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Climate Change, Environmental Health, and Economic Development in Africa: Integrated Pathways for Resilience and Sustainable Development

Daniel Chigudu*

University of South Africa, Preller St, Muckleneuk, Pretoria, 0002, South Africa. *Corresponding Author's Email: chigud@unisa.ac.za

Abstract

Africa stands at the frontline of the global climate crisis, facing disproportionate risks to environmental health and economic development despite contributing minimally to global greenhouse gas emissions. Climate change intensifies the continent's vulnerabilities, including food and water insecurity, infectious disease burdens, and environmental degradation, while threatening to reverse hard-won development gains. This paper explores integrated pathways for building resilience and achieving sustainable development in Africa by examining the interconnectedness of climate change, environmental health, and economic growth through a comprehensive conceptual framework and systematic analysis of barriers and enablers. It reviews continental strategies such as the African Union's Climate Change and Resilient Development Strategy and Action Plan, which emphasise adaptation, mitigation, and inclusive, low-carbon economic transformation as central pillars for resilience. The analysis highlights the critical need for cross-sectoral policy coordination, investment in renewable energy and green infrastructure, and strengthening of health systems to withstand climate shocks. By leveraging Africa's vast renewable energy potential and fostering innovation in climate-smart agriculture and circular economies, the continent can chart a path toward equitable, climate-resilient development that safeguards public health and economic prosperity. The paper concludes that integrated, multisectoral approaches—grounded in regional cooperation, robust governance, and inclusive stakeholder engagement—are essential for enabling Africa to adapt to climate change, protect environmental health, and achieve the Sustainable Development Goals.

Keywords: Africa, Climate Change, Economic Development, Environmental Health, Sustainable Development.

Introduction

Africa is at the frontline of the global climate crisis, facing disproportionate risks to environmental health and economic development despite minimally contributing to global greenhouse gas emissions (1). The continent's vulnerability is driven by its high dependence on climate-sensitive sectors such as agriculture, fisheries, and natural resources, combined with low adaptive capacity resulting from weak economies, underdeveloped infrastructure, and limited institutional effectiveness. Climate change exacerbates existing challenges, such as food and water insecurity, infectious disease burdens, and environmental degradation, while threatening to reverse hard-won development gains and deepen this. The impacts of climate change on environmental health are profound and multifaceted. Increased frequency and severity of extreme weather events—such as droughts, floods, and heatwaves—directly affect the health and well-being of African populations, particularly among the most vulnerable groups, including children, women, and those living in poverty. These events compromise access to clean water, food security, and healthcare services, heightening the risk of malnutrition, waterborne diseases, and heat-related illnesses, as illustrated in Figure 1 (1). At the same time, climate-induced disruptions to agriculture and infrastructure undermine livelihoods, reduce productivity, and impose significant economic costs. Projections indicate that, without urgent action, some African regions could experience GDP losses of up to 15% by 2050 due to climate change (1).

Given the interconnected nature of these challenges, integrated and cross-sectoral approaches are essential for building resilience and achieving sustainable development by 2030, as conceptualised in the analytical framework presented in Figure 1 (2). Critical steps include

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mainstreaming climate adaptation and mitigation into national development strategies, fostering policy coherence across sectors, and investing in climate-resilient infrastructure and health systems. Furthermore, leveraging Africa's vast renewable energy potential and promoting innovation in climate-smart agriculture and circular economies can drive inclusive, low-carbon economic transformation (1). Achieving these goals requires robust governance, regional cooperation, and inclusive stakeholder engagement to ensure that the benefits of resilience and sustainable development are shared equitably across the continent.

Small island developing states (SIDS) like Mauritius and Seychelles face unique climate, health, and economic risks compared to Sahelian countries. These include extreme weather events, sea level rise, coastal erosion, saltwater intrusion, and pressure on freshwater resources, health facilities, and rural economic development (3). These regional pathways help tailor policy responses to adaptation, coastal protection, and strengthening health systems, aligning with the unique drivers of environmental change and vulnerability.

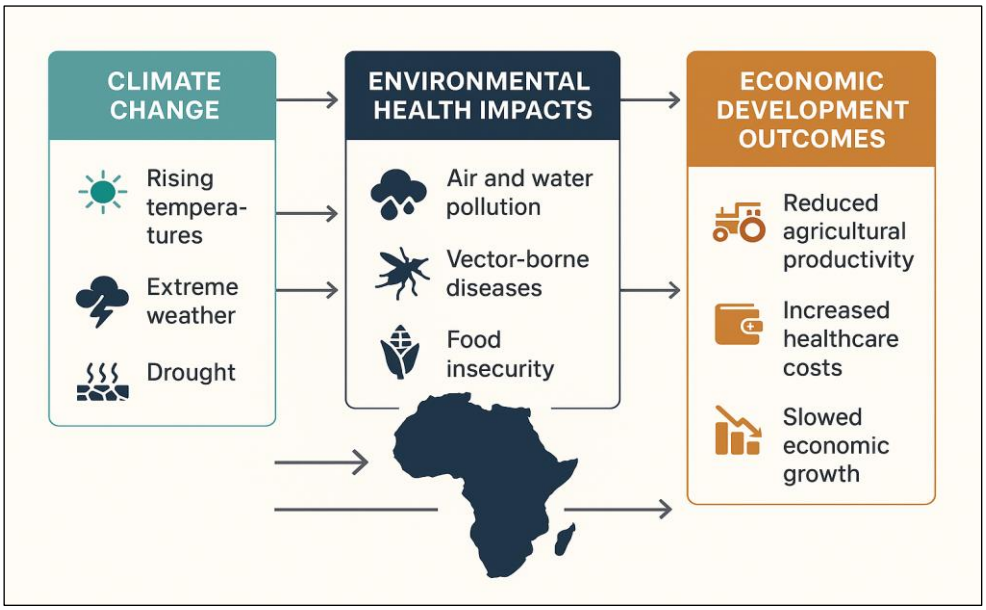

Figure 1: Environmental Health Framework

This paper aims to systematically review and synthesise the literature on the interactions between climate change, environmental health, and African economic development. Specifically, the objectives are:

- To analyse how climate change affects environmental health outcomes and economic growth trajectories across diverse African contexts.
- Improve integrated pathways and strategies that enhance resilience and promote sustainability, focusing on cross-sectoral and multisectoral approaches.

The analysis centres on sub-Saharan Africa, considering the region's ecological diversity, social heterogeneity, and varying economic structures. The paper highlights shared challenges and context-specific opportunities for climate-resilient development by examining case studies and continental strategies (2). Building on the background and rationale, the following sections will assess the current evidence on the linkages between climate change, environmental health, and economic development in sub-Saharan Africa. This will provide a foundation for identifying effective, integrated strategies to build resilience and achieve sustainable development by 2030.

The study develops a conceptual framework highlighting environmental health as a key mediator between climate change and African economic growth. It provides a theoretical foundation for understanding climate-development linkages and offers policy insights from successful African interventions, filling a gap in understanding the climate-health-economy nexus.

Methodology

This study employed a systematic review methodology to comprehensively assess and synthesise the literature on the interactions between climate change, environmental health, and economic development in Africa, following established best practices for transparency and rigour. The literature search was conducted across multiple academic and policy databases to ensure broad coverage and inclusion of relevant studies. The databases included Web of Science, Scopus, PubMed, African Journals, and Grey literature and policy documents from organisations such as the World Health Organisation, African Union, and regional bodies. Studies were included if published between 2000 and 2025; addressed at least two of the three focus areas: climate change, environmental health, and economic development; and focused on African contexts, with particular attention to sub-Saharan Africa's diverse ecological and socio-economic settings. Studies were excluded if they focused outside Africa, lacked integration of at least two of the three focus areas, or were unavailable in English or French, the dominant languages of scientific publication in the region.

A comprehensive search strategy was developed using combinations of keywords and subject headings tailored to each database. Core search terms included: "climate change," "environmental health," "economic development," "resilience," "Africa," and "sustainable development" . The search strategies were adapted to each database's indexing system (e.g., MeSH for PubMed) to maximise the retrieval of relevant literature. Data extraction was performed using a standardised template, capturing bibliographic details, geographic and sectoral focus, study design, and main findings. Thematic analysis was conducted by regions (e.g., West, East, Southern Africa), sector (e.g., agriculture, health, energy), and intervention type (e.g., policy, technology, capacity building). This approach enabled the identification of cross-cutting themes and context-specific insights. The review process adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Each study was critically appraised using established quality assessment tools to evaluate methodological rigour, relevance, and risk of bias. All data used were from published, publicly available sources. This rigorous, multi-database systematic review protocol ensures the findings' credibility, transparency, and reproducibility, providing a robust foundation for subsequent analysis and recommendations.

Results

Conceptual Framework

This section introduces the concept of the nexus and the underlying conceptual framework, establishing how climate change, environmental health, and economic development are deeply interconnected and must be addressed through integrated, systems-level approaches for sustainable and resilient African outcomes (4).

The climate change, environmental health, and economic development nexus in Africa represents a complex and dynamic interplay of biophysical, social, and financial systems. Climate change is a critical driver, influencing environmental conditions and exacerbating vulnerabilities in health and economic sectors, particularly in regions already facing resource constraints and socio-economic challenges (1). Climate change impacts—such as rising temperatures, altered rainfall patterns, and increased frequency of extreme weather events—directly affect environmental health by degrading air and water quality, reducing agricultural productivity, and facilitating the spread of vector- and water-borne diseases. These environmental and health stresses, in turn, undermine economic development by decreasing labour productivity, increasing healthcare costs, and damaging critical infrastructure (1). For example, projections indicate that Western and Eastern Africa could lose up to 15% of their gross domestic product (GDP) by 2050 without robust climate action (1). Conversely, economic development strategies that do not account for environmental sustainability can exacerbate climate risks and health burdens, creating a feedback loop that further constrains growth and resilience (1). Sustainable development, therefore, requires integrated approaches that simultaneously address climate adaptation and mitigation, protect environmental health, and promote inclusive economic growth.

A conceptual framework for this nexus highlights several key linkages:

- Direct Pathways: Climate change affects environmental determinants of health (e.g., air, water, food security), influencing population

health outcomes and economic productivity (5).

- Indirect Pathways: Economic activities, such as agriculture and energy production, impact both climate (through emissions) and environmental health (through pollution and resource depletion), which in turn affect human well-being and long-term development prospects.
- Feedback Loops: Poor health and environmental degradation reduce economic output, limit adaptive capacity, and increase vulnerability to future climate shocks, perpetuating cycles of poverty and ecological decline (6). This integrated perspective underscores the need for cross-sectoral policies, investments in green infrastructure and health systems, and adoption of climate-smart technologies to achieve resilience and sustainable development in Africa (1). Figure 1 below illustrates the dynamic interconnections among climate change, environmental health, and economic development in Africa, highlighting the direct and indirect pathways through which climate impacts drive health outcomes and financial performance, as well as the feedback loops that can either exacerbate or mitigate vulnerability and resilience across the region.

The integrated perspective in Figure 2 highlights the need for cross-sectoral policies, green infrastructure investments, and climate-smart technologies to achieve resilience and sustainable development in Africa, highlighting the dynamic interconnections between climate change, health outcomes, and economic performance.

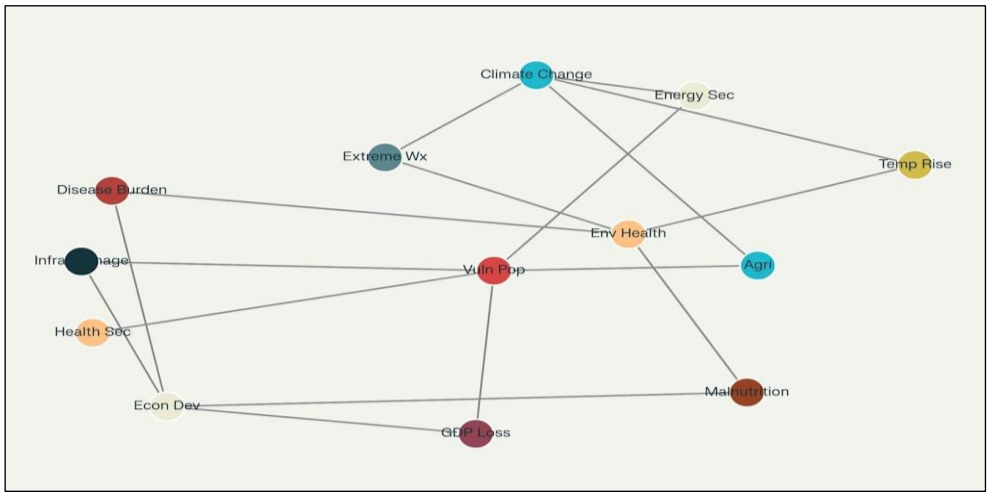

Figure 2: Africa: Climate, Economy Nexus

The chart above represents the nexus among climate change, environmental health, and economic development in Africa. It illustrates how climate change drives environmental health challenges (such as increased disease burden and malnutrition), affecting economic development through impacts like GDP loss and infrastructure damage. The diagram also highlights feedback loops and the vulnerability of key sectors—agriculture, health, and energy—emphasising these challenges' cyclical and interconnected nature.

Integrated Theoretical Models

The intersection of climate change, environmental health, and economic development in Africa is best addressed through integrated theoretical models that recognise the complexity and interdependence of these domains. Two prominent frameworks inform this approach:

- The Sustainable Development Model: This model integrates economic, environmental, and social objectives, replacing traditional growth-led paradigms with a holistic approach that prioritises poverty reduction, environmental sustainability, and inclusive prosperity (6). It emphasises that pro-poor growth and poverty eradication are achievable only through policies that address economic, social, and environmental challenges, rather than focusing solely on market-driven growth (6).
- The Climate-Resilient Development Pathway: As articulated in the African Union's Climate Change and Resilient Development Strategy

and Action Plan (2022–2032), this pathway advocates for anticipatory governance, cross-sectoral policy coherence, and the mainstreaming of climate risk management into development planning (5). It highlights the need for transformative adaptation, nature-based solutions, and the mobilisation of finance, technology, and inclusive participation to build resilience across sectors and communities (5).

Pathways for Integration and Resilience

Integrating climate risk assessments into national and regional development strategies, infrastructure planning, and sectoral policies (3). This ensures that investments and interventions are climate-resilient and reduce systemic vulnerabilities. Promoting sustainable agricultural practices, resilient irrigation, and value chain diversification to enhance food security and rural livelihoods (6). Also, ambitious renewable energy targets should be set, private sector participation should be incentivised, and regional energy markets should be fostered to support low-carbon development (7). Ensuring that adaptation and resilience strategies address the needs of women, youth, and marginalised groups disproportionately affected by climate impacts (4). Pathways could include establishing platforms for transboundary cooperation, harmonising climate risk management practices, and pooling resources for adaptation and resilience projects (8).

Relevance to the SDGs and Africa's Agenda 2063

These theoretical models and pathways align directly with the United Nations Sustainable Development Goals (SDGs) and Africa's Agenda 2063. The SDGs provide a comprehensive blueprint for ending poverty, protecting the planet, and ensuring prosperity for all. However, a climate risk-blind pursuit of these goals can exacerbate vulnerabilities. Integrated approaches that simultaneously advance climate adaptation and SDG targets—especially those related to health (SDG 3), clean water (SDG 6), affordable energy (SDG 7), reduced inequalities (SDG 10), and sustainable cities (SDG 11)—are essential for reducing systemic risks and achieving transformational adaptation (9). Agenda 2063, Africa's blueprint for inclusive growth and sustainable development, explicitly recognises the need for climate-resilient pathways. It calls for harmonised action on climate adaptation, renewable energy, sustainable agriculture, and resilient infrastructure to safeguard the continent's prosperity and unity (10).

Application of the Models

Countries like Kenya and South Africa have embedded climate risk management into their national development plans, aligning them with the SDGs and Agenda 2063 targets (11). The African Union's Climate Change and Resilient Development Strategy provides a continental framework for collective action, fostering regional cooperation and resource mobilisation (12). Joint monitoring mechanisms, such as the Africa Sustainable Development Report and the Africa Regional Forum on Sustainable Development, track progress towards the SDGs and Agenda 2063, ensuring accountability and adaptive learning (12). Integrated theoretical models and pathways that prioritise cross-sectoral coherence, inclusivity, and resilience are essential for Africa to achieve the SDGs and the transformative ambitions of Agenda 2063 in the face of escalating climate risks.

The new framework for climate-health economic development research uses multidimensional operationalisation to better understand the pathways through which environmental health governs climate-economy mechanisms. It emphasises economic development as the expansion of human freedoms and capabilities, reflecting the importance of climate resilience across different sectors. Productive Capital encompasses infrastructure quality, innovation capacity, economic diversity, and productivity across sectors, recognising climate resilience in robust, adaptive production systems that withstand environmental shocks (13). Human Capital, encompassing life expectancy, education, nutrition, and social protection, demonstrates the bidirectional relationship between environmental health and human capabilities, promoting long-term development and knowledge exchange among generations. African countries are increasingly using Natural Capital accounting frameworks to value ecosystems for climate regulation, agricultural productivity, and adaptation services, recognising the economic value of intact ecosystems (12). Social capital,

including governance, cohesion, institutional capacity, gender equality, and community resilience, significantly enhances climate resilience and development outcomes through improved coordination, trust, and collective efficacy (14).

Equity Lens

The framework for climate action in Africa emphasises fairness, distributive justice, and gendered considerations. It addresses uneven distribution of climate risks, health harms, and development opportunities, focusing on those most affected and those with the most knowledge. The framework directs adaptation finance, environmental, and health benefits to communities most exposed and least provided for (7). Procedural justice is crucial in climate change mitigation, involving local leadership and agency. Women's participation and leadership should be increased, and solutions should align with community priorities. Recognition justice honours diverse values and knowledge systems, reflecting African interconnectedness and collective well-being philosophies. Intergenerational and gender equity are essential, as climate-health harms can undermine development unless action safeguards future generations' rights (15).

The framework emphasises structural change for a just transition, focusing on poverty, unequal access to resources, discriminatory rules, and power inequity. It calls for transformative governance, fair financing, and domestic resource mobilisation reforms to ensure justice and climate resilience in African contexts.

Building on the conceptual framework, the model provides the theoretical underpinnings for understanding how climate-induced environmental changes cascade through health systems to affect economic trajectories in Africa. The following review synthesises current research on the impacts of climate change on environmental health and economic development in Africa, drawing on recent empirical studies, policy analyses, and interdisciplinary reviews to highlight key trends, challenges, and knowledge gaps in this nexus.

Environmental Health Impacts

Climate change profoundly alters Africa's environmental health landscape, with far-reaching consequences for air, water, soil quality, disease patterns, and food safety. Rising temperatures, erratic rainfall, and extreme weather events drive environmental changes that directly and indirectly affect public health (16). Warming temperatures and increased frequency of wildfires contribute to deteriorating air quality, raising levels of delicate particulate matter and other pollutants, especially in urban areas. Projections indicate that premature deaths from air pollution could rise significantly under high-warming scenarios. In contrast, decisive climate and air quality action could prevent thousands of deaths annually in Africa by 2063. Climate change disrupts the hydrological cycle, leading to more frequent and severe droughts and floods that degrade water quality and exacerbate water scarcity. Pollution from urban runoff, agricultural expansion, and deforestation further threatens water resources. Most rural populations depend on groundwater, which is increasingly vulnerable to climate-induced changes in recharge and contamination (2, 17) These disruptions increase the risk of waterborne diseases such as cholera, typhoid, and shigellosis, particularly in areas lacking improved sanitation (17).

Altered rainfall patterns and rising temperatures accelerate soil erosion, reduce soil fertility, increase desertification, undermining agricultural productivity and food security (11). Climate change is shifting the epidemiology and geography of infectious diseases. Warmer temperatures and changing precipitation expand the habitats of vectors such as mosquitoes, increasing the incidence and geographic range of malaria, dengue, and other vector-borne diseases (18). Outbreaks of waterborne diseases are also rising due to flooding and compromised sanitation. Between 2030 and 2050, climate change is expected to cause an additional 250,000 deaths annually from infectious diseases, undernutrition, diarrhoea, and heat stress, with the majority occurring in Africa (18). Climate-induced agricultural disruptions—droughts, floods, and heatwaves—reduce crop yields and livestock productivity, worsening food insecurity and malnutrition, especially for women and children (19). The nutritional quality of staple foods is threatened by increased greenhouse gas concentrations and temperature stress, while food price volatility and decreased agricultural output further limit access to safe, nutritious food (11).

Economic Impacts

The economic repercussions of climate change in Africa are severe and multifaceted, affecting macroeconomic stability, sectoral productivity, and household livelihoods. Africa is losing an estimated 2–5% of its GDP annually due to climate extremes, with projections of up to 15% GDP loss in some regions by 2050 if urgent action is not taken (1, 20). Loss and damage costs are estimated between $289.2 billion and $440.5 billion, and the cost of adaptation could reach $30–50 billion annually over the next decade (20). Agriculture, which employs over 60% of Africa's workforce and contributes 30–40% of GDP in many countries, is highly vulnerable to climate shocks. Droughts, floods, and temperature extremes reduce crop and livestock yields, increase pest and disease outbreaks, and drive food price volatility, threatening food security and rural livelihoods (6, 20).

Extreme weather events damage transport, energy, and water infrastructure, raising maintenance costs and impeding economic growth. Between 2005 and 2020, flood-induced damage in Africa exceeded $4.4 billion, and climate-related infrastructure losses undermined the productive potential of public and private investments (21). Increased disease burden, malnutrition, and heat-related illnesses reduce labour productivity and strain health systems, imposing additional economic costs (18). Water scarcity and erratic rainfall threaten hydropower generation and tourism, which are critical to economic diversification and job creation (20). By 2030, up to 118 million impoverished Africans could be exposed to drought, floods, and extreme heat, further hindering poverty reduction and economic growth (22). Climate change exacerbates existing inequalities, disproportionately affecting women, children, and marginalised communities. African governments are diverting up to 9% of their budgets to respond to climate extremes, impacting fiscal space for development investments and increasing debt vulnerability (1, 21). Climate change is a significant threat multiplier for Africa's environmental health and economic development. Its impacts are layered, compounding existing vulnerabilities and requiring urgent, integrated adaptation and resilience strategies.

Implications for Agriculture, Industry, Infrastructure, Labour Productivity, and Livelihoods

Climate change poses substantial risks to Africa's key economic sectors, cascading effects on livelihoods and the continent's development trajectory. Agriculture in sub-Saharan Africa is highly vulnerable to climate variability and extremes due to its dependence on rain-fed systems and limited adaptive capacity. Erratic rainfall, prolonged droughts, and increased frequency of floods have reduced crop yields, livestock losses, and declining soil fertility, threatening food security and rural livelihoods (23). For instance, yields from rain-fed agriculture could decline by up to 50% by 2020 in some regions, with staple crops like maize and millet particularly affected (24, 25). The spread of pests and diseases, such as the fall armyworm, has also been linked to changing climate conditions, further undermining agricultural productivity.

Industries—especially those reliant on natural resources, such as mining and agro-processing—face increased operational costs, supply chain disruptions, and heightened competition for water and energy resources due to climate extremes. In South Africa, the mining sector is exposed to physical risks (floods, heatwaves) and transition risks (changing international trade regulations and carbon pricing), threatening jobs, exports, and economic competitiveness.

Africa's infrastructure is highly exposed to climate hazards. Extreme weather events, such as cyclones and floods, have caused extensive damage to roads, bridges, ports, and energy systems, with Mozambique alone losing around $2 billion in infrastructure during the 2019 cyclones (24). Rising sea levels threaten coastal infrastructure and tourism, while the majority of future infrastructure still to be built presents both a risk and an opportunity for climate-resilient planning (24).

Climate change directly reduces labour productivity through heat stress, increased disease burden, and undernutrition. Indirect effects include job losses from disrupted agricultural cycles and damaged infrastructure. Sub-Saharan Africa's workforce, especially in agriculture and informal sectors, is at risk, with heat stress and vector-borne diseases reducing working hours and wages. The combined impacts on agriculture,

industry, infrastructure, and labour severely threaten livelihoods, especially for rural and urban poor populations who rely on climate-sensitive sectors. Climate shocks often force households to adopt negative coping strategies, such as reducing food intake, selling assets, or migrating, perpetuating poverty and vulnerability cycles (23).

Vulnerability and Equity

Multiple, intersecting factors, including poverty, weak governance, limited access to resources, and social inequalities, shape Africa's vulnerability to climate change (8). The Notre Dame Global Adaptation Initiative Index highlights that nine of the ten most climate-vulnerable countries globally are in Africa, underscoring the continent's limited resilience. Vulnerability is not evenly distributed. It varies by region, sector, gender, age, and socio-economic status. For example, women and girls face heightened risks due to their roles in food production, water collection, and caregiving, while lacking equal access to land, finance, and decision-making (25). Technological, institutional, and financial barriers further constrain adaptation, with adaptation finance falling far short of needs. Addressing vulnerability and equity requires targeted, inclusive adaptation policies prioritising at-risk groups, integrating social protection (such as cash transfers and insurance), and promoting gender-sensitive and rights-based approaches to climate resilience (8).

Disproportionate Impacts on Marginalised, Rural, and Urban Poor Populations

Marginalised groups—including the rural poor, women, youth, and urban informal settlers—bear a disproportionate share of climate change impacts due to structural inequalities and limited adaptive capacity (25). Rural households, especially those dependent on smallholder agriculture, experience significant income losses during climate shocks. A 1°C rise in temperature can increase poor households' reliance on climate-sensitive agriculture by 53% while reducing off-farm incomes by 33% (25). Women-headed households and plot managers are particularly vulnerable, often losing more income and off-farm opportunities during extreme events (25). Over 60% of urban dwellers in sub-Saharan Africa live in informal settlements, where inadequate housing, poor drainage, and limited access to services heighten exposure to floods, heatwaves, and disease outbreaks. Urban poor populations are also more likely to work in informal, climate-sensitive jobs, making them especially vulnerable to economic shocks from climate hazards (26).

Climate change exacerbates gender inequalities, with girls and women facing increased burdens related to water collection, caregiving, and food insecurity. Disrupted education, increased risk of early marriage, and heightened exposure to gender-based violence are among the climate-related challenges for girls (8). During climate shocks, young people and children face increased work burdens and health risks (25). The intersection of poverty, gender, age, and geography intensifies vulnerability, making climate justice and equity central to adaptation strategies. Rights-based, inclusive approaches that address these intersecting vulnerabilities are essential for building resilience and ensuring no one is left behind (8).

Integrated Pathways for Resilience

Africa's pursuit of resilience in the face of climate change is anchored in integrated adaptation and mitigation strategies that address environmental, social, and economic vulnerabilities. These strategies are increasingly recognised as essential for safeguarding development gains and advancing the continent's sustainable development agenda (4). Nature-based solutions are gaining prominence across sub-Saharan Africa as communities and governments seek to harness natural systems' protective and restorative power. NBS involve protecting, managing, and restoring ecosystems, such as forests, wetlands, and mangroves, to reduce climate risks and provide co-benefits for people and biodiversity. There has been a surge in NBS projects in recent years, with nearly 300 new initiatives between 2012 and 2023 securing over $21 billion in funding. Examples include: wetland restoration in Lagos, Nigeria, to mitigate urban flooding; mangrove reforestation in Guinea-Bissau and Cameroon for coastal protection and fisheries support; and agroforestry and hillside tree planting to stabilise soils, enhance water quality, and support rural livelihoods (27).

NBS not only buffer communities against hazards like floods and droughts but also create jobs, boost agricultural yields, and protect biodiversity. Hybrid approaches, such as integrating mangroves with engineered sea walls (green-grey

infrastructure"), enhance resilience and cost-effectiveness. Ecosystem restoration initiatives—such as reforestation, afforestation, agroforestry, and silvopastoral systems—hold significant potential for climate mitigation and adaptation. The Restoration Initiative demonstrates how community-led restoration of degraded lands in Kenya and the Central African Republic has improved ecological integrity, increased carbon sequestration, and fostered local ownership (27). Restoration of mangroves, forests, and arid lands supports biodiversity, enhances landscape connectivity, and improves resilience to climate shocks.

Climate-smart agriculture is a cornerstone of Africa's adaptation strategy, aiming to increase productivity, strengthen resilience, and reduce greenhouse gas emissions from the agricultural sector. CSA practices include development and dissemination of climate-resilient crop varieties (e.g., drought-tolerant maize and rice); efficient water harvesting and irrigation systems; soil conservation, composting, and agroforestry; and improved post-harvest and food processing technologies (28). The West Africa Agricultural Productivity Program has delivered over 160 climate-smart crop varieties and trained millions of farmers, resulting in productivity gains of up to 150%, increased incomes, and improved food security (28).

Transitioning to clean, renewable energy is central to Africa's mitigation and resilience agenda. The African Energy Transition Programme, guided by Agenda 2063 and the Paris Agreement, seeks to shift the continent from fossil fuels to renewable sources such as solar, wind, hydropower, and geothermal (9). Strategic objectives include building energy infrastructure for economic and social development, starting with agriculture; scaling up renewable energy deployment and local manufacturing of efficient equipment; developing integrated electricity networks to lower costs and enhance energy security; and decarbonising energy and other sectors to align with national and international climate commitments (9). Access to affordable, clean energy reduces emissions and supports productive uses, job creation, and poverty reduction.

Integrated Policy and Institutional Approaches

Effective adaptation and mitigation require cross-sectoral policy coherence, robust governance, and inclusive stakeholder engagement. The African Union's Climate Change and Resilient Development Strategy and Action Plan (2022–2032) emphasises harmonised action, anticipatory planning, and integrating climate risk management into national and regional development frameworks (4). Key interventions include: strengthening national health systems and water resource management; promoting private sector engagement in climate adaptation; and enhancing early warning systems and disaster preparedness.

Policy and Institutional Integration

Effective climate resilience in Africa hinges on robust policy and institutional integration that bridges adaptation, health, and economic development across all sectors. National Adaptation Plans (NAPs) have emerged as foundational roadmaps, aligning climate adaptation with national development priorities and the Paris Agreement's Global Goal on Adaptation (29). NAPs outline interconnected local, national, and regional activities, including adaptation finance, sectoral planning, and monitoring systems. For example, Uganda's whole-of-government approach in developing sectoral NAPs for agriculture and health fosters bankable projects and attracts diverse funding sources. At the same time, Zimbabwe's adaptation finance strategy mobilises resources from public, private, and international channels to close adaptation gaps (29).

Health-in-all-policies is increasingly recognised as a critical approach, especially as climate-linked health emergencies rise across Africa (30). The Clim-HEALTH Africa initiative exemplifies regional collaboration, supporting countries in developing health adaptation plans, integrating climate risks into national health programs, and establishing early warning systems for climate-sensitive diseases (30). Despite progress, only 22 African countries have health adaptation plans, and fewer than 20% mention health in their nationally determined contributions, highlighting the need for deeper integration (30).

Economic diversification is another key strategy, reducing reliance on climate-sensitive sectors and promoting structural transformation. While

diversification can open new markets and foster resilience, its effects on vulnerability are complex and context-dependent. For instance, Rwanda's move into agro-processing has created higher-value products and jobs. However, diversification alone does not eliminate climate risks and may introduce new vulnerabilities if not managed inclusively. Cross-sectoral governance is essential for mainstreaming climate adaptation. Successful examples, such as Zambia's Interim Climate Change Secretariat, demonstrate how cross-ministerial structures foster policy coherence and integrated planning across water, agriculture, health, and infrastructure sectors. However, many national policies still focus on immediate disaster management rather than long-term adaptation, underscoring the need for sustained, cross-sectoral institutional mechanisms.

Community-Based and Participatory Approaches

Community-based and participatory adaptation approaches are vital for building resilience at the grassroots level, particularly among Africa's most vulnerable populations. Community-Based Adaptation empowers local actors, including subnational authorities and civil society—to co-design and implement adaptation strategies tailored to their unique socio-economic and ecological contexts (31). Community-Based Adaptation leverages local knowledge, participatory scenario planning, and inclusive decision-making to ensure that adaptation actions are relevant, equitable, and sustainable (31). Indigenous knowledge systems are pivotal in climate adaptation, especially in rural and communal farming communities. Studies from Zimbabwe and across Africa show that traditional practices, such as rainfall forecasting through tree phenology, soil fertility management, and climate-proof agriculture, enable communities to anticipate and respond to climate variability (32). Integrating indigenous knowledge with scientific climate information enhances local adaptive capacity and preserves cultural identity.

Local innovation is also central to effective adaptation. Initiatives such as aquaponics in Uganda, sustainable agroforestry in West Africa, and participatory scenario planning in Kenya demonstrate how communities develop context-specific solutions to address food security, water management, and livelihood diversification (31). Scaling up these innovations requires enabling policies, technical support, and access to finance. Social capital—networks of trust, mutual aid, and community organisations—significantly enhance resilience. Evidence from Ethiopia shows that households with more substantial social capital are better able to withstand climate shocks, access resources, and adapt to changing conditions. Social capital provides an alternative safety net where formal insurance is absent, supporting collective action and knowledge sharing. Integrating national policy frameworks with community-based, participatory approaches—rooted in indigenous knowledge, local innovation, and social capital—is essential for African climate resilience. This dual approach ensures that adaptation is both top-down and bottom-up, bridging policy with practice and empowering the most affected communities.

Discussion

Synthesis of Findings and Interpretation

Evidence across Africa demonstrates that integrated pathways—combining climate adaptation, environmental health, and economic development—are essential for building resilience and achieving sustainable development. Practical approaches include nature-based solutions, climate-smart agriculture, renewable energy transitions, and cross-sectoral governance that mainstreams climate risk management into national and regional policies. Community-based adaptation, indigenous knowledge, and innovative finance mechanisms have also proven critical for enhancing local adaptive capacity and delivering co-benefits for health, livelihoods, and ecosystems (2, 4). However, persistent barriers such as institutional silos, funding gaps, and data limitations continue to impede progress, highlighting the need for robust policy integration, capacity building, and international cooperation (33).

The study highlights in Figure 3 the importance of integrated pathways in Africa, including climate adaptation, environmental health, and economic development, for building resilience and sustainable development.

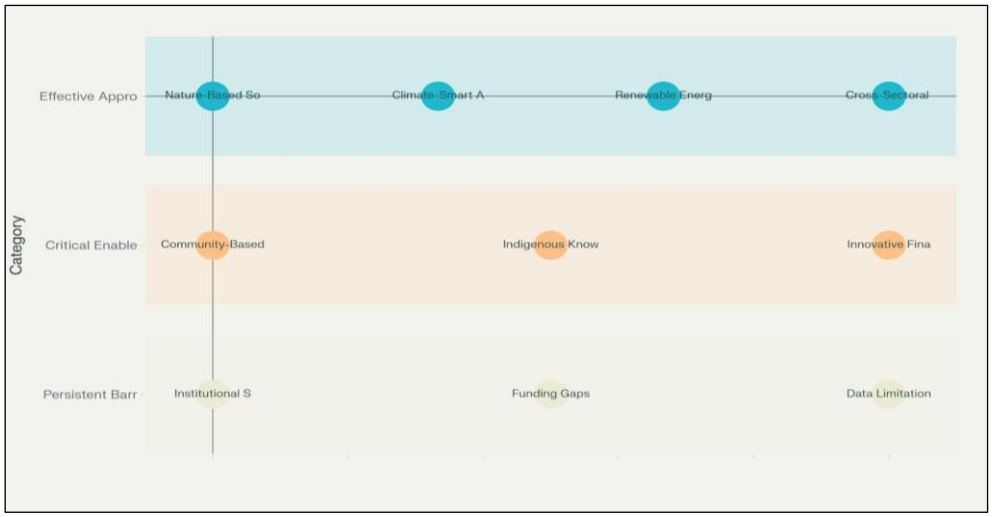

Figure 3: Pathways and Obstacles to Integrated Climate, Health, and Economic Resilience in Africa

The figure illustrates how integrated pathways—such as nature-based solutions, climate-smart agriculture, renewable energy transitions, and cross-sectoral governance—enhance resilience, improve public health, and support sustainable economic development. It also highlights the critical role of community-based adaptation, indigenous knowledge, and innovative finance in strengthening local adaptive capacity and delivering co-benefits for livelihoods and ecosystems. At the same time, the figure identifies ongoing obstacles, including institutional silos, funding gaps, and data limitations, which continue to impede progress. This visual summary underscores the study's conclusion: robust policy integration, capacity building, and international cooperation are essential to overcome these barriers and achieve transformative, sustainable development outcomes across the continent.

Case Studies and Best Practices

Across Africa, many projects and policies demonstrate how integrated approaches can simultaneously advance climate, health, and economic development goals. These interventions often combine climate adaptation, public health strengthening, and livelihood support, leveraging local knowledge and multisectoral partnerships.

Senegal - Climate-Smart Village of Daga Birame: In Senegal, the Daga Birame climate-smart village initiative exemplifies locally-led adaptation. Collaborative efforts focus on introducing resilient crop varieties, climate education, and sustainable land management. This has improved food security, reduced vulnerability to climate shocks, and fostered community engagement in climate action.

Nigeria - Community-Led Biodiversity and Aquaculture Projects: Communities in Nigeria's Owode Town have turned to organic waste management to restore depleted forests and biodiversity, while aquaculture hubs in Abesan and Shagari Estates innovate to secure food production amid climate threats. Subsistence farmers in Abatete are addressing gully erosion through soil conservation and agroecological practices, enhancing environmental and economic resilience.

Ethiopia - Productive Safety Net Program (PSNP) and Climate Resilient Green Economy (CRGE) Strategy: Ethiopia's PSNP provides social protection and cash transfers to vulnerable households, increasing their resilience to drought and food insecurity. The CRGE strategy integrates community involvement, reforestation, and climate-smart agriculture, resulting in improved food security, reduced emissions, and strengthened adaptive capacity.

South Africa - Renewable Energy Independent Power Producer Procurement Program (REIPPPP): South Africa's REIPPPP has attracted significant private investment in wind and solar energy, reducing reliance on fossil fuels and creating jobs. The program's success is rooted in clear government policy, competitive tenders, and community involvement, which have led to increased renewable capacity and local socio-economic benefits.

Mozambique and Zambia - Strategic Programs for Climate Resilience: Mozambique's national

program mainstreams climate resilience into central budgets, infrastructure, and agriculture, aligning with the National Adaptation Programme of Action. Zambia's program strengthens early warning systems, integrates climate resilience into infrastructure, and supports farmers in climate-affected regions. Both programs benefit from international finance and technical support, emphasising institutional capacity building and cross-sectoral planning (5)

Senegal - Dionewar Island Natural Barriers: On Dionewar Island, communities have innovated with natural barriers to combat coastal erosion, combining local knowledge with ecosystem-based adaptation. This has protected livelihoods, reduced displacement, and preserved critical habitats.

Kenya - Community Health Worker Programs: A home-based malaria case-management program in Kenya trained volunteer community health workers in hard-to-reach villages. This improved malaria treatment access, reduced disease prevalence, and eased pressure on health facilities, demonstrating the value of community engagement in health adaptation (34).

Regional case studies reveal shared vulnerability drivers and context-specific challenges across Sahelian and island settings. These comparative insights inform the policy entry points that follow.

Lessons Learned

Based on the framework and empirical lessons, this section presents strategic intervention points for integrated policies to improve climate resilience, health outcomes, and economic development in Africa.

Projects are more effective when communities are fully involved in design and implementation, ensuring interventions are contextually relevant and sustainable. Successful interventions align with national development and adaptation strategies and foster strong partnerships across sectors and levels of government (4, 6). Training, technical support, and knowledge exchange are critical for scaling and sustaining integrated interventions (22). Combining traditional practices with modern science enhances the effectiveness and acceptance of adaptation measures. International and private sector funding and technology transfer enable the implementation and replication of successful models (4).

Critical success factors are systematically presented in Figure 4, which illustrates the key pillars identified for effective African integrated climate adaptation projects, including local ownership, policy alignment, capacity building, knowledge integration, and access to finance and technology.

Figure 4: Key Success Factors for Integrated Climate Adaptation Projects in Africa

The figure highlights five pillars essential for effective and sustainable interventions: local ownership and participation, policy alignment and institutional integration, capacity building and knowledge sharing, blending indigenous and scientific knowledge, and access to finance and technology. Each pillar is visually represented to emphasise its role in ensuring that adaptation initiatives are contextually relevant, scalable, and resilient, ultimately supporting the broader goals of climate resilience, public health, and sustainable development across the continent.

Challenges and Limitations

Limited finance and human capacity can hinder scaling and sustainability, mainly where interventions depend on external support. Lack of high-quality data and monitoring systems can impede evidence-based policy and adaptive management (1). While many projects are successful at the pilot or local level, scaling up requires enabling policy environments, sustained investment, and institutional coordination. Best practices are most transferable when adapted to local contexts, supported by strong governance, and embedded in broader policy frameworks. Regional cooperation and knowledge networks further enhance the spread and impact of integrated interventions (4).

Figure 5 outlines implementation challenges and enablers for scaling climate adaptation interventions in Africa, emphasising the primary barriers and critical factors for successful replication and expansion of effective models.

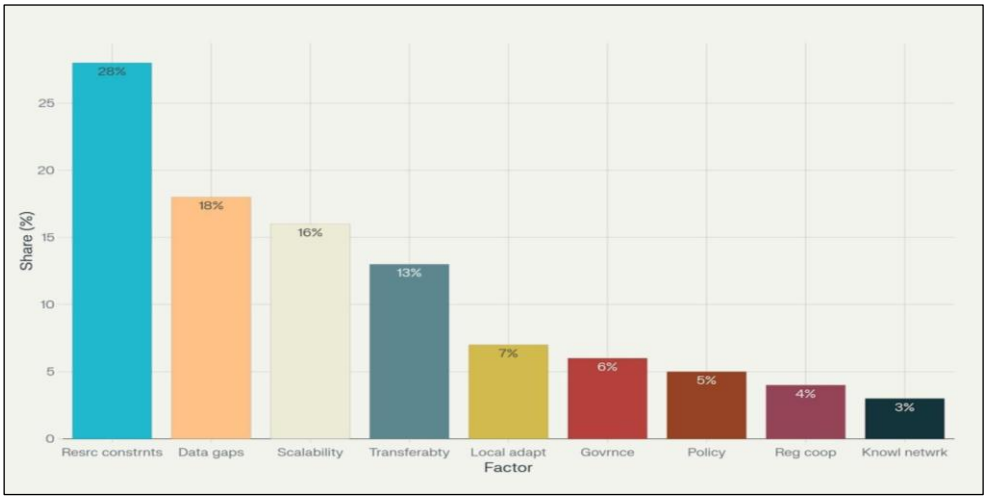

Figure 5: Climate Adaptation Intervention Challenges and Enablers

The chart visually organises key barriers, such as resource constraints, data and monitoring gaps, and scalability issues, alongside enablers like adaptation to local contexts, strong governance, supportive policy frameworks, and regional cooperation. This depiction emphasises that overcoming these challenges through targeted investments, institutional coordination, and context-sensitive approaches is critical for ensuring that effective climate adaptation models can be sustained and expanded across diverse African settings.

Barriers, Enablers, and Gaps

Africa's efforts to build climate resilience and integrate environmental health and economic development face several persistent barriers. Many African countries struggle with fragmented governance, where adaptation and resilience efforts are confined to specific ministries or sectors. This leads to inconsistent or conflicting policies, unclear mandates, and weak coordination among government agencies, NGOs, and research organisations. The absence of a unified national political agenda on climate change further marginalises vulnerable groups and limits the mainstreaming of adaptation into development planning. Adaptation efforts are hampered by inadequate and unpredictable funding. Only 46% of committed adaptation finance is disbursed, and key sectors such as health and ecosystems remain underfunded (33). Limited access to credit, insurance, and private sector investment further constrains the ability to implement and scale climate-resilient solutions (33).

Severe gaps in climate, health, and socio-economic data undermine evidence-based policy and adaptive management. Many health facilities lack robust data systems, and most countries do not have integrated or centralised databases for monitoring population health or climate impacts, making it challenging to design, implement, and evaluate interventions. There is a shortage of technical, institutional, and human capacity to design, implement, and monitor integrated adaptation strategies. Knowledge deficits about the systemic nature of climate risks and their links to development goals persist at all levels (29). Insecure land tenure discourages long-term

adaptation investments, particularly in rural and farming communities.

Despite these barriers, several factors have proven critical in advancing integrated resilience efforts. Mechanisms like the African Development Bank's Adaptation Benefits Mechanism and partnerships with organisations such as the World Meteorological Organisation and the World Bank have mobilised new funding streams, technical support, and capacity building for adaptation (6). Initiatives such as Clim-HEALTH Africa, WASCAL Graduate Studies, and training programs for disaster risk management and early warning systems have built local expertise and institutional capacity across the continent (30). Integrating climate science with development planning, as seen in Rwanda's multisectoral data-driven approach, supports more effective, context-specific adaptation. Inclusive governance—engaging local communities, women, and marginalised groups—ensures that adaptation strategies are equitable and locally relevant. Establishing interministerial committees, cross-sectoral working groups, and regional platforms enables coherent policy development and resource sharing.

Despite progress, several critical research and implementation gaps remain. There is a need for systematic, long-term monitoring of adaptation interventions and their health and economic impacts. Most current evaluations are short-term or project-based, limiting learning and scaling of best practices. Few countries have fully integrated climate, health, and economic data systems. Investments in centralised, real-time databases and improved data sharing across sectors are essential for evidence-based decision-making. Much research on climate-health-economy linkages is conducted outside Africa or lacks local contextualisation. Locally driven studies and participatory research are needed to inform policies that reflect Africa's diverse realities. More research is needed on how to scale successful pilot projects and adapt them to different ecological, social, and economic contexts. Barriers to translating research into policy and practice persist, including limited engagement between researchers and policymakers and insufficient mechanisms for mainstreaming evidence into national strategies. Despite progress, several critical research and implementation gaps remain, as systematically documented in Figure 6.

The Figure 6 is organised into three columns: barriers (such as institutional silos, funding limitations, and data gaps), enablers (including international partnerships, capacity building, and inclusive policy), and research gaps (such as long-term monitoring, integrated data systems, and scalability). Arrows illustrate how enablers can help overcome barriers, while addressing research gaps is essential for supporting resilient and sustainable development. This visual highlight the interconnected challenges and opportunities that shape Africa's ability to integrate climate adaptation, environmental health, and economic development for long-term resilience.

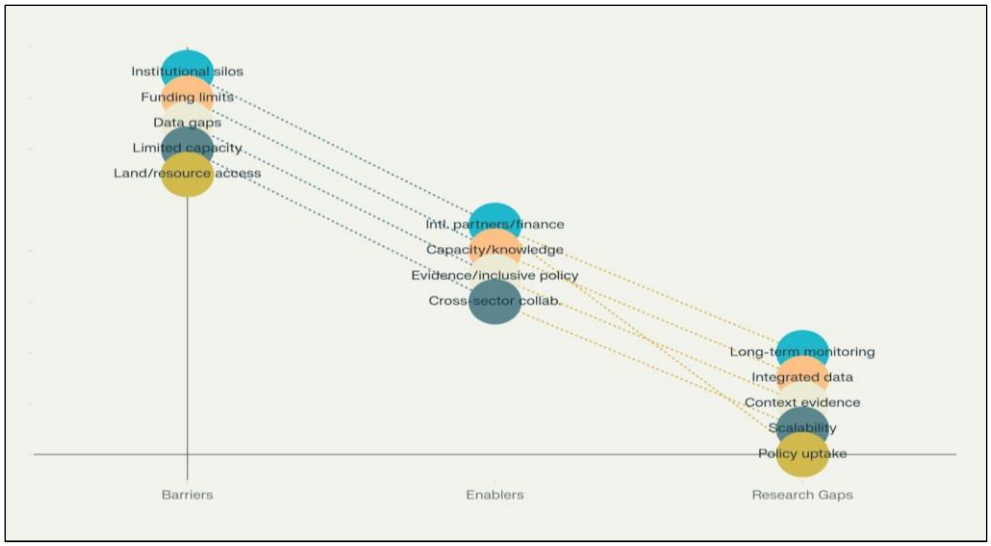

Figure 6: Barriers, Enablers, and Research Gaps for Integrated Climate Resilience in Africa

Policy Recommendations and Future Directions

For African Governments: embed climate resilience, environmental health, and economic development objectives into national development plans, sectoral policies, and budgetary frameworks establish cross-sectoral coordination mechanisms and dedicated climate resilience offices to ensure coherent policy implementation and long-term planning; mobilise domestic resources and leverage innovative mechanisms (e.g., the Adaptation Benefits Mechanism) to increase adaptation funding, particularly for vulnerable sectors and communities; integrate gender and social equity into climate adaptation and resilience strategies, ensuring that the needs of women, youth, and marginalised groups are prioritised; and invest in integrated data platforms, climate information services, and monitoring frameworks to support evidence-based decision-making and track progress on resilience and SDG targets (35).

For Regional Bodies: develop harmonised climate action plans, standardise risk assessment methodologies, and promote transboundary collaboration on shared vulnerabilities such as water, energy, trade, and coordinate training, knowledge exchange, and technical assistance to strengthen institutional and community-level adaptive capacity across member states.

For International Partners: scale up support for African-led adaptation and mitigation initiatives, prioritising projects that demonstrate integrated, multisectoral benefits and build local ownership; and invest in context-specific research, pilot projects, and technology transfer that blend indigenous knowledge with modern science and address Africa's diverse climate-health-economy nexus (6).

Implications for Agenda 2030 and Agenda 2063

Integrated, climate-resilient development is fundamental to realising the United Nations Agenda 2030 (SDGs) and Africa's Agenda 2063. Mainstreaming climate risk management and resilience into all development sectors will: safeguard and accelerate progress on poverty reduction, health, food security, and economic growth (SDGs 1-3, 7, 13); enable Africa to harness its renewable energy, biodiversity, and demographic dividend for inclusive, green growth; reduce systemic vulnerabilities and optimise resource use, ensuring that climate adaptation and mitigation simultaneously deliver multiple SDGs and Agenda 2063 targets; and strengthen Africa's voice and leadership in global climate governance, positioning the continent as a key factor in shaping a just, sustainable, and resilient future.

A just transition is the framework's way of making climate action in Africa low-carbon and fair, ensuring no community is worse off as economies decarbonise. It pairs social protection and reskilling for fossil-fuel-dependent workers with investment in green jobs and directs climate finance to frontline communities. It emphasises participatory governance, equitable resource allocation, and gender-responsive actions to close inequality gaps and promote long-term inclusive wellbeing.

Conclusion

This review underscores that integrated approaches—linking climate change adaptation, environmental health, and economic development—are essential for building resilience and advancing sustainable development in Africa. Evidence shows that strategies such as nature-based solutions, climate-smart agriculture, clean energy transitions, and inclusive governance deliver multiple co-benefits: they reduce vulnerability to climate shocks, improve public health, and foster broad-based economic growth. Integration also supports the realisation of Agenda 2030 and Agenda 2063, enabling African societies to address interconnected risks, close equity gaps, and seize opportunities for green and inclusive transformation.

Researchers, policymakers, and practitioners are urged to adopt and scale integrated, cross-sectoral approaches that mainstream climate, health, and economic priorities into planning, implementation, and monitoring. This includes strengthening institutional coordination, investing in data and capacity, and fostering partnerships across all levels—from local communities to regional and international bodies. Embracing indigenous knowledge, supporting local innovation, and ensuring the meaningful participation of marginalised groups will be critical to achieving resilient, healthy, and economically robust African societies. Accelerated action and sustained commitment are needed to secure Africa's future

and fulfil development goals and Africa's Agenda 2063.

Abbreviations

AfDB: African Development Bank, AU: African Union, CRGE: Climate Resilient Green Economy, CSA: Climate-Smart Agriculture, GDP: Gross Domestic Product, NAP: National Adaptation Plan, NBS: Nature-Based Solutions, NGOs-Non-Governmental Organisations

Productive Safety Net Program (PSNP), REIPPPP: Renewable Energy Independent Power Producer Procurement Program, SDGs: Sustainable Development Goals, WHO: World Health Organisation.

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Author Contributions

The author contributed to the manuscript's conception, design, literature review, analysis, and drafting.

Conflict of Interest

The author declares no conflict of interest related to this research or its publication.

Declaration of Artificial Intelligence (AI) Assistance

The authors declare that they did not use AI-assisted tools (ChatGPT, OpenAI) during the writing process.

Ethics Approval

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