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A Critical Analysis of the "Pepper Soup of Innovation" and Emerging Technologies in Achieving Africa's Sustainable Development Goals

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ABSTRACT

This study examines Africa's "Pepper Soup of Innovation," a metaphor for its complex, unique innovation ecosystems, and their interaction with emerging technologies to advance Sustainable Development Goals (SDGs). This study utilises a case study methodology situated in African national contexts, and this helps to make clear how different combinations of local knowledge, entrepreneurship, government involvement, and international collaboration produce scalable solutions through the use of technology that is contextually relevant to the specific countries. This study further identified persistent barriers to technology uptake for SDG delivery in those countries, such as: infrastructure challenges, affordability, digital divisions, outdated regulatory environments, and scarcity of skills. By systemically mapping these real-world instances against SDGs and aspects of innovation ecosystems, this study has identified important leverage points for policy intervention and ecosystem development. This study offers recommendations for policymakers, practitioners, and researchers operating in the development space. It stresses the importance of investing in infrastructure, building capacity, and strengthening existing and emerging cross-boundary innovation networks. By framing the integration of technology in Africa's "Pepper Soup" ecosystem, further insight can be gained about inclusive, sustainable development through emerging technologies in the African context.

Keywords: Africa, Innovation, Emerging Technologies, Sustainable Development Goals (SDGs), Pepper Soup of Innovation

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1. INTRODUCTION

1.1 Background on Africa's sustainable development challenges

The Sustainable Development Goals (SDGs) comprise seventeen (17) related global objectives adopted by the United Nations as a part of the 2030 Agenda for Sustainable Development (United Nations Development Programme, n.d.). The SDGs are intended to deal with important social, economic, and environmental problems. They will help eradicate poverty, reduce inequalities, promote sustainable economic growth, and advancement in technology while safeguarding the earth and ensuring prosperity for everyone (Weiland et al., 2021; Odumesi & Sanusi, 2023). Specifically, achieving these goals in the African context would require a multidimensional approach that would strategically balance technological advances with existing socio-economic realities to drive innovation for inclusive and sustainable development rather than further entrenching inequalities.

Emerging technologies, such as artificial intelligence (AI), blockchain, big data analytics, e-governance platforms, and mobile payment systems, are expected to have very high potential in speeding up the achievement of the Sustainable Development Goals (SDGs) in Africa. They will be able to facilitate improved digital inclusion to education, health care, e-commerce, and financial services in underserved areas, strategic economic growth through investments in Science, Technology, and Innovation (STI) leading to entrepreneurship, job creation, and knowledge-based economies and encouraging sustainable practices through improved transparency in resource management through blockchain and the use of AI in agriculture and disaster management (United Nations Development Programme, 2019).

The Sustainable Development Goals (SDGs) face serious challenges within Africa, such as rampant poverty, food insecurity, health challenges, climate insecurity and environmental destruction. However, the continent possesses enormous advantages: a highly youthful population, a bountiful store of natural resources, and a growing economy (Denabo-Juju et al., 2020; Ejim, 2023). Emerging technologies, including Artificial Intelligence (AI), blockchain, big data analytics, e-governance platforms, and mobile payment systems, are seen as key to fast-tracking development towards the SDGs (Jorzik et al., 2024). These technologies open opportunities for rethinking existing developmental pathways, improving service delivery, and hastening economic growth in a sustainable manner.

The African Union's Science, Technology, and Innovation Strategy for Africa (STISA-2024) is directly aligned with the SDGs in terms of positioning Science, Technology, and Innovation (STI) as an enabling factor for development across the continent (United Nations Development Programme, 2019). The various relevant stakeholders must cooperate strongly in mobilising resources for innovatively driven solutions that respond to Africa's unique challenges while harnessing inclusive growth.

Technology is at the forefront of hastening the necessary actions needed to reach the Sustainable Development Goals (SDGs), especially in Africa, where Science, Technology, and Innovation (STI) are necessary to combat multidimensional challenges and promote sustainable development (United Nations Economic Commission for Africa, 2023; Senja-Shafira et al., 2024). Emerging technologies such as Artificial Intelligence (AI), Blockchain, the Internet of Things (IoT), renewable energy solutions, and enhanced digital connectivity are

providing innovative solutions to some of today's most complex global challenges-from poverty reduction to climate action. The technological leveraging of these tools is indispensable for achieving the SDGs efficiently and inclusively in Africa because of significant barriers posed by resource constraints, infrastructural deficits, and socio-economic inequalities (Asaju, 2022; Opesemowo & Adekomaya, 2024).

1.2 The 'Pepper Soup of Innovation' metaphor

The 'Pepper Soup of Innovation' metaphor provides a compelling framework on which to base the complex interrelations that form African innovation ecosystems. This metaphor compares the diverse ingredients and preparation of pepper soup (Tandzong et al, 2022; Mafe et al, 2024), a famous West African dish, to the multifaceted environment that supports successful innovation in the African context. The main features of the 'Pepper Soup of Innovation' metaphor are:

i. Diverse ingredients: All stakeholders, resources, and sources of knowledge contribute to innovation.
ii. Blending of flavours: Interactions, synergies among elements of innovation ecosystems.
iii. Cooking process: Time and patience need to be involved in innovations, maturing and developing.
iv. Cultural Significance: Emphasising the importance of embedding or embedding innovations in African cultures and norms.
v. Adaptability: Emphasising the need for innovation to be flexible and customised to different parts of Africa.

This metaphor provides a useful viewpoint for examining how emerging technologies can be effectively integrated into African innovation ecosystems to address sustainable development challenges. It encourages the integrative approach of considering the interrelationships among technological developments, local knowledge bases, policy frameworks, and socio-cultural factors. Thus, this will provide sufficient diving analysis into the complex intricacies of the relationships between innovation, technology, and sustainable development in the African context, while providing actionable insights for policymakers, innovators, and researchers.

1.3 Emerging technologies and their potential impact

Emerging technologies like Artificial Intelligence (AI), the Internet of Things (IoT), blockchain, big data, robots, and green technologies play a big role in Africa's growth (Distor et al., 2023; Floyd & Bayou, 2023). They have an impact on many areas linked to the Sustainable Development Goals (SDGs) (Ruhana et al, 2024). These new ideas can change how we tackle development and create solutions that fit local needs in places with poor infrastructure and weak institutions (Asaju, 2022). In the 'Pepper Soup of Innovation' metaphor, these technologies are key parts that can solve big development problems. Artificial Intelligence (AI) can make healthcare and farming better, while blockchain can make supply chains and government more open. Mobile and digital technologies help more people use banks and get services like school and healthcare. Green technologies are vital to handle climate change and grow without harming the environment.

To truly tap into this transformative potential, we need to take a thoughtful and context-aware approach. The way emerging technologies are adopted and their impact in Africa depends on several factors, including how ready the technology is, the strength of institutional frameworks, the policy and regulatory landscape, and how open the culture is to change (Kala, 2023; Udo et al, 2024). It is essential to tackle issues like infrastructure gaps, skill shortages, funding limitations, and governance challenges. Plus, we must critically assess the distributional effects, potential risks like digital exclusion and ethical concerns, and the importance of inclusive governance to ensure that outcomes are fair and sustainable (Adam & Alhassan, 2021; Alhassan et al., 2023). In the end, leveraging emerging technologies for Africa's sustainable development calls for strategic investments, collaborative partnerships, and frameworks that are sensitive to local contexts, emphasising equity, inclusivity, and building local capacities.

1.4 Research Focus and Parameters

The main objective of this study is to take a close look at how emerging technologies can help push Africa's Sustainable Development Goals (SDGs) forward, through the 'Pepper Soup of Innovation' metaphor. This means breaking down this metaphor to better understand the diverse innovation ecosystems across Africa and examining how these new technologies are being adopted and their effects on important sectors related to the SDGs. The research also seeks to identify and evaluate the obstacles and facilitators of technology adoption in the unique socio-economic and political landscapes of Africa, assess how well relevant policies align, and suggest a multidisciplinary framework to effectively harness emerging technologies for inclusive and sustainable development results.

This research highlights the period from 2018 to 2023, which has been a significant era for technological progress and policy development in Africa. It examines various African nations that are home to dynamic innovation ecosystems and technology hubs, including Nigeria, South Africa, Ghana, Kenya, Ethiopia, and Rwanda. The study focuses on crucial emerging technologies like Artificial Intelligence (AI), blockchain, the Internet of Things (IoT), digital agriculture, and renewable energy, assessing how they are being adopted and their impact on Sustainable Development Goal (SDG) sectors: agriculture, healthcare, education, energy, and governance.

2. EMERGING TECHNOLOGIES IN AFRICA

2.1 Overview of relevant emerging technologies

Emerging technologies are increasingly vital in tackling Africa's socio-economic and environmental issues, paving the way for innovative solutions to meet the Sustainable Development Goals (Ofori & Arthur, 2024; Ruhana et al., 2024). Artificial Intelligence (AI) is making strides across various sectors such as healthcare, agriculture, finance, and governance, leading to better diagnostics, precision farming, financial inclusion, and improved public service delivery, with forecasts suggesting significant economic benefits (Mienye et al., 2024; Nwosu et al., 2024). Digital Twins provide virtual simulations that help optimise operations and decision-making in both industrial and urban development (Abayadeera & Ganegoda, 2024). The decentralised nature of blockchain technology opens up new avenues for greater transparency and security in supply chains, financial services, and governance (Aro et al., 2024; Shoetan & Familoni, 2024).

The Internet of Things (IoT) enhances resource management across different sectors by connecting devices and facilitating data exchange, which supports the development of smart cities and climate-resilient agriculture (Dhanaraju et al, 2022; Adaramola et al, 2024). Innovations in renewable energy, like solar, wind, and bioenergy, are essential for improving energy access and meeting climate objectives, promoting affordable, clean energy, and sustainable industrial growth (Abban, 2022; Jaiswal et al, 2022). Mobile and digital financial technologies have transformed financial inclusion, empowering Micro, Small, and Medium Enterprises (MSMEs) and boosting e-commerce (Ezeocha, 2024; Muliono, 2024).

To effectively harness and integrate these technologies into Africa's distinct innovation landscape, we need to consider a mix of socio-cultural factors, economic challenges, policy frameworks, infrastructure readiness, skills development, environmental sustainability, and ethical governance (Jude & Abubakar, 2019; Udo & Agbai, 2023). While these technologies hold great potential for speeding up progress towards the Sustainable Development Goals (SDGs), their actual impact is influenced by local conditions. This means we need supportive policies, investments in digital infrastructure, capacity building, and inclusive governance to ensure everyone has fair access and to fully unlock their transformative power across the continent.

2.2 Current state of technology adoption in Africa

The technological adoption landscape in Africa between 2018 and 2023 has demonstrated substantial advancements, largely driven by the expansion of digital infrastructure, policy reforms, and a broader innovation ecosystem (Ukorah et al., 2023; World Bank Group, 2024). The African Union's Science, Technology, and Innovation Strategy for Africa 2024 (STISA-2024) indicates that the technological capabilities of AU Member States have nearly doubled (from 25% to 41%) over the last ten years, highlighting the availability of digital access, increasing Research and Development, and the growing number of innovation hubs (African Union digital strategy, 2020; African Union, 2024; Humans of Globe article, 2024).

The rate of digital access continues to increase, with approximately 473 million Africans online by 2023 and projections of over 300 million users to be added in 2025, which changes the socio-economic and political landscape (White & Case, 2022; Staff Writer, 2024). However, the digital divide between urban and rural areas and infrastructure gaps continues as a challenge to inclusive adoption (Okocha & Dogo, 2023; Hernandez et al., 2024).

In sectors of agriculture and health, technology adoption has gone mobile-first in nature (Mhlanga & Ndhlovu, 2023; Babatunde et al., 2024). For instance, Kenya's "Silicon Savannah" continues to lead the way with financial technology, with a fintech sector worth roughly US$7.18 billion in 2023 (Fintechnews Africa, 2024). Mobile payment systems such as M-Pesa are taking financial inclusion to a whole new level (Mhlanga & Ndhlovu, 2023). However, not limited to fintech, emerging technologies such as Artificial Intelligence (AI), blockchain, and the Internet of Things (IoT) are being more broadly adopted in agriculture, healthcare, education, and governance to improve the delivery of services and efficiency of operations. Artificial Intelligence (AI), for example, is used for disease diagnosis and precision farming, while IoT is used for more efficient resource use and support of smart cities (Raghunath & Syamala-Devi, 2022; Kumar et al., 2023). Renewable energy technologies, such as solar and wind, will be crucial for achieving energy access and meeting climate goals (Urioste, 2024).

Some African governments, like South Africa, Nigeria, Ghana, Kenya, and Zambia, have developed strategic roadmaps for governing emerging technologies, which outline a path for responsible use, data protection, and cybersecurity (Musoniet al., 2023; Balogun & Adeniran, 2024). However, while most African countries are shifting towards developing policies, the regulatory environment still lags behind the technology itself, leaving considerable uncertainty surrounding the legality of operations (Udo & Agbai, 2023).

Below is an overview of the current state of technology adoption in Africa relevant to this study:

Table 1: Africa's Evolving Technology Adoption Landscape (2018–2023) and Statistical Indicators from the 'Pepper Soup of Innovation' Perspective

Dimension	Overview	Statistics & Trends (2018–2023)	Implications for Innovation & SDGs
Innovation Ecosystem	Africa's technology landscape is a vibrant and diverse "Pepper Soup of Innovation", representing a mixture of indigenous forms of creativity, global technology, and efforts to develop the local 'policy' landscape.	The rapid growth of digital platforms, AI startups and cloud services coexists with the quality of digital connectivity, fragmented technology stacks, and disparate policy readiness (Lee et al., 2024).	Highlights a need to make sense of how our unique "ingredients" (connectivity, policy, and capacity) combine to sustain innovation in local and sustainable ways.
Internet and Mobile Connectivity	A mobile-first economy with an uneven adoption of the Internet and coverage gaps.	Connectivity has been steadily increasing, but internet usage is only 37% compared to 67% globally (Ousmanne, 2024). Mobile broadband coverage is 83%, but usage is only 27% (GSMA, 2024; World Bank, 2024). Mobile subscribers are projected to increase from 44% in 2023 to surpass 50% by 2030, an increase from 527 million subscribers in 2023 to 751 million by 2030 (GSMA	Connectivity gaps hamper inclusive digital access, especially in rural areas, limiting the deployment of technologies related to the SDGs.

		Intelligence, 2023). Digitally developed African countries are Libya, with an ICT Development Index score of 88.1. Morocco and Seychelles follow closely with scores of 86.8 and 84.7 (Okamgba, 2024).	
Cost and Affordability	High costs restrict access to devices and services.	Entry-level broadband costs 4.2% of GNI per capita; the global target should not cost more than 2% (International Telecommunication Union, 2021). Taxes and levies increase smartphone prices by 10% to 30% in Sub-Saharan Africa, limiting accessibility for a large population (Okafor, 2023).	Affordability is still a major barrier to widespread adoption and digital inclusion, and is impacting equity goals in the SDGs.
Cloud and Digital Services	Increased enterprise adoption of cloud and digital tools is enabling innovation across the private and public sectors.	50% of organisations adopted cloud computing in 2023, and are projected to be 61% in 2 years (Allderman, 2023)	While cloud adoption leads to scalable innovation, the extent will depend on the underlying infrastructure and the regulatory maturity that supports SDG-related services.
AI and emergent technologies	AI start-ups and applications are expanding across multiple sectors like health, fintech, agriculture, etc.	Around 2,400 AI companies operated across Africa in 2024, with 40% classified as startups driving innovation across sectors (Agwaibor, 2024).	AI has disruptive potential for the SDGs, but needs an enabling environment and governance to manage the hype versus the reality.

Digital Divide and Inequality	Significant disparities in access and use of technology by gender and the rural-urban divide.	A larger proportion of rural women, around 84% than urban women, around 16% lack access to or ownership of mobile phones (Gillwald & Partridge, 2022).	Digital inequities risk worsening social issues and undermining inclusive development goals.
Infrastructure and regulatory barriers	Restricted electricity, data centres, and ICT regulatory maturity prohibit technology uptake.	Only 43% have reliable electricity in Africa, half of the global access rate of 87% (Patel, 2019; Afrobarometer, 2022).	Infrastructure and governance inadequacies are key bottlenecks to ramping up emerging technologies for an SDG impact.
Sectoral Highlights	Mobile money, FinTech, renewable energy, and e-governance show consistent movement amidst difficulties and significant progress.	Mobile money transactions will be above $500 billion in 2025 and over the next four years to reach $2.1 trillion in 2027 (Adepetun, 2023; Juniper Research, 2023). Renewable energy investment more than doubled from $17 billion in 2019 to $36.6 billion in 2023, a 115.3% increase, mirroring global renewable growth from $282 billion to $619.1 billion (119.5%) over the same period (Moses, 2023).	Sector-based innovations highlight the possible pathways for progress in the SDGs and the need for specific policy and capacity support.

The technology adoption landscape in Africa is characterised by rapid growth and innovation that is hindered by structural challenges. The term "Pepper Soup of Innovation" conveys the complex and heterogeneous mix of culture, technology, and policy in navigating the barriers to advancing the Sustainable Development Goals. Fully realising the potential of new technologies for inclusive and sustainable development across the continent requires addressing and overcoming deficits in infrastructure, affordability, digital divides, and regulatory considerations.

2.3 Opportunities and challenges in technology implementation

2.3.1 Opportunities in Technology Implementation

The rapid diffusion of Information and Communication Technologies and Fintech solutions empowered access to financial services and, therefore, economic inclusion and growth across Africa (Djoufouet & Pondie, 2022; Nkechika, 2022). Mobile banking platforms like M-Pesa provide financial inclusion at scale by leapfrogging the "traditional" banking infrastructure and enabling the achievement of SDG 1 (no poverty) and SDG 8 (decent work and economic growth) (Abdulhamid, 2020). On the other hand, digitalisation will help boost intra-African trade, streamline supply chains, and drive innovation, leading directly to SDG 9 (industry, innovation, and infrastructure) (Kere & Zongo, 2023).

Technological progress in renewable energy, especially solar microgrids, offers scalable, sustainable solutions to the perpetual energy shortages, being central to the achievement of SDG 7 (affordable and clean energy) and SDG 13 (climate action) (Su et al., 2023; Trinh & Chung, 2023). Case studies in Ghana, Kenya, and South Africa have adopted these potentials to address the issues of access to electricity, poverty alleviation, and the environment. Integration of ICT and AI in education and health is further enhancing the penetration of quality education (SDG 4) and health services (SDG 3), particularly in rural and underserved areas (Aririguzoh et al., 2021; Diallo, 2023; Saini et al., 2023). The youth-centered innovation ecosystems supported by tech hubs in Nigeria, Kenya, and Rwanda nurture local entrepreneurship and produce solutions aligned to the needs of society (Darboe, 2021).

ICT-based governance solutions such as blockchain may help enhance transparency and reduce corruption under SDG 16 (peace, justice, and strong institutions) (Nwozor et al., 2022; Okewu et al., 2023). There is also a rise in public-private partnerships and global donor-led programs that support digital service delivery across the continent (Akubuike, 2022).

2.3.2 Challenges in Technology Implementation

While these opportunities exist, there remain several challenges impeding Africa's technology deployment and scale-up (Gwagwa et al., 2020; Kala, 2023). The prevailing infrastructural deficit, especially in electricity and broadband access, poses a major impediment in rural settings, which discourages any form of digital transformation and worsens inequalities (Okoye et al., 2023).

Affordability remains a matter of concern; costly devices and high internet costs keep access away from those pegged at low incomes or marginalised, as the digital divide has gender and rural-to-urban forms (SDGs 5 and 10) (Banya Global, 2023). The inability to cultivate appropriate digital literacy and skills worsens the possible craftsmanship of local innovations, in turn worsening the quality and sustainability of technology adoption (SDGs 4 and 8) (Montoya, 2018). Institutional and policy fragmentation pose an impediment to the effective integration of technologies into industries (Enaifoghe & Ndebele, 2023). With only a minority of countries with an official AI strategy and a harmonised data governance framework, such constitutional incoherence causes chaos in investment, cross-border collaborations, and security (SDG 16, 17) (Council of Europe, 2020). Globally, technology-based solutions mostly collapse due to contextual misfits; technologically speaking, they do not take into account local languages, social norms, and market realities (Arakpogun et al., 2021; Kala, 2023).

With digitalisation moving fast, new matters of security and trust come into being, which must be addressed through data protection, cybersecurity, and consumer safeguards (Banwo & Ighodalo, 2023; Saeed et al., 2023). Socio-cultural resistance stemming from a lack of digital literacy and mistrust in institutions could paralyse the uptake of innovation unless such resistance is taken into consideration with inclusive and context-based frameworks (Amin et al., 2022) such as the "Pepper Soup" metaphor.

While emerging technology provides Africa with the unprecedented opportunity to leapfrog development gaps and achieve inclusive and sustainable economic growth, this has to be ensured by closing infrastructure and affordability gaps, closing skills gaps, strengthening policy and regulatory frameworks, enhancing local capacity, and fostering trust in digital systems. Only a multi-stakeholder approach that takes into account the differences in context can grab the opportunity to channel technology toward the development path of the continent and deliver on the SDGs.

2.4 Case studies of successful technology integration

The following Table 2 provides African case studies of technology integration across all 17 Sustainable Development Goals (SDGs). In Table 2, this study shows the "Pepper Soup of Innovation" metaphor, which is about mixing digital, circular, and data-driven solutions with contextuality and inclusivity for sustainability.

Table 2: African Case Studies of Technology Integration Across the 17 SDGs - 'Pepper Soup of Innovation' Perspective

SDG	Technology/Innovation	Country/Context	Outcomes & Impact
SDG 1 No Poverty	Mobile Money (M-Pesa)	Kenya, 10+ countries	Over 95% financial access, poverty reduction, microloans, and empowered microenterprises (Islam et al., 2022).
SDG 2 Zero Hunger	FarmDrive, Digital Agri Platforms, Satellite Hotlines	Kenya, Ethiopia, Rwanda	Improved yields, tailored agri-advice, AI/IoT-led smallholder inclusion (AppsAfrica, 2023).
SDG 3 Good Health	Zipline Drones, mHealth Apps, Remote Diagnostics	Rwanda, Ghana, Nigeria	Faster medicine delivery, improved rural healthcare access, reduced child/maternal mortality (Fakiya, 2023).
SDG 4 Quality Education	uLesson, Eneza, ACETEL	Nigeria, Kenya, Ghana	Equitable e-learning, low-bandwidth/mobile education, expanded rural access (ThisDayLive, 2022; GSMA, 2023).
SDG 5	Soronko Academy,	Ghana, Nigeria,	Increased women's

Gender Equality	Women in Tech/Fintech	Pan-Africa	digital literacy, leadership, and financial inclusion (Honuon, 2020).
SDG 6 Clean Water	Smart Meters, Water Assurance Fund, IoT Monitoring	Ghana, South Africa, Kenya	Expanded rural water service, usage monitoring, and improved household access (Project Maji, 2022; Amankwaa et al., 2023).
SDG 7 Affordable & Clean Energy	Off-Grid Solar, Mini-Grids, PAYGO	Nigeria, Ethiopia, Kenya	Rural electrification, clean energy adoption, and female micro-entrepreneurship (Beath, 2024; Smith, 2024).
SDG 8 Decent Work & Economic Growth	Andela, Ajira, Digital Gig Platforms	Nigeria, Kenya, Pan-Africa	Youth upskilling, remote work, and increased digital sector employment (Spencer, 2020).
SDG 9 Industry/Infrastructure	Tech Hubs, Incubators, Kigali Smart City	Rwanda, Kenya, Ghana	Startup growth, resilient industry, and model urban digital planning (Xinhua, 2024)
SDG 10 Reduced Inequalities	Mobile Financial Inclusion for Marginalised	Kenya, Ghana, South Africa	Reduced digital divide, inclusive banking for rural/disability groups (Mpofu & Mhlanga, 2022; Yap et al., 2023)
SDG 11 Sustainable Cities	Smart Lighting, Ride-Sharing, Urban Mobility IoT	Tunisia, Kenya, Morocco	Cost-effective, sustainable urban services, real-time transport optimisation (Müller-Eie & Kosmidis, 2023).
SDG 12 Responsible Consumption	Plastic Ban, E-Waste Recycling, Circular Platforms	Kenya, Ghana	Plastic waste reduction, safe e-waste recycling, and informal sector upskilling (Greenpeace Africa, 2020)
SDG 13 Climate Action	AI for Flood Risk, Solar Megaproject (Noor)	Kenya, Morocco, Ghana	Early warning systems, renewable energy scaling, and carbon emissions reduction (UNESCO, 2021).

SDG 14 Life Below Water	Marine Sensor Arrays, Ocean Monitoring	Seychelles, Mauritius, Tanzania	Coral reef mapping, real-time illegal fishing detection, water quality (Palmer et al., 2021).
SDG 15 Life on Land	Drones, GPS & AI for Conservation	Kenya, Rwanda	Enhanced anti-poaching, ecosystem monitoring, and resource management (DroneBlogger, 2023; Griffith et al., 2023)
SDG 16 Peace & Justice	e-Government Platforms, Digital Identity	Rwanda, Ghana, Nigeria	Reduced corruption, transparency, and trust in institutions (Jaiyeola & Musumhi, 2023).
SDG 17 Partnerships	AU Digital Transformation Initiative, AfriLabs	Continental, Pan-Africa	Cross-sector partnerships, funding/research collaboration (African Union, 2020).

Africa's "Pepper Soup of Innovation" is an embodied metaphor for the fast-changing, interrelated, and place-based tech ecosystem that is influencing progress on the SDGs on the continent. The case studies presented in this study have shown that, when fully integrated and scaled, emerging technologies can create meaningful and measurable social, economic, and environmental impact across the entire range of SDGs. To make these successes sustainable requires a systemic lens of inclusion, capacity, and enabling governance, the type of "ingredients" that Africa needs to advance as a sustainable future.

3. CONCLUSION

Emerging technologies are transforming how Africa aims towards the Sustainable Development Goals (SDGs) in a vibrant and heterogeneous innovation ecosystem that can be referred to as the "Pepper Soup of Innovation." Emerging technologies have shown transformational potential by creating growth opportunities and enabling improved financial inclusion, access to health and education services, governance, and environmental sustainability with off-grid solar energy solutions and data-driven resource management across many sectors. Nonetheless, persistent challenges of a lack of infrastructure, digital divides, inadequate regulatory contexts, insufficient capacity, and a shortage of funding and investment are still limiting the scope and equity of technology adoption. To really benefit these innovations, there needs to be strategic coordination through inclusive policy, multi-stakeholder collaboration, and aligning these innovations with continental institutions, frameworks and collaborative agendas such as the African Union's STISA and Agenda 2063. It means investing in digital and energy infrastructures, creating human capital, contextualising technologies for local socio-economic and cultural realities, and strengthening systems of governance and collaborative ecosystems.

The metaphor of "Pepper Soup" demonstrates how sustainable progress relies on the combination of different technological, institutional and social "ingredients", applied in adaptive and inclusive ways. In the end, Africa's potential to transform new technological opportunities into inclusive and resilient development will depend on integrated, context-relevant models of innovation that account for equity, capacity-building and connected systems considerations, ensuring that no one is left behind on the journey to the 2030 Agenda and beyond.

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