











Perspective



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Introducing African-led Innovation to tackle the challenges of climate change in Africa

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Abstract

Africa faces severe challenges from climate change, including rising temperatures, erratic rainfall, extreme weather events, and sea-level rise, which endanger ecosystems, livelihoods, and socio-economic stability. Africa-led innovation, driven by African communities, organizations, and governments, recognizes the continent's unique context and aims to empower communities to address climate change while promoting economic development, social equity, and environmental sustainability. Agriculture, water scarcity, clean energy access, and sustainable urbanization are critical concerns. Africa-led solutions are necessary alongside global efforts to tackle climate change. Environmental challenges like water and air pollution and droughts pose risks to public health, the economy, and social structure. Africa-led innovation leverages local resources and expertise and has yielded successful initiatives, including community-based adaptation, renewable energy expansion, climate-smart agriculture, coastal adaptation, forest conservation, and sustainable urban development. Collaboration, financing, policy frameworks, and knowledge sharing are crucial for scaling up Africa-led innovation. Prioritizing sustainable approaches, combining traditional knowledge with modern advancements, and ensuring affordable solar energy solutions in rural areas are essential. Supporting African-led initiatives, investing in research institution capacity building, and fostering collaboration at all government levels will contribute to a resilient future for Africa in the face of climate change.

Perspective

Climate change poses a significant global challenge, with Africa being particularly vulnerable to its adverse impacts. The continent is experiencing rising temperatures, erratic rainfall patterns, increased frequency of extreme weather events, and sea-level rise, which threaten ecosystems, livelihoods, and socio-economic stability [1]. Africa-led innovations have emerged as a potent strategy for addressing climate change by harnessing the continent's ingenuity, knowledge, and resources. It acknowledges Africa's distinct context, needs, and capacities, advocating for locally-driven solutions that are both relevant and sustainable. The primary goal of Africa-led innovation is to empower African communities to combat climate change while simultaneously fostering economic development, social equity, and environmental sustainability. This approach emphasizes the importance of local leadership, expertise, and active participation in finding solutions to these challenges [2].

Climate change presents numerous concerns in Africa, particularly in the agricultural sector, which is critical to many African economies. The impact of changing weather patterns directly jeopardizes food security and rural livelihoods. Moreover, the rise in water scarcity, more frequent droughts, and shifting disease patterns pose severe health risks. Access to clean energy, infrastructure development, and sustainable urbanization are also pressing issues. While global efforts are crucial, there is an increasingly recognized need for Africa-led solutions to address the continent's unique challenges [3]. African nations face a range of environmental issues that directly impact the well-being of their populations, including water and air pollution, as well as recurrent droughts [4].

Africa-led innovations have delivered promising outcomes in addressing climate change concerns. Community-based adaptation initiatives, blending traditional knowledge with modern approaches, have been implemented in various African

countries, enhancing resilience to climate impact. For instance, in Kenya, a project empowers female entrepreneurs to distribute and sell renewable energy products, reducing dependence on fossil fuels and improving rural energy access [5]. Likewise, the "Ghana Bamboo Bikes Initiative" pioneers the production of sustainable and affordable bamboo bicycles, fostering local job creation and environmental protection [6]. Despite Africa's minimal contribution to global environmental changes, it faces a significant vulnerability to their consequences, which not only jeopardize public health but also impact the continent's economic and social structure [7]. This review explores the diverse array of African-led innovations in addressing climate change challenges in Africa and provides recommendations for further African-led initiatives to sustain the fight against climate change on the continent.

Africa's innovative approaches to climate change

Community-based adaptation initiatives in Ethiopia: Ethiopia has taken significant steps towards implementing community-based adaptation initiatives to tackle climate change. The country has been hit by recurring droughts, leading to reduced agricultural productivity and food security, which resulted in rural-urban migration. To address these issues, Ethiopia put in place programs such as the Productive Safety Net Program (PSNP) and the Climate Resilient Green Economy Strategy (CRGE) [8]. These initiatives prioritize community involvement, capacity-building, and sustainable land management practices. The PSNP has been successful in providing social protection programs to vulnerable communities, increasing their resilience to climate shocks, and improving household agricultural income and food security [9]. These strategies have led to the promotion of renewable energy sources, reforestation efforts, and the adoption of climate-smart agriculture practices, resulting in reduced emissions and improved adaptation [8,9].

Renewable energy expansion in South Africa: South Africa has made impressive advancements in expanding renewable energy sources to mitigate climate change and improve energy access. The Renewable Energy Independent Power Producer Procurement Program (REIPPPP) has been instrumental in attracting significant private sector investment in renewable energy projects, such as wind and solar power, through the Risk Mitigation IPP Procurement Programme (RMIPPPP) through a combination of competitive tender processes, clear government policies, and support for different renewable energy technologies [10]. As a result, South Africa has increased its renewable energy capacity, reduced its dependency on fossil fuels, and contributed to the reduction of greenhouse gas emissions [11]. Moreover, the REIPPPP has promoted job creation and local community involvement in renewable energy projects, leading to socio-economic development. These efforts have established South Africa as a leader in renewable energy deployment in Africa [10,11].

Climate-smart agriculture in Kenya: Kenya has made notable progress in promoting climate-smart agriculture practices to address climate change challenges and enhance agricultural resilience. The country faces the dual challenge of adapting to changing weather patterns and improving food security. To tackle these challenges, initiatives such as the Climate-Smart National Agricultural and Rural Inclusive Growth Project (NARIGP) Agriculture Program have been implemented [12]. The Climate-Smart Agriculture Program in Kenya has focused on promoting sustainable farming practices, such as conservation agriculture, agroforestry, and integrated pest management. These practices enhance soil health, water management, and crop productivity while reducing greenhouse gas emissions. Additionally, the NARIGP has improved smallholder farmers' access to financial services, market linkages, and climate-smart Innovative solutions like applications, climate-resilient seeds,

and data analytics, contributing to increased agricultural productivity and income [13].

Coastal adaptation in Senegal: Senegal, located on the West African coast, is exposed to sea-level rise and coastal erosion. The country has implemented successful coastal adaptation measures to protect vulnerable communities and ecosystems. The "Adaptation to Coastal Erosion in Senegal" (ACES) project has focused on nature-based solutions, including the construction of coastal defenses, as well as the restoration and protection of mangrove forests [14]. The ACES project has demonstrated the effectiveness of mangrove restoration in reducing coastal erosion and enhancing resilience to climate change impacts. Additionally, the project has involved local communities in decision-making processes and provided alternative livelihood opportunities, such as sustainable aquaculture and eco-tourism, promoting socio-economic development and environmental conservation [15].

Forest conservation in Gabon: Gabon has made significant efforts to conserve its rich biodiversity and mitigate climate change through forest conservation. The country has vast tropical rainforests that play a crucial role in carbon sequestration and supporting biodiversity. Gabon's National Climate Change Strategy prioritizes forest conservation and sustainable management [16]. The country has implemented policies to reduce deforestation, promote sustainable forestry practices, and enhance protected areas through initiatives such as the Gabonese Forest Strategy and the Gabon-Low Emissions Development Strategy [17]. These efforts have contributed to maintaining high levels of forest cover and conserving critical habitats for endangered species. Additionally, they have helped mitigate climate change by reducing greenhouse gas emissions from deforestation [16,17].

Resilient water management in Tunisia: Tunisia has successfully implemented water management strategies to address the impacts of climate

change, particularly water scarcity and drought. The country's National Water Strategy prioritizes the sustainable use and management of water resources in response to changing climatic conditions [18]. Tunisia has invested in infrastructure development, including constructing water reservoirs, implementing efficient irrigation systems, and promoting water-saving practices in agriculture and urban sectors [18,19]. These measures have led to improved water availability, enhanced agricultural productivity, and strengthened water resilience in the face of climate variability, benefiting rural communities and economic sectors that rely on water resources [19].

Sustainable urban development in Rwanda: Rwanda has made remarkable progress in promoting sustainable urban development as part of its climate change response. The country has prioritized sustainable urbanization and climate resilience in its Vision 2050 and National Strategy for Climate Change and Low Carbon Development [20]. Rwanda has implemented various initiatives, such as the Kigali Green City Project, which aims to develop a climate-resilient and environmentally friendly city. The country has integrated climate considerations into urban planning, emphasizing green infrastructure, waste management, renewable energy, and efficient public transportation systems. These efforts have led to reduced greenhouse gas emissions, improved air quality, and an enhanced quality of life for urban residents [21]. Most importantly, Rwanda has initiated a project 'KivuWatt' that removes methane from Lake Kivu, aiming not only to provide electricity, but also to reduce a potential hazard such as a possible limnic eruption of this greenhouse gas on the lake [22]. In addition, taking into account that there has been a significant increase in greenhouse emissions that has contributed to an alarming warming rate of the planet, a reduction of methane can undoubtedly mitigate global warming.

Zai Technology: the Zai technology, a traditional farming technique developed in Burkina Faso, has

been promoted and practiced in countries like Mali, Niger, and Ghana to combat environmental degradation as a result of climate change and improve farm yield. It involves creating small planting pits filled with organic matter before planting the seeds, which enhances soil fertility and moisture retention. The technology's success in the drought-prone 1970s reduced emigration and led to its adoption in other Sahelian countries. Understanding the determinants of the adoption of Zai technology can guide policy interventions and sustainable development efforts in Africa [23].

Green revolution in Africa: The Green Revolution (GR) strategy offers a potential solution to combat climate change in Africa by enhancing food crop productivity and sustainability. Through institutions like the Consultative Group on International Agricultural Research (CGIAR), the GR promotes the transfer of technology and improved crop varieties that can withstand climate challenges. While Africa initially lagged behind in adopting these advancements, positive growth has been observed in the post-GR period with the adoption of improved varieties. This strategy contributes to poverty reduction, lower food prices, and increased access to nutritious food, benefiting vulnerable populations [24]. Additionally, investments in agricultural innovation and productivity growth have helped Africa adapt to climate change, enhance smallholder competitiveness, and promote sustainable practices. By incorporating climate-resilient crop varieties and implementing sustainable agricultural techniques, such as conservation agriculture and efficient irrigation methods, the GR strategy supports Africa in addressing climate challenges, achieving food security, and fostering sustainable economic development [24]. Continued research and investment in crop improvement are essential to developing climate-smart agriculture that enhances productivity, resilience, and environmental sustainability across the continent [25].

Innovative water technologies in Africa: African countries are embracing innovative water technologies as a response to climate change and to enhance sustainable agricultural practices. These technologies include solar-powered water pumps, fog harvesting, drip irrigation, and the integration of indigenous knowledge and agroforestry practices. Hydroponics is gaining popularity in areas with poor soil quality and limited water resources, combining traditional wisdom with modern techniques. African countries are proactively tackling water-related challenges posed by climate change through the utilization of these technologies [26]. Rainwater harvesting, a traditional practice in Namibia, has been adapted using modern techniques such as plastic tanks or barrels to supplement household water supplies and address water scarcity caused by climate change. By adopting these innovative water technologies and incorporating indigenous methods, African countries are taking proactive measures to mitigate the impact of climate change on water resources, ensuring greater efficiency and sustainability in agriculture and water management [27].

Innovative solar-power energy sources: solar energy has enormous potential in Africa, particularly in North and South Africa, due to factors like proximity to the equator and abundant sunshine. South Africa alone has significant potential for solar power generation [28]. In North Africa, a solar farm covering just a small portion of the region could meet the electricity needs of the entire European Union. With high solar irradiation levels in countries like Algeria, Morocco, Egypt, and Tunisia, Northern Africa is well-suited for solar energy production. The continent's renewable energy market, including solar power, holds promise for economic growth, poverty reduction, and sustainable development. However, there are challenges to overcome in terms of adoption and implementation [28].

Traditional agriculture in African countries: traditional agriculture approaches in Africa for combating climate change include agroforestry,

intercropping, crop rotation, cover cropping, traditional organic composting, and integrated crop-animal farming [29]. These approaches contribute to climate change adaptation, carbon sequestration, soil health, biodiversity, and food security in Africa [29]. Terracing is a conventional agricultural practice where flat surfaces are constructed on steep inclines to prevent soil erosion and enhance water retention. This method is widely employed in countries like Burkina Faso, Ghana, and Mali, enabling farmers to cultivate crops such as millet, sorghum, and cotton in regions characterized by hilly landscapes and limited rainfall [26].

Recommendations

The progress made by African countries in addressing climate change through locally-driven initiatives is significantly impressive. These success stories highlight the importance of using local knowledge, resources, and leadership to develop sustainable solutions. However, it is critical to note that the success of such projects is dependent on a number of critical elements. Partnerships and collaborations among governments, non-governmental organizations, research institutions, and local communities are also critical for mobilizing resources and scaling up these Africa-led innovation efforts. Adequate financing mechanisms, effective policy frameworks, and supportive institutional environments are also necessary for success. Knowledge sharing, technology transfer, and capacity-building initiatives can further strengthen the impact of Africa-led innovation in tackling climate change challenges [2]. These initiatives highlight the potential of Africa-led innovation and emphasize the importance of local leadership, community engagement, and supportive policies in addressing climate change in Africa. It is essential to share these success stories and lessons learned to inspire further action and collaboration to tackle climate change challenges in Africa and beyond. Climate adaptation programs can benefit from a combination of grassroots approaches and

innovative technology. In light of the interconnectedness between food, water, and energy, we suggest African nations give priority to sustainable approaches that utilize a blend of African-led innovative traditional knowledge and contemporary advancements to tackle climate change issues in Africa. It is essential to focus on initiatives that enhance the availability of affordable solar energy solutions in rural regions, as this is essential for accessing clean water and sustaining agricultural activities [26]. Furthermore, we propose enhancing support for all forms of African-driven initiatives and community-based research with resources for capacity building within research institutions located in Africa to effectively tackle the adverse impacts of climate change [30]. Securing a resilient future for the African continent amidst the challenges posed by climate change is possible if all these approaches are robustly encouraged at all levels of government on the continent.

Conclusion

Africa is confronting significant challenges from climate change, but it has shown resilience through Africa-led initiatives that combine traditional knowledge and modern technology. Collaborative efforts among governments, research institutions, and local communities are crucial for scaling up these initiatives. Access to affordable solar energy solutions in rural areas is vital for clean water and sustainable agriculture. It is recommended to support African-driven initiatives and research institutions, invest in capacity building, and share success stories to inspire further action. Africa-led innovation can play a key role in addressing climate change and achieving sustainable development on the continent.

Competing interests

The authors declare competing interests.

Authors' contributions

Conceptualization: Olalekan John Okesanya, Olaniyi Abideen Adigun, Olaleke Noah Olabode, Hakeem Kayode Hassan, Abioye Sunday Micheal. Data curation: Olalekan John Okesanya, Olaniyi Abideen Adigun. Formal analysis: Deborah Oluwaseun Shomuyiwa, Oso Tolutope Adebimpe, Faith Atewologun. Investigation: Olaniyi Abideen Adigun, Jerico Bautista Ogaya, Emery Manirambona. Methodology: Olalekan John Okesanya, Deborah Oluwaseun Shomuyiwa, Emery Manirambona. Project administration: Don Eliseo Lucero Priso III. Resources: Faith Atewologun, Oso Tolutope Adebimpe. Supervision: Don Eliseo Lucero Priso III, Oso Tolutope Adebimpe. Visualization: Jerico Bautista Ogaya, Don Eliseo Lucero Priso III, Oso Tolutope Adebimpe. Validation: Deborah Oluwaseun Shomuyiwa, Jerico Bautista Ogaya. Writing original draft: Olalekan John Okesanya, Olaniyi Abideen Adigun, Olaleke Noah Olabode, Hakeem Kayode Hassan, Abioye Sunday Micheal. Writing review & editing: Olalekan John Okesanya, Deborah Oluwaseun Shomuyiwa, Jerico Bautista Ogaya, Emery Manirambona, Oso Tolutope Adebimpe, Don Eliseo Lucero Priso III. All authors contributed equally to the writing of this paper. All authors have read and approved the final draft of this article.

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