduce greenhouse gas emissions where possible (FAO, 2013). A comprehensive study by Lipper et al. (2014) in Nature Climate Change highlighted the potential of CSA to

transform agricultural systems to support food security under changing climatic conditions. Successful implementations often involve partnerships between international organizations, local governments, and farming communities to tailor CSA practices to specific local contexts.

The development and distribution of climate-resilient crop varieties is another crucial best practice. The Consultative Group on International Agricultural Research (CGIAR) has been at the forefront of this effort. For instance, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has developed drought-tolerant varieties of crops such as sorghum, pearl millet, and groundnut that have shown significant yield improvements in Sub-Saharan Africa (ICRISAT, 2018). These efforts often involve collaboration between international research institutions, national agricultural research systems, and seed companies to ensure improved varieties reach smallholder farmers.

Implementing early warning systems and weather-based insurance schemes have proven to be an effective best practice. The African Risk Capacity (ARC), a specialized agency of the African Union, has pioneered in this area by combining early warning systems with insurance mechanisms to help member states improve their capacities to plan, prepare, and respond to extreme weather events (ARC, 2020). A study by Greatrex et al. (2015) in Agricultural and Food Security reviewed several index insurance initiatives in Africa and found that they can contribute significantly to climate resilience when implemented alongside other risk reduction measures.

Improving water management and irrigation practices is critical, given the increasing water scarcity in many parts of Sub-Saharan Africa. The Comprehensive Africa Agriculture Development Programme (CAADP), an initiative of the African Union, has identified water management as a key priority area (NEPAD, 2015). A review by Xie et al. (2014) in Agricultural Water Management assessed the potential for expanding irrigation in Sub-Saharan Africa and highlighted the need for integrated approaches to water resource management. Successful partnerships in this area often involve coordination between water resource management authorities, agricultural ministries, and international development agencies.

Knowledge sharing and capacity building have proven to be fundamental best practices. The Climate Change, Agriculture and Food Security (CCAFS) program, collaboration between CGIAR and Future Earth, has been instrumental in this regard. CCAFS has supported the establishment of climate-smart villages as learning platforms for various stakeholders (Aggarwal et al., 2018). Additionally, digital platforms like the African Farm Radio Research Initiative have shown promise in disseminating agricultural information to rural communities (Farm Radio

International, 2011). These initiatives often involve partnerships between research institutions, extension services, and media organizations.

While these best practices have shown promising results, their long-term success depends on continued collaboration, adaptation to local contexts, and sustained investment. As Thornton et al. (2018) argue in Agricultural Systems, addressing climate change impacts on agriculture in Africa will require transformative changes and innovative solutions that go beyond incremental adaptations. Global climate partnerships must therefore remain flexible and responsive to emerging needs and opportunities in the agricultural sector, continuously evolving their best practices to meet the challenges of a changing climate in Sub-Saharan Africa.

2.4. Challenges in Global Climate Partnerships on Agriculture in Sub-Saharan Africa

Global climate partnerships aimed at enhancing agricultural resilience in Sub-Saharan Africa have delivered promising results but continue to grapple with deeply rooted structural and operational challenges. These obstacles are particularly acute for smallholder farmers who constitute the backbone of the region's agricultural sector and often determine the effectiveness, scalability, and sustainability of climate-smart interventions.

Contextual Complexity and Limited Scalability of Interventions

One of the most pressing challenges is the difficulty in scaling up successful climate-smart agriculture (CSA) practices across diverse agro-ecological and socio-economic zones. While many pilot projects show high promise, translating these localized successes into broad regional strategies remains problematic. Whitfield et al. (2015) underscore that CSA effectiveness is highly context-specific, making 'one-size-fits-all' solutions impractical. For smallholder farmers, this means that interventions must be carefully adapted to local soils, climates, traditions, and production systems, requiring time, resources, and extensive participatory planning.

Limited Access to Finance and Agricultural Inputs

Smallholder farmers across the region frequently lack access to affordable credit, savings mechanisms, insurance, and essential inputs like drought-tolerant seeds or water-efficient irrigation technologies. The Rural and Agricultural Finance Learning Lab (2016) reports that formal institutions meet only 3% of smallholders' financing needs. This financial exclusion significantly limits their ability to adopt climate-resilient practices promoted by partnerships, resulting in uneven uptake and missed opportunities for building local resilience.

Fragmentation and Poor Coordination across Stakeholders

Climate adaptation efforts in Sub-Saharan Africa frequently suffer from overlapping mandates, fragmented implementation, and weak alignment between national, local, and international actors (African Capacity Building Foundation [ACBF], 2023). This lack of coordination undermines the coherence and scalability of climate-smart interventions. Ampaire, Mabon, et al. (2017) found that adaptation policies in East Africa are inconsistently coordinated, leading to resource duplication and gaps in service delivery. For smallholder farmers, such fragmentation often results in conflicting guidance, uneven support, and reduced access to reliable markets and knowledge services which are critical components for effective climate-smart agriculture (CSA) deployment. Evidence from Zambia's CSA accelerator program confirms that without integrated support systems, farmers face challenges in adopting CSA technologies due to inconsistent extension messaging, limited access to climate information, and weak market linkages (Homann-Kee Tui et al., 2023).

Gaps in Climate and Agricultural Data

High quality, timely data are essential for tailoring interventions, forecasting climate risks, and measuring partnership impact. Yet, many areas in Sub-Saharan Africa suffer from weak data systems and unreliable climate monitoring infrastructure. Ramirez-Villegas et al. (2013) emphasize how data limitations impede accurate modeling and hinder agricultural impact assessments. This directly affects smallholder farmers, who depend on seasonal forecasts, extension services, and risk assessment tools to inform planting decisions and investment choices.

Governance Constraints and Political Instability

Strong institutional capacity and political stability are prerequisites for effective partnership implementation. However, many Sub-Saharan countries face ongoing governance challenges, including weak rule of law and low administrative accountability (Mo Ibrahim Foundation, 2017). For smallholder farmers, this instability can disrupt access to services, impede long-term planning, and deter private investment in CSA initiatives. Partnerships often struggle to operate effectively in fragile contexts, risking discontinuity and reduced impact.

Balancing Short-Term Food Security with Long-Term Climate Resilience

Smallholder farmers in Sub-Saharan Africa often grapple with immediate survival needs including food security, market access, and livelihood protection, which can overshadow the long-term goals of climate resilience (Kapari et al., 2023). Hansen et al. (2019) highlight the trade-offs between short-term productivity gains and enduring sustainability, noting that interventions focused solely on yield improvement may inadvertently undermine ecological resilience. Partnerships must therefore carefully

design interventions that integrate quick wins (e.g., input subsidies or improved crop varieties) with deeper investments in ecological adaptation, institutional strengthening, and capacity building to ensure both immediate impact and long-term sustainability.

2.5. The Adequacy of Responses to Climate Change in Africa's Agricultural Sector

The adequacy of responses to climate change in Africa's agricultural sector remains a subject of critical scrutiny. Despite a proliferation of initiatives and interventions, their overall effectiveness is often questioned given the scale, urgency, and complexity of the challenge. As Kotir (2011) observes, while awareness of climate change impacts has grown significantly, the implementation of adaptation strategies has been slow and frequently inadequate. This gap between awareness and action is particularly concerning given the sector's vulnerability to climate variability and extreme events.

One area where responses have shown promise is the development and adoption of climate-smart agriculture (CSA) practices. CSA aims to sustainably increase productivity, enhance resilience, and reduce greenhouse gas emissions where feasible (Zougmoréet al., 2018). Empirical evidence from several African countries supports the effectiveness of CSA interventions. For instance, case studies from Rwanda, Tanzania, and Zambia demonstrate that CSA practices such as drought-tolerant crop varieties, agroforestry, and integrated soil fertility management have led to improved yields, enhanced soil health, and greater farmer resilience to climate shocks (Msaki, et al., 2015). A systematic review of 164 studies across Algeria, Senegal, Benin, Nigeria, and Zambia further confirms that CSA strategies positively impact smallholder productivity and food security, especially when supported by climate information services and policy incentives (Ariom et al., 2022). Despite this promise, the scale of adoption remains limited relative to the scale of need. Financial constraints, limited access to extension services, and inconsistent policy frameworks continue to hinder widespread uptake (Finizola e Silva et al., 2024). This indicates that while CSA is conceptually sound and empirically validated, its implementation is not yet adequate to meet the full scope of climate challenges facing the continent.

The adequacy of climate information services and early warning systems has yielded mixed results. While advancements in weather forecasting and climate modeling have expanded across the continent, translating this data into actionable advice for smallholder farmers remains a persistent challenge. Vaughan et al., (2019) found that although climate services are increasingly available, their integration into agricultural

decision-making is still limited, undermining their potential impact on adaptive planning.

In terms of policy responses, many African countries have made strides in incorporating climate change considerations into agricultural frameworks. Yet, implementation often falls short due to limited financial resources, weak institutional capacities, and fragmented coordination across sectors. According to Ampaire, Wangari, et al. (2017), despite the proliferation of climate policies in East Africa, significant gaps persist in operationalizing these frameworks effectively.

The financial adequacy of climate responses is particularly troubling. Although global climate finance has grown, only a small fraction reaches small-scale agriculture in Africa. As the Climate Policy Initiative reports (2019), Africa receives less than 15% of the climate finance it requires annually, with agriculture receiving an even smaller share. This financial shortfall severely constrains the ability of farmers to adopt climate-resilient technologies and practices.

Finally, the adequacy of research and technology development shows both progress and limitations. While there have been notable advances in breeding climate-resilient crop varieties and developing adaptive farming techniques, dissemination and uptake remain slow. Challinor et al. (2016) warn that crop-breeding systems are not keeping pace with the rate of climate change, and that without accelerated variety development and delivery, yields may decline within the next decade

3. Methodology

This study employs a qualitative desk review methodology, analyzing peer-reviewed literature, policy documents, and program evaluations published between 2010 and 2024. Five countries Rwanda, Ethiopia, Mali, Zambia, and Malawi were selected based on their active engagement in global agricultural partnerships and geographic diversity. Thematic coding was applied to extract patterns related to partnership structure, stakeholder agency, and climate-smart outcomes. Data triangulation was used to validate findings across sources, and a comparative matrix was developed to assess cross-country variations. Limitations include reliance on secondary data and uneven documentation across cases.

4. Analysis and Discussion

4.1. Evaluating the Outcomes of Global Partnerships in Climate Change Mitigation

Global partnerships have played a pivotal role in advancing climate change mitigation within Sub-Saharan Africa's agricultural sector. These collaborations have facilitated the dissemination of climate-smart technologies, institutional capacity building, and improved agricultural productivity. For instance, Rwanda's Strategic Plan for Agricultural Transformation (PSTA IV) enabled the adoption of drought-resistant crop varieties and expanded irrigation infrastructure, resulting in yield increases of up to 60% in greenhouse farming zones (MINAGRI, 2018; UNDP, 2024). Similarly, Ethiopia's irrigated wheat program reduced import dependency by 35%, demonstrating the tangible benefits of coordinated interventions (AGRA, 2025). Zambia's Climate Information and Early Warning Systems (CIEWS) project reached over 100,000 farmers with localized forecasts, enhancing adaptive decision-making and reducing crop losses (UNDP, 2022a). These outcomes reflect strong output validity, as defined by Marsh and McConnell (2010), yet input validity remains limited. Many partnerships lack inclusive planning and stakeholder co-design, which undermines long-term sustainability and local ownership (McConnell, 2010; CASA, 2023b).

4.2. Identifying Best Practices for Responsive and Sustainable CSA Interventions

Several best practices have emerged from global climate partnerships that enhance the responsiveness and sustainability of climate-smart agriculture (CSA) interventions. Integrated soil management, agroforestry, and climate-resilient crop varieties have proven effective when tailored to local agro-ecological contexts (AU-IBAR, 2024; CGIAR, 2022). Localized climate services such as real-time weather forecasts and community-based dissemination platforms have empowered farmers to make informed planting decisions, as seen in Zambia and Rwanda (UNDP, 2024; CASA, 2023a). Insurance mechanisms like those developed by the African Risk Capacity (ARC) have enabled rapid recovery from climate shocks through parametric payouts triggered by satellite-based rainfall thresholds (ARC, 2022; Greatrex et al., 2015). Inclusive programming, particularly gender-sensitive approaches and farmer-led innovation platforms, has further strengthened equity and community ownership (Cocchini & ter Steeg, 2019; Neufeldt et al., 2015). These practices are most effective when embedded in participatory governance frameworks and supported by coherent institutional coordination.

4.3. Analyzing Challenges and Power Dynamics Affecting African Stakeholder Agency

Despite notable achievements, global climate partnerships continue to face structural challenges that constrain African stakeholder agency. Power asymmetries persist, with donor-driven agendas often overshadowing local priorities and reinforcing dependency (Resnick & Birner, 2010; CASA, 2023b). Fragmented coordination among actors and overlapping mandates reduce implementation fidelity and hinder policy coherence (ACBF, 2023; Ampaire, Wangari, et al., 2017). Weak climate and agricultural data systems further impede adaptive planning and impact assessment, limiting the effectiveness of interventions (Ramirez-Villegas et al., 2013). Financial exclusion remains a critical barrier, as smallholder farmers often lack access to climate finance and agricultural inputs necessary for CSA adoption (Rural and Agricultural Finance Learning Lab, 2016). Interdependency theory, as articulated by Keohane and Nye (2001), suggests that African institutions can negotiate influence by leveraging strategic assets and contextual expertise. Ethiopia's wheat program and Zambia's co-produced climate services exemplify how localized knowledge and institutional leadership can reshape partnership dynamics and enhance agency (Gebreselassie & Bekele, 2021; Mwale et al., 2022).

4.4. Assessing the Adequacy of Climate Change Responses for Smallholder Farmers

The adequacy of climate change responses in Sub-Saharan Africa's agricultural sector remains insufficient relative to the scale of vulnerability faced by smallholder farmers. While CSA practices have demonstrated positive impacts such as improved yields, enhanced soil health, and greater resilience to climate shocks, their adoption remains limited due to financial, infrastructural, and policy constraints (Zougmoré et al., 2018; Msaki et al., 2015). Many policy frameworks lack operational depth and fail to integrate the climate adaptation into mainstream agricultural planning (Ampaire, Mabon, et al., 2017). Climate information services, though increasingly available, are not yet fully embedded in agricultural decision-making, reducing their potential impact (Vaughan et al., 2019). Furthermore, climate finance flows remain inadequate, with less than 15% of required funding reaching African agriculture annually (Climate Policy Initiative, 2019). Research systems also lag behind the pace of climate change, with crop-breeding programs struggling to deliver adaptive varieties quickly enough (Challinor et al., 2016). These gaps highlight the need for a paradigm shift toward equity-centered governance, institutional reform, and epistemic justice elevating smallholders as co-creators of climate strategies rather than passive beneficiaries.

5. Conclusion

Global climate partnerships have emerged as vital instruments in mitigating the impacts of climate change on agriculture across Sub-Saharan Africa. This study finds that while these partnerships have facilitated the dissemination of climate-smart technologies, strengthened institutional capacities, and improved agricultural productivity, their effectiveness remains uneven and context-dependent. Notable gains such as increased yields, expanded early warning systems, and enhanced resilience are evident in countries like Rwanda, Ethiopia, and Zambia. However, these successes are often geographically concentrated and pilot-bound, with limited scalability and sustainability.

The analysis reveals persistent structural challenges, including power asymmetries, fragmented coordination, inadequate data systems, and financial exclusion. These constraints undermine African stakeholder agency and limit the responsiveness of interventions to local needs. Moreover, while output validity is frequently achieved, input validity, particularly the meaningful inclusion of smallholder farmers in planning and implementation remains underdeveloped. The adequacy of climate responses is further compromised by underfunded research systems, weak policy operationalization, and insufficient climate finance reaching small-scale agriculture.

Ultimately, achieving climate resilience in African agriculture requires more than technical innovation. It demands governance reform, equity-centered design, and epistemic justice repositioning smallholders as co-creators of strategy rather than passive recipients. Interdependency theory affirms that African institutions can negotiate influence within global partnerships by leveraging contextual expertise, institutional legitimacy, and strategic assets.

Recommendations

To strengthen the effectiveness, equity, and sustainability of climate-smart agricultural partnerships in Sub-Saharan Africa, this study proposes the following recommendations:

1. Co-Design with Local Stakeholders: Embed participatory planning processes that include smallholder farmers, indigenous knowledge holders, and decentralized governance actors to ensure contextual relevance and foster ownership.
2. Expand Inclusive Climate Finance: Develop and scale blended finance models, weather-indexed insurance schemes, and community-based credit systems to enable smallholders to adopt climate-resilient technologies.

3. Strengthen Multi-Level Coordination: Establish integrated frameworks that align national, local, and international actors to reduce fragmentation and enhance policy coherence and implementation fidelity.
4. Invest in Data Infrastructure: Build interoperable climate and agricultural data systems, including localized early warning platforms and farmer-accessible digital tools, to support adaptive planning and evidence-based decision-making.
5. Balance Short-Term and Long-Term Goals: Design interventions that reconcile immediate food security needs with long-term ecological investments such as agroecology, soil regeneration, and landscape restoration.
6. Enhance Capacity Development: Support peer learning platforms, strengthen extension services, and invest in institutional capacity for researchers and policymakers to drive innovation and policy uptake.
7. Accelerate Adaptive Research: Increase funding for crop breeding, digital agriculture, and climate-smart innovations tailored to African agro-ecologies, ensuring that research systems keep pace with climate variability.

6. Limitations and Further Study

This study is constrained by its reliance on secondary data, which may omit undocumented local innovations or informal stakeholder dynamics. The desk review approach limits direct engagement with farmer perspectives, and country-level comparisons may mask intra-national disparities. Additionally, the theoretical framing, while robust may not fully capture indigenous epistemologies or informal governance mechanisms. Future research should incorporate participatory fieldwork and mixed-methods approaches to deepen contextual understanding.

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