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Artificial Intelligence in monitoring and verifying sustainable development goal 7 progress in Africa

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Abstract

The review focuses on how Artificial Intelligence (AI) can transform the monitoring and verification of Sustainable Development Goal 7 (SDG 7), the goal of access to reliable, affordable, sustainable, and modern energy for all in Africa. Endowed with vast renewable resources, much of the African continent struggles with an energy access deficit, compounded by weak infrastructure, underinvestment, limited data availability, and fragmented governance. Traditional monitoring and verification approaches are typically manual, sporadic, and inadequate to ascertain dynamic change in electricity access, renewable energy adoption, and clean cooking usage. It discusses how AI techniques such as machine learning, deep learning, remote sensing integration, computer vision, and natural language processing can supply real-time, inexpensive, and scalable solutions to measure indicators of SDG 7. The paper references case studies and platforms like AtlasAI, Energy Access Explorer, and satellite-based electrification mapping tools as points of evidence on how AI can supplement ground surveys and add data granularity, predictive forecasting, and infrastructure verification. The article outlines opportunities in addition to constraints in AI adoption, touching on technical, institutional, and ethical concerns such as algorithmic bias, data privacy, lack of localized models, and narrow national capacity. The article also recognizes the importance of inclusive policy-making frameworks, open data standards, and domestic capacity development in enhancing equitable and responsible AI adoption. The review finally asserts that, with proper planning, AI can significantly catalyze the attainment of energy justice and sustainability in Africa by enabling more intelligent planning of energy, effective investments, and better governance structures.

Keywords: Sustainable Development Goal 7; Artificial Intelligence in Energy Monitoring; Energy Access and Equity in Africa; Machine Learning and Remote Sensing; Data-Driven Sustainable Development

1. Introduction

1.1. Background on SDG 7 in Africa

The Sustainable Development Goals (SDGs), adopted in 2015 by the United Nations as part of the 2030 Agenda for Sustainable Development, constitute a universal call to action to end poverty, protect the planet, and ensure prosperity for all. Among the 17 interconnected goals, SDG 7 is singularly focused on ensuring "access to affordable, reliable,

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sustainable and modern energy for all." [1] This goal comprises three primary targets: ensuring universal access to electricity and clean cooking (Target 7.1), substantially increasing the share of renewable energy in the global energy mix (Target 7.2), and doubling the global rate of improvement in energy efficiency (Target 7.3). Two additional sub-goals, 7.a and 7.b, address international cooperation and infrastructure development for expanding clean energy services, particularly in developing countries [2]. In Africa, the relevance of SDG 7 cannot be overstated. The continent is characterized by an acute and persistent energy access crisis. According to the International Energy Agency (IEA) (2023), over 560 million people in Sub-Saharan Africa still lack access to electricity, and approximately 900 million lack access to clean cooking solutions [3]. Rural electrification lags behind urban areas, and disparities between regions (e.g., North Africa versus Central Africa) remain significant. Despite abundant renewable resources such as solar, wind, hydro, and geothermal Africa's energy mix continues to be dominated by fossil fuels and biomass, with renewable energy contributing less than 25% in many countries [4]. The situation is further complicated by challenges such as underdeveloped grid infrastructure, political instability, low levels of investment, lack of reliable data, and fragile energy governance. These obstacles limit progress toward SDG 7, hinder energy poverty alleviation, and exacerbate environmental degradation [5]. Furthermore, the lack of timely and accurate monitoring of energy development metrics poses a significant barrier to informed decision-making and sustainable planning. Tracking progress towards energy access and sustainability in African countries is often hampered by outdated or missing data, unreliable reporting mechanisms, and inadequate technological infrastructure [6].

1.2. Challenges in Monitoring SDG 7 Progress

Monitoring and verifying SDG 7 targets require robust, consistent, and transparent systems that can track electricity access, clean cooking access, energy efficiency improvements, and renewable energy integration in real-time. In many African countries, the tools and systems for such comprehensive tracking are either nonexistent or severely limited. National statistical systems often suffer from insufficient technical capacity, data fragmentation, poor quality control mechanisms, and a lack of standardized indicators [7]. One of the main challenges is the lack of disaggregated and real-time data. In rural or informal urban settings, where off-grid systems and informal energy sources are common, conventional data collection approaches fail to capture the full picture. For example, while grid connection may be recorded, the quality, affordability, and reliability of electricity services are rarely accounted for [8]. Similarly, access to clean cooking fuels is often measured by proxies that do not accurately reflect usage patterns, such as the number of stoves distributed rather than their actual adoption or sustained use. Another significant barrier is the asynchronous data reporting and long update cycles. Many countries report data intermittently or rely on international organizations to compile and verify their statistics. This results in delays of months or even years before meaningful insights can be drawn [9]. Such latency reduces the ability of policymakers and development agencies to intervene promptly and effectively. Additionally, there is the issue of fragmented data ecosystems. Ministries of energy, environment, statistics, and finance often operate in silos, with limited data-sharing protocols and poor coordination. This fragmentation not only inhibits a holistic view of energy access and sustainability but also reduces the efficiency and transparency of energy policy formulation and implementation. The COVID-19 pandemic highlighted the fragility of existing data systems. With restricted field activities, traditional data-gathering mechanisms such as household surveys and grid audits were severely disrupted, underscoring the need for digital, automated, and intelligent monitoring systems [10].

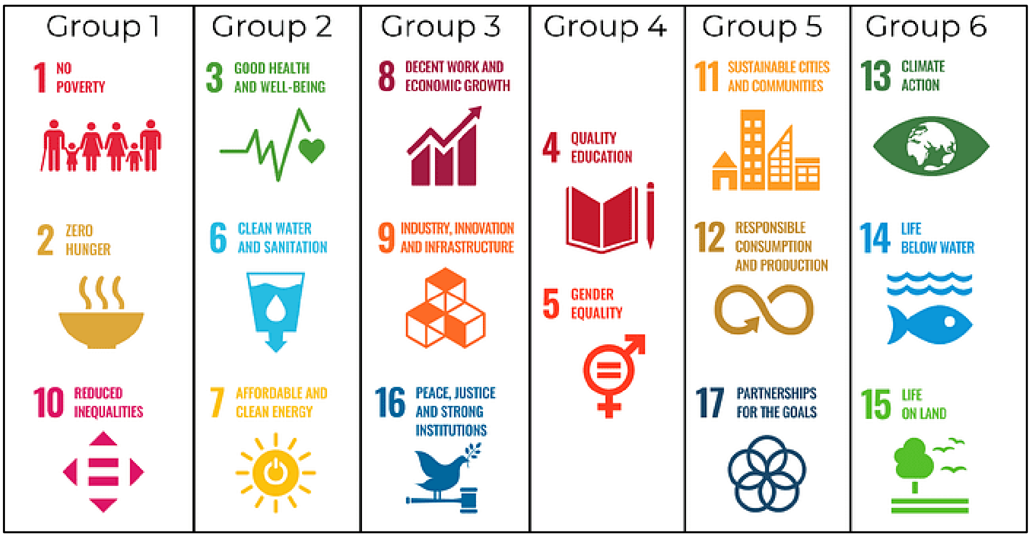

Figure 1 SDG and their grouping [11]

1.3. Role of Artificial Intelligence

Artificial Intelligence (AI), with its capabilities in automation, pattern recognition, prediction, and decision-making, holds transformative potential for overcoming the limitations of traditional energy monitoring systems in Africa. AI encompasses a variety of technologies including machine learning, deep learning, natural language processing (NLP), and computer vision all of which can be leveraged to enhance how we gather, analyze, and apply energy data [12]. Machine learning (ML) algorithms can be trained to forecast electricity demand and supply patterns, detect anomalies in grid systems, and estimate electrification rates based on remote sensing or socio-economic datasets. Deep learning models, which can process large volumes of satellite imagery, offer the ability to identify infrastructure changes, monitor solar panel installations, and assess rural electrification in near real-time [13]. Computer vision can aid in automatically detecting energy infrastructure (such as transmission lines and mini-grid systems) from high-resolution imagery, while natural language processing can analyze textual data (e.g., policy documents, investment reports, and development plans) to evaluate national alignment with SDG 7 goals [14]. One of the most promising applications of AI is the fusion of remote sensing data with ground-level data to build dynamic energy access maps. Tools like Google Earth Engine, AtlasAI, and open-source satellite databases can be integrated with AI models to estimate electricity availability and reliability at granular levels. This offers a scalable and cost-effective way to supplement or replace traditional surveys in remote or under-resourced areas [15]. Moreover, AI can help identify energy inequality hotspots, model future access scenarios, optimize renewable energy deployment, and evaluate the socio-economic impact of energy programs. The potential benefits extend beyond technical efficiency to include transparency, inclusivity, and responsiveness in energy governance [16].

1.4. Motivation and Scope of the Review

Given the growing urgency to achieve SDG 7 and the increasing complexity of Africa's energy landscape, there is a pressing need to examine how AI can be strategically deployed to enhance monitoring and verification mechanisms. Existing literature has focused primarily on the use of AI in energy generation, smart grids, and forecasting. However, its application in the monitoring of SDG progress especially in Africa remains underexplored. This review paper seeks to address this gap by analyzing the current and potential role of AI technologies in tracking progress toward SDG 7 in Africa. The review will systematically assess how AI has been applied or can be applied in: Monitoring electrification progress, Evaluating clean cooking adoption, Tracking renewable energy penetration, Measuring energy efficiency gains, Supporting data-driven policymaking for SDG 7. The paper also explores the institutional, technical, and ethical challenges associated with AI deployment in the African context, such as data availability, digital infrastructure gaps, and algorithmic bias. Furthermore, it considers the policy and investment frameworks necessary to foster AI adoption in public sector energy monitoring. By synthesizing case studies, technological innovations, and regional policy initiatives, the paper will highlight pathways for scaling AI-driven monitoring tools and frameworks. It aims to inform researchers, policymakers, energy planners, and development organizations about the transformative opportunities AI offers for Africa's sustainable energy future.

1.5. Research Objectives and Questions

The objectives of this review are threefold: To review existing literature and applications of AI in monitoring and evaluating energy access, renewable integration, and clean energy transitions in African countries. To identify gaps, limitations, and opportunities in the current data ecosystems and how AI technologies can bridge these gaps. To provide actionable insights and recommendations for stakeholders seeking to implement AI-driven monitoring solutions in line with SDG 7. The key questions this paper addresses include: What are the current barriers to effective monitoring of SDG 7 in Africa? How can AI technologies enhance the quality, frequency, and scope of energy-related data in Africa? What are the existing examples (pilot or deployed) of AI being used to track energy access or renewable integration? What are the institutional and infrastructural requirements for scaling AI solutions in SDG 7 monitoring? How can AI be aligned with local contexts to ensure inclusive, ethical, and equitable outcomes?

1.6. Significance of the Study

This review is timely and significant for several reasons. First, it aligns with the global push toward digital transformation and smart development in Africa. As countries increasingly adopt national AI strategies and digital public infrastructure, integrating these efforts into energy development and sustainability goals is both strategic and necessary. Second, the findings of this paper will support the design of evidence-based interventions, enabling stakeholders to better allocate resources, target underserved populations, and measure the impact of their efforts. The use of AI can also contribute to increased transparency and accountability, especially in the deployment of development aid and public funds. Lastly, by focusing on the African context, this study adds value to the global discourse on AI and sustainability. Africa's unique challenges and opportunities offer lessons that can inform international frameworks and encourage more contextualized AI innovation for the Global South.

2. Literature Review

2.1. Overview of SDG 7 Indicators and Data Requirements

Sustainable Development Goal 7 (SDG 7) comprises five targets with corresponding indicators that are central to global energy transformation efforts. These indicators include [17]:

- Proportion of population with access to electricity.
- Proportion of population with primary reliance on clean cooking fuels and technology.
- Renewable energy share in the total final energy consumption.
- Energy intensity measured in terms of primary energy and GDP.
  - International financial flows to developing countries in support of clean energy research and infrastructure.
  - Installed renewable energy-generating capacity in developing countries.

Monitoring these indicators necessitates robust, high-frequency, and spatially disaggregated data. For example, measuring electrification (7.1.1) typically requires census data, utility records, geospatial analysis, and field surveys, while evaluating clean cooking adoption (7.1.2) demands household-level data on cooking habits, technology uptake, and emissions exposure. These challenges are compounded in Africa by limited statistical capacities, fragmented data governance, and inconsistent methodologies across countries. Existing data sources include the World Bank's Multi-Tier Framework for Energy Access (MTF), the International Renewable Energy Agency (IRENA), and national electrification programs. However, these sources often have limitations in terms of update frequency, local accuracy, and granularity. As a result, African countries face significant obstacles in maintaining up-to-date and verifiable information about energy access and renewable energy development which are obstacles that AI could potentially address [18].

2.2. AI Technologies Applicable to SDG 7 Monitoring

Artificial Intelligence encompasses a range of subfields and methods that can be harnessed to enhance SDG 7 monitoring. In the context of energy systems and sustainability, the most relevant AI techniques include: Machine Learning (ML) and Predictive Analytics [19] - Machine learning algorithms can identify patterns in large datasets, enabling predictive models for electricity consumption, renewable energy generation, and infrastructure development. ML has been applied to estimate energy demand in off-grid areas, detect usage anomalies in smart grids, and predict system failures. In sub-Saharan Africa, ML models trained on socioeconomic data and satellite imagery have been used to estimate electrification rates with high accuracy. [20] For example, (Stokes et al., 2019) employed night-time light data and ML to predict poverty and energy access in rural African communities. More recently, platforms like AtlasAI and Fraym have refined such models to generate high-resolution maps of energy access down to the village level. Deep Learning and Image Recognition [21] - Deep learning, a subset of ML based on artificial neural networks, is particularly useful in processing complex data types such as satellite imagery and sensor data. Deep learning models can detect solar panel installations, monitor changes in energy infrastructure, and assess environmental conditions affecting renewable energy deployment. Computer vision, a branch of AI involving image recognition has enabled the identification of mini-grids, diesel generators, and distributed solar systems from satellite images. These tools have been instrumental in tracking infrastructure growth and validating government electrification claims. Natural Language Processing (NLP) [19]- NLP enables machines to read, interpret, and extract insights from human language. This has practical applications in analyzing energy policy documents, budget statements, and investment flows. In the African context, NLP can be used to assess the alignment of national energy plans with SDG 7 targets, monitor government commitments, and detect discrepancies between stated goals and actual investments. For instance, the Energy Access Explorer (developed by the World Resources Institute) combines NLP and spatial analysis to extract relevant insights from planning documents across East Africa. AI and Remote Sensing Integration [22] - The integration of AI with remote sensing technologies (e.g., Landsat, Sentinel, MODIS satellites) allows for real-time tracking of energy infrastructure and environmental conditions. AI-driven remote sensing has enabled the creation of dynamic energy access maps and identification of off-grid solar systems. For example, researchers at Stanford University combined convolutional neural networks (CNNs) with satellite imagery to map electrification in rural Rwanda, showing how AI could provide low-cost, scalable monitoring of SDG 7 indicators [23].

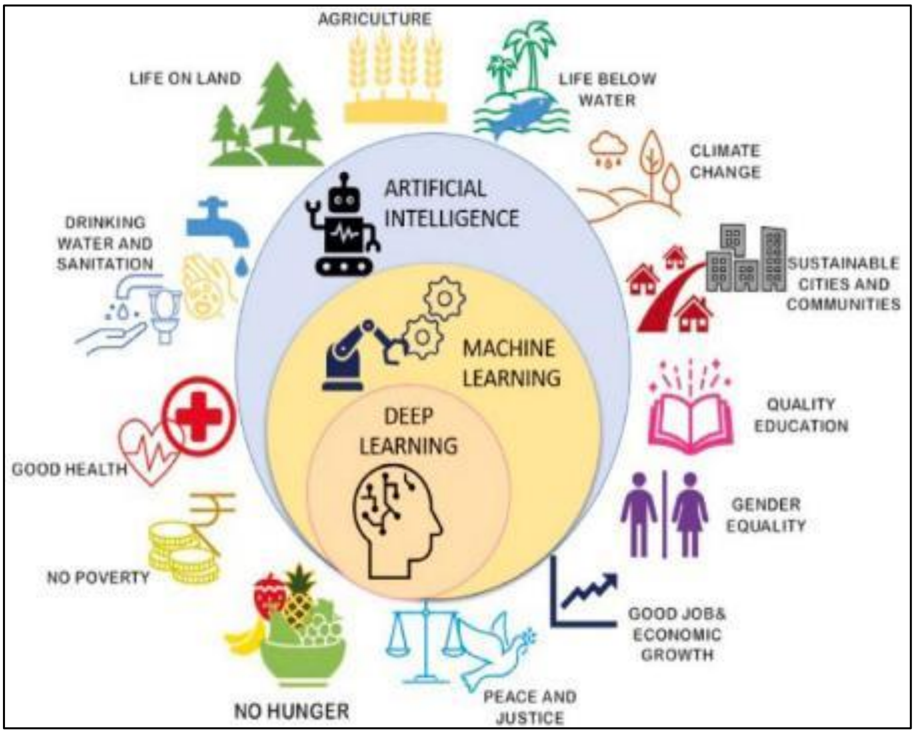

Figure 2 AI and Its subset driving SDG [24]

2.3. Existing AI Applications in Africa Related to Energy Monitoring

A number of pioneering AI-based tools and projects have emerged across the African continent, demonstrating the feasibility and potential of AI for energy monitoring: AtlasAI and Fraym [25] - AtlasAI uses AI and satellite data to create real-time development intelligence for Africa. Its platform combines socioeconomic data with deep learning to monitor infrastructure expansion, including energy access. Governments and development partners in countries like Nigeria and Kenya have used AtlasAI to identify under-electrified areas and optimize resource allocation. Fraym, another data intelligence firm, applies ML and geospatial analysis to create detailed population profiles. Its models can estimate energy access and cooking fuel usage, which are vital for tracking SDG 7 indicators. Google's Project Sunroof and AI for Earth [26] - While originally launched for the U.S., Project Sunroof and Microsoft's AI for Earth have inspired similar initiatives in African countries. These tools use AI to assess rooftop solar potential, which is critical for expanding renewable energy access in urban and peri-urban areas. Energy Access Explorer [27] - Developed by the World Resources Institute, this platform integrates AI, geospatial data, and machine learning to assist energy planners in identifying areas with the greatest energy access needs. In Uganda and Tanzania, the platform has been used to support renewable energy planning and investment prioritization. OpenStreetMap and AI [28] - Through tools like Mapillary and OpenStreetMap AI integrations, volunteers and machines collaborate to identify electricity infrastructure such as poles, lines, and transformers. These systems can be augmented with deep learning to automate infrastructure inventory mapping in rural Africa.

2.4. Limitations of Current Approaches and Gaps in Literature

Despite encouraging progress, several limitations persist in both academic and applied AI efforts for SDG 7 in Africa: Limited Ground-Truth Data [29] - Most AI models require large datasets for training and validation. However, many African countries lack reliable and disaggregated ground-truth data for energy access, making it difficult to build or validate robust models. For example, in the absence of up-to-date census or grid connection data, AI predictions can only be approximations. Underrepresentation of Clean Cooking [30] - While significant attention has been given to electrification monitoring, the AI-based tracking of clean cooking (Indicator 7.1.2) remains underexplored. Clean cooking solutions are diverse, ranging from LPG to biogas to improved biomass stoves, and data on adoption and sustained use are scarce. AI applications in this area are virtually non-existent in the literature. Geographical Bias [31] - Many existing AI studies have been concentrated in a few countries especially Kenya, Nigeria, Rwanda, and Ghana due to better data availability and donor interest. This creates geographical bias and limits the generalizability of insights to other regions such as Central or Sahelian Africa. Lack of Open-Access Platforms [32] - While several private sector and donor-funded tools use AI to track energy access, many of these platforms are proprietary or lack full transparency. This limits reproducibility, peer review, and national ownership of AI-based monitoring tools. Ethical and Governance

Challenges [33]- Few studies have explored the ethical implications of using AI in energy monitoring. Concerns around data privacy, surveillance, and algorithmic bias are especially relevant in low-governance settings. Moreover, national AI policies in Africa are still in their infancy, with only a handful of countries having adopted comprehensive strategies as of 2024.

2.5. Insights from Other Developing Regions

A growing body of literature from South Asia, Southeast Asia, and Latin America provides useful lessons for Africa. [34] In India, for instance, AI and IoT technologies have been used extensively in the Saubhagya scheme to monitor household electrification. [35] In Indonesia and Brazil, AI has supported renewable energy grid integration and energy efficiency monitoring. These cases reveal the importance of multi-stakeholder collaboration, government leadership, and open data standards in successfully deploying AI for energy development. Africa can adapt such models while tailoring them to local socio-political contexts and infrastructural realities. The review of existing studies reveals the following key insights: AI holds immense potential for enhancing the frequency, resolution, and reliability of SDG 7 monitoring data in Africa. Current applications focus predominantly on electrification, with limited attention to clean cooking and energy efficiency. Tools integrating AI and satellite imagery have demonstrated high accuracy in mapping energy infrastructure and access gaps. Despite progress, significant data, policy, and capacity gaps hinder the widespread application of AI in energy monitoring. There is a critical need for more inclusive, open, and ethical AI frameworks adapted to African energy realities.

Table 1 Comparative Analysis of Relevant Literatures.

Paper References	Objectives	Results	Findings	Practical Implications
[36]	Assess environmental sustainability performance in selected African countries. Utilize explainable machine learning for performance evaluation.	Cameroon's environmental sustainability performance is particularly poor. Eritrea shows better sustainability, not threatened by epidemics.	Cameroon's environmental sustainability performance is particularly poor. Eritrea shows better performance and is not epidemic-threatened.	Recommendations for policymakers to enhance SDG contributions. Insights for international investors on sustainable practices.
[37]	Identify bibliometric trends in AI for SDGs. Analyze concept-evolution trajectories in AI applications.	Incremental trend in AI publications for SDGs globally. Most AI applications found in SDGs 3 and 7.	Incremental trend in AI publications for SDGs observed globally. AI applied most in SDG 3 and SDG 7.	Identifies AI applications for achieving Sustainable Development Goals. Highlights trends in AI research for developmental challenges.
[19]	Examine big data and AI's role in advancing SDGs. Analyze literature on AI applications for healthcare, energy, and industry.	Identified key SDGs impacted by AI and big data. Highlighted ethical concerns like data privacy and algorithmic biases.	AI enhances healthcare, energy, and industry for SDGs. Ethical concerns include data privacy and algorithmic biases.	AI and big data can address global challenges sustainably. Ethical and regulatory dimensions require balanced attention.
[38]	Explore AI's role in renewable energy and sustainability. Identify major topics for enhancing energy	AI enhances renewable energy efficiency and forecasting. Collaboration accelerates sustainable energy	AI enhances renewable energy efficiency and forecasting. Collaboration accelerates sustainable energy	AI enhances renewable energy efficiency and forecasting. Collaboration accelerates sustainable energy transitions and innovation.

	efficiency and management.	transitions and innovation.	transitions and innovation.	
[39]	Explore AI's role in achieving Sustainable Development Goals. Analyze expert consensus on AI's impact on sustainability.	Experts view AI positively for advancing Sustainable Development Goals. Goals 6, 7, 8, 9, 11, 13, 14, and 15 show high positive impacts.	Experts view AI positively for advancing Sustainable Development Goals. Goals 6, 7, 8, 9, 11, 13, 14, and 15 show high positive impacts.	AI positively impacts various Sustainable Development Goals. Highlights need for nuanced discussions on specific goals.
[40]	Explore AI's role in promoting sustainable development Examine AI's impact on achieving UN SDGs	AI contributes to sustainability in organizational, technical, and processing aspects. Proposed model guides organizations in leveraging AI for sustainable development.	AI contributes to sustainability in organizational, technical, and processing aspects. Proposed model guides organizations in leveraging AI for sustainable development.	AI integration in organizations for sustainable development Essential elements for leveraging AI in achieving SDGs
[41]	Explore relation between Sustainable Development, Earth Observation, and Machine Learning. Understand EO and ML's role in achieving Sustainable Development Goals.	Earth Observation plays a key role in monitoring Sustainable Development Goals. Machine Learning is crucial for analyzing Earth Observation data.	Earth Observation aids in achieving Sustainable Development Goals effectively. Machine Learning enhances analysis of Earth Observation data significantly.	Earth Observation and Machine Learning can support the achievement of Sustainable Development Goals. New methods and techniques, including Machine Learning, are needed for monitoring sustainable development.
[42]	Analyze AI research addressing sustainable development goals (SDGs). Explore collaboration patterns between global regions in AI research.	A small share of AI papers explicitly focus on sustainable development. Emerging interests in SD found in specific AI subjects and areas.	Small share of papers focus on sustainable development goals. Emerging interest in sustainable development in specific AI subject areas.	The results can be used to improve the connection between technical knowledge, strategic planning, and sustainable development policies. The paper identifies emerging interests in sustainable development in specific areas of artificial intelligence research.
[43]	Investigate AI's influence on Sustainable Development Goals. Focus on poverty reduction and infrastructure development in	AI has a strong influence on the attainment of Sustainable Development Goals, particularly on poverty reduction and infrastructure development.	AI influences SDGs like poverty reduction, infrastructure development in emerging economies. AI improves data collection, education, finance sector for development goals.	AI can contribute to poverty reduction in emerging economies. Governments should invest in AI for SDG attainment.

	emerging economies.	AI improves data collection, revolutionizes agriculture education and finance sector.		
[44]	Explore AI and DL applications in sustainability sectors. Address challenges and future research directions for AI and DL.	AI and DL contribute to SDGs, renewable energy, and health. Challenges include explainability, scalability, ethics, and energy efficiency.	AI and DL contribute to SDGs, renewable energy, and health. Challenges include explainability, scalability, ethics, and energy efficiency.	AI and DL optimize renewable energy management and waste handling. Enhancing explainability and ethics in AI models is crucial.

3. Discussions

3.1. The Role of AI in Enhancing Monitoring of SDG 7

The monitoring of SDG 7 requires continuous, accurate, and localized data to assess progress toward universal access to affordable, reliable, and modern energy services. In Africa, where traditional data collection systems often suffer from logistical, financial, and infrastructural limitations, Artificial Intelligence (AI) emerges as a transformative tool capable of filling these gaps. AI enhances monitoring by automating the extraction, processing, and interpretation of large volumes of heterogeneous data. Machine learning and deep learning models can analyze satellite imagery to estimate electrification rates, identify renewable energy infrastructure, and detect changes over time. These models can also incorporate socioeconomic variables such as income, population density, and urbanization to create predictive maps of energy demand and access disparities. Importantly, AI contributes to real-time or near real-time monitoring, enabling policymakers to make timely decisions. This real-time insight is essential for identifying lagging areas, tracking renewable energy projects' progress, and targeting interventions in vulnerable communities. Moreover, AI can uncover hidden trends that conventional methods might overlook, such as seasonal energy usage patterns, grid reliability variations, or correlations between clean cooking adoption and cultural practices.

3.2. Opportunities for Integrating AI in Africa's Energy Ecosystem

Africa presents a unique opportunity for AI integration due to several concurrent trends:

Rapid Mobile and Internet Penetration: The expansion of mobile phone usage, digital financial services, and mobile internet access across Africa has created new data sources (e.g., mobile metadata, smart meter data, user-generated reports) that can be mined using AI to track energy consumption patterns and identify underserved regions. Expanding Renewable Energy Projects: The continent is witnessing a surge in solar mini-grids, solar home systems (SHS), and large-scale renewable installations. AI can optimize their deployment by analyzing terrain, solar irradiation, population distribution, and proximity to existing infrastructure. Emergence of EnergyTech Startups: Innovative African startups such as Nuru, Lumos, and Bboxx are deploying smart energy devices embedded with AI capabilities for energy demand forecasting, fault detection, and user behavior analysis. These technologies can feed back into national monitoring systems, enriching SDG 7 data with localized insights. Collaborative Data Initiatives: International platforms like the Global Electrification Platform (GEP), IRENA's Energy Transition database, and Google Earth Engine have made high-resolution data more accessible. These datasets can be harnessed by African institutions to build AI models that are locally relevant and globally consistent.

3.3. Challenges of AI Application in Monitoring SDG 7 in Africa

Despite the promise of AI, numerous challenges persist in its effective deployment across Africa for SDG 7 monitoring. These include: Data Scarcity and Quality - AI models require large, high-quality datasets for training and validation. Many African countries lack comprehensive and up-to-date energy access data, particularly in remote and conflict-prone regions. The absence of standardized data collection methodologies further complicates efforts to build transferable AI models across national borders. Additionally, clean cooking, a critical dimension of SDG 7 is underrepresented in available datasets. Data on fuel type, stove efficiency, and indoor air pollution are typically collected through sporadic household surveys, rendering AI-based monitoring ineffective in this domain without significant data improvement. Algorithmic Bias and Inaccuracy - AI systems are only as good as the data they are trained on. If training datasets are skewed toward urban areas or better-served populations, AI models may produce biased outputs that marginalize rural or impoverished communities. For instance, an AI model trained predominantly on data from Nigeria's urban centers may underperform in sparsely populated regions of Mali or Chad. Moreover, the use of proxy indicators such as night-time lights to infer electrification can misrepresent ground realities. A village may have night-time light emissions due to generators but still lack reliable and affordable energy access. AI must be used alongside ground-truthing and domain knowledge to avoid misleading conclusions. Lack of Institutional and Technical Capacity - Many African countries lack the skilled workforce and institutional frameworks necessary to develop, deploy, and govern AI tools. Government agencies often depend on external consultants or international organizations to implement AI-based monitoring systems, which limits national ownership and sustainability. In addition, weak data governance frameworks can result in fragmented data ecosystems, lack of interoperability, and limited trust in AI outputs. There is an urgent need to build national capabilities in data science, energy informatics, and AI ethics to ensure long-term success. Ethical and Privacy Concerns - AI tools that rely on mobile data, satellite imagery, or user tracking raise critical questions about privacy, data consent, and digital rights. In low-regulation environments, such concerns may be neglected, leading to potential misuse or exploitation of data. AI also raises equity concerns particularly if its deployment favors areas with better digital infrastructure while excluding the most vulnerable populations. Careful policy design is needed to ensure that AI promotes inclusion and justice in the energy transition.

3.4. Opportunities for AI in Renewable Energy Verification

AI also plays a key role in verifying Africa's renewable energy progress under SDG 7. Accurate measurement of the share of renewables in final energy consumption (7.2.1) and installed capacity (7.b.1) is vital for understanding the sustainability of national energy systems. AI can support: Infrastructure Mapping - Deep learning applied to satellite data can detect solar panels, wind turbines, and hydroelectric dams. Platforms like Microsoft's AI for Earth and Google's DeepMind have demonstrated the feasibility of using AI to detect renewable installations at scale. Energy Forecasting - AI models can predict solar and wind output based on weather data, improving integration of renewables into the grid. This helps grid operators plan for intermittency and balance energy loads more effectively. Policy Verification - Natural Language Processing (NLP) can analyze national energy policies and investment flows to determine alignment with renewable energy commitments. AI can be used to verify if claimed investments translate into actual project development. Carbon Accounting - AI-driven models can estimate the emissions savings of renewable projects, providing evidence for climate action reporting and green financing.

3.5. The Potential of AI in Clean Cooking Monitoring

As mentioned, clean cooking (Indicator 7.1.2) remains the most under-monitored component of SDG 7 in Africa. However, AI has untapped potential in these areas: Sensor Data Analysis - Smart stoves embedded with IoT sensors can track usage frequency, fuel type, and efficiency. AI can process this data to assess sustained adoption and performance of clean cooking technologies. Behavioral Analysis - AI can be used to analyze patterns in cooking practices through surveys, mobile apps, or NLP-based analysis of social media to design culturally appropriate interventions. Supply Chain Optimization - AI can help optimize distribution networks for clean cooking fuels (e.g., LPG, ethanol), improving affordability and accessibility. Currently, such AI-based innovations remain at a pilot stage. More research and investment are needed to scale their application across diverse African contexts.

3.6. Policy Implications and Strategic Recommendations

To fully harness AI for SDG 7 monitoring and verification in Africa, a number of policy and institutional actions are needed such as; Develop National AI Strategies for Energy - Governments should formulate AI strategies specifically tailored to the energy sector, focusing on data governance, capacity building, and infrastructure development. These strategies should also prioritize ethical considerations and inclusivity. Strengthen Open Data Ecosystems - Promoting open data standards and platforms will enhance AI innovation and collaboration. Governments, donors, and private firms must ensure that energy data is accessible, interoperable, and standardized. Build Local AI Capacity - Investments in training programs, research partnerships, and innovation hubs are critical to grow a local AI ecosystem. Collaboration with universities, technical institutes, and civil society organizations will help anchor AI in local knowledge systems. Embed AI in National Monitoring Systems - AI tools should be embedded within national statistical offices and energy planning agencies to improve official reporting and target setting. This integration must be accompanied by legal safeguards and transparency measures. Foster Multi-Stakeholder Collaboration - Effective AI deployment requires the involvement of government, academia, private sector, and civil society. Platforms for co-creation and knowledge sharing must be established at national and regional levels.

3.7. Toward an AI-Enabled Energy Justice in Africa

Ultimately, the promise of AI must be aligned with the broader goal of energy justice ensuring that all Africans have equitable access to clean, affordable, and sustainable energy. AI must be used not only to monitor progress but also to empower communities, reduce inequalities, and support climate resilience. For this to happen, AI deployment must be participatory, inclusive, and context-sensitive. It must reflect African priorities, values, and aspirations not merely replicate imported models. By combining AI innovation with indigenous knowledge, Africa can leapfrog traditional energy pathways and pioneer new models of digital and sustainable development.

4. Conclusion

The integration of Artificial Intelligence (AI) into the monitoring and verification of SDG 7 in Africa represents a pivotal opportunity to address long-standing challenges in the continent's energy sector. As the African region grapples with widespread energy poverty, uneven data availability, and infrastructure gaps, AI emerges not just as a digital solution but as a strategic enabler of sustainable development. Its capabilities in data processing, pattern recognition, predictive modeling, and decision support provide African governments, development partners, and private entities with novel tools to enhance transparency, efficiency, and accountability in tracking progress toward universal energy access. From the analyses presented in this review, it is clear that AI's role in SDG 7 is multifaceted. It is already reshaping how electrification data is gathered through satellite-based image processing, how clean cooking adoption is understood through smart sensors and behavioral analytics, and how renewable energy infrastructure is detected and verified at scale. These innovations are critically important in a region where traditional data collection mechanisms are often slow, costly, or inconsistent. AI bridges this gap by enabling near real-time monitoring and providing predictive insights that allow for proactive policy adjustments and targeted interventions. Moreover, the convergence of AI with other digital technologies such as the Internet of Things (IoT), remote sensing, and cloud computing, further strengthens its potential impact. For example, the deployment of AI-powered smart grids can facilitate demand forecasting and load balancing, which are crucial for integrating intermittent renewable energy sources. Similarly, AI-enabled platforms can match investment needs with renewable energy potential, accelerating the financing and deployment of clean energy projects across underserved regions. However, the discussions have also revealed considerable challenges. Africa's digital divide marked by limited access to high-quality data, insufficient computational infrastructure, and a scarcity of skilled AI professionals remains a significant barrier to fully leveraging these technologies. Additionally, algorithmic bias, data privacy concerns, and a lack of localized models threaten to undermine AI's equity and effectiveness in the region. Without careful attention to these risks, AI could inadvertently reinforce the very inequalities that SDG 7 seeks to overcome. Institutional readiness is another critical dimension. Many national statistical offices and energy ministries are yet to integrate AI into their core operations due to financial constraints, regulatory ambiguity, and limited interagency collaboration. To address this, governments need to invest in building AI literacy, develop robust data governance frameworks, and engage in partnerships with academia, startups, and international organizations. In terms of policy implications, African nations should take bold steps to design AI strategies that are tailored to the realities of the energy sector. These strategies should prioritize open data platforms, foster innovation ecosystems, and support the development of inclusive AI models that reflect local energy consumption patterns, cultural norms, and socio-economic conditions. Regulatory bodies must also be equipped to manage ethical concerns associated with AI, ensuring that data is collected and used responsibly, especially when derived from vulnerable or marginalized populations. It is equally vital to strengthen regional cooperation and knowledge-sharing platforms. Pan-African institutions such as the African Union, the African Development Bank, and regional economic communities (RECs) have a pivotal role to play in promoting harmonized AI frameworks, funding cross-border pilot projects, and facilitating south-south learning exchanges. Furthermore, AI should not be viewed merely as a monitoring instrument, but as a catalyst for energy justice. When deployed thoughtfully, AI can amplify the voices of underserved communities by ensuring their energy needs are reflected in national statistics and planning. It can also empower local innovators and entrepreneurs to co-create context-appropriate solutions that address the continent's diverse energy challenges. In closing, achieving SDG 7 in Africa is not only about electrification metrics or renewable energy percentages. It is about fostering inclusive, participatory, and transparent systems that guarantee clean and affordable energy for all. Artificial Intelligence, with its immense analytical and predictive capabilities, holds great promise in transforming this vision into reality. However, this promise will only be fulfilled if AI is guided by a strong ethical compass, rooted in local contexts, and deployed in service of people and planet. As we move into an increasingly digital energy era, Africa must seize this moment to shape AI not as a foreign technology, but as a locally adapted tool for sustainable development and resilience.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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