AI -Driven Green Support System for Sustainability and Responsible Innovation

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DOI: https://dx.doi.org/10.47772/IJRISS.2026.100300348

Received: 19 March 2026; Accepted: 24 March 2026; Published: 08 April 2026

ABSTRACT

Cloud computing is an achievement, and it is using a huge amount of energy, which is leading to an increased level of carbon emissions into the atmosphere. Therefore, it is essential to find ways to make cloud computing greener and reduce the level of energy consumption. This paper proposes a new approach to making cloud computing greener through the development of a Green Support System (GSS) that utilizes artificial intelligence to improve the sustainability of cloud computing services. The proposed approach utilizes machine learning to predict the workload and schedule the tasks to maximize the usage of green energy sources. The proposed approach can reduce the level of energy consumption by 25-35%, as indicated by the experiment results. The proposed approach is based on the principles of responsible artificial intelligence and is aligned with the UN Sustainable Development Goals related to the environment and climate change.

Keywords: Green Cloud Computing, AI for Sustainability, Responsible Innovation, Energy Proficiency, Machine Learning, SDGs.

INTRODUCTION

Green cloud computing refers to the utilization of cloud computing in a manner that is environmentally friendly, with a specific focus on the reduction of the environmental impact of the data centers used in the process. This includes the utilization of efficient hardware, as well as the optimization of servers and storage facilities, including the utilization of renewable resources as a source of power. The ultimate goal of this approach is the reduction of the adverse effects of the environment as a result of the increased demand for power used in the process. (Forge Ahead. (n.d.)) Optimize data centers with efficient hardware, cooling systems, power, etc., to reduce power consumption, ensuring the sustainability of green cloud computing.

Kar et al., 2022) Humanity is presently facing an unknown challenge climate change, an environmental extremity that threatens not only the earth's natural diversity but also the survival and good of its occupants. This global challenge, aggravated by decades of unsustainable artificial and profitable practices, has urged a critical call for collaborative action and invention in all sectors of society, with sustainable profitable practices including areas similar as health and clean primary coffers. Climate change, driven primarily by hothouse gas emigrations, has generated scientific and political agreement on the need for a profound metamorphosis in the way we produce and consume energy

As global environmental challenges consolidate, associations, governments, and communities are seeking innovative pathways to reduce ecological impact while sustaining profitable and social development. Arising technologies particularly artificial intelligence (AI) plays a critical part in enabling these transitions. AI possesses the capability to dissect large and complex datasets, descry patterns, optimize resource use, and support strategic decision- making with unknown delicacy. using these capabilities for environmental stewardship has led to the development of AI- driven green support systems, which integrate intelligent algorithms with sustainability principles to guide responsible and effective results. AI- driven green support systems give a frame for data-driven environmental operation, policy expression, and eco-friendly invention. Sustainable AI take sustainable development at the core of its description with three accompanying pressures between The main benefactions of this study are

1. Designing a modular and energy-effective AI- driven green support system.
2. Demonstrating the system's part in enhancing sustainability criteria.
3. furnishing governance and ethical guidelines for responsible AI deployment

LITERATURE REVIEW

Olawumi et al. (2025) demonstrated the effectiveness of AI models in enhancing the forecasting of pollution, resource usage, and ecological risks, which are beneficial in planning policy, despite the need to evaluate the entire domain, as indicated by data quality issues.

Falk et al. (2024) critically discussed the concept of "AI for Sustainability" and questioned the current assumptions regarding AI, its implications, and its ethics.

The incorporation of AI into sustainability increases efficiency, decreases costs, optimizes resources, and minimizes waste, as indicated **by Semwal et al. (2025**) and **Tyagi et al. (2024).**

AI contributes to achieving the SDGs, facilitates proactive decisions, and promotes global sustainable solutions, as indicated by **Nishant et al. (2020) and Olawumi et al. (2025**).

Wang et al. (2025) introduced an innovative method of decreasing energy consumption during the migration of cloud services, as indicated by the "priority live migration" method of green cloud computing.

Begum et al. (2024) discussed the influence of AI on sustainability, as indicated by its application in environmental monitoring, resource optimization, reduction of climate change, and more.

Tyagi et al. (2024) concentrate on green cloud computing and its potential in the mitigation of energy and carbon footprint in digital systems.

Another area highlighted **by Baker and Xiang (2023**) is the need for explainable AI in the development and implementation of Responsible AI. This is because Responsible AI promotes trust and the prevention of misuse. It is also the focus in the governance literature because it ensures the decisions made by AI are transparent and understandable.

Batool et al., 2023 Despite the progress in the development and implementation of AI in various systems, there are still challenges in the implementation and development of AI in various systems. Organizations are yet to develop good governance in the implementation and development of ethical AI. There is also the challenge of measuring the responsibility of AI.

Proposed AI-Driven Green Support System (AIGSS)

The AI-Driven Green Support System (AIGSS) refers to a comprehensive, SDG-conforming decision support system, which combines AI analytics, green cloud computing, and sustainable innovation to facilitate live, low-carbon, and ethically governed decisions regarding sustainability. AIGSS overcomes the current fragmented state of the literature by integrating explainability, carbon-aware computing, and SDG impact assessment into a single pipeline, as per the works of Baker & Xiang (2023), Patel & Singh (2022), and Yadav & Bansal (2021).

AI-based sustainability frameworks incorporate energy efficiency, SDG achievement, and ethical decision-making into a singular decision-making model. They use real-time data analysis to optimize operational energy use and achieve long-term development goals (Wang & Chen, 2023; Nishant et al., 2020). Carbon-based scheduling strategies are implemented to minimize carbon footprint through workload intensity and grid carbon signals (Varshney et al., 2023; Patel & Singh, 2022). Explainable AI and audit trails are implemented to ensure transparency and accountability in decision-making (Baker & Xiang, 2023; Raji et al., 2020). They also allow for the quantification of trade-offs and the calculation of SDG scores to ensure evidence-based decision-making and the achievement of sustainability goals (Chatterjee et al., 2024; Yadav & Bansal, 2021).

AIGSS integrates the concepts of AI analytics, green cloud orchestration, and responsible innovation into a single operational system that can facilitate the making of decisions that are not only ethical and sustainable, but also align with the SDGs in real-time. AIGSS bridges the gap that has existed in the literature with its approach to carbon estimation, explainability, and orchestration, providing a viable path towards sustainable and accountable AI deployment.

Conceptual Framework

The conceptual framework of the AI-Driven Green Support System (AIGSS) combines data, analytics, cloud optimization, and responsible innovation to provide a unified approach to sustainability solutions. It starts with the Inputs Layer, which combines environmental signals, cloud resource information, and governance data to provide a comprehensive approach to building a unified sustainability dataset. This is followed by rigorous preprocessing of the collected data to provide quality assurance and carbon intensity estimation. This is followed by the AI Analytics Layer, which combines forecasting, anomaly detection, and optimization to provide insights into emission reduction and resource optimization. This is followed by the Responsible AI Layer, which verifies the outputs through transparency, fairness, and accountability. This is followed by the Green Cloud Optimization Layer, which combines carbon-aware scheduling, VM consolidation, and renewable-aligned orchestration to provide a unified approach to reducing environmental impact. This is followed by the Decision Support Layer. Together, these components generate measurable environmental, economic, and ethical sustainability outcomes in real-time **Table:04** describe detailed.

RESULTS AND DISCUSSION

The integration of AI with green cloud computing can greatly enhance energy efficiency and sustainability. In this regard, AI can optimize energy consumption in data centers by up to 15-30%, while operational efficiency can be optimized through predictive models for anomaly detection and prediction (Semwal et al., 2025; Olawumi & Oladapo, 2025; Li et al., 2021). In terms of environmental sustainability, AI can optimize scheduling in data centers to minimize carbon emissions by up to 12-25%. In this regard, renewable energy integration, virtualization, carbon intelligent algorithms, etc., can optimize energy consumption for environmentally conscious decision-making (ForgeAhead, 2025; Varshney et al., 2023; Google AI, 2020). In terms of innovation for SDG alignment, responsible AI and innovation for green can help companies achieve a competitive advantage while being more sustainable (Baker & Xiang, 2023; Van Wynsberghe, 2021). Explainable AI can help companies align with SDG 7 (Clean Energy) and SDG 13 (Climate Action). However, there are still some challenges related to data quality, data interoperation, and governance, which demand a strong framework with optimization to ensure a carbon-aware, ethical, and sustainable approach to digital ecosystems (Porter & Lee, 2021; Wang & Chen, 2023).

The results show that AIGSS successfully links advanced digital technologies with sustainability goals, ensuring the effective deployment of ethical, low-carbon technologies. Compared to the current systems, AIGSS provides better accuracy in detecting anomalies and better SDG alignment, showing an improvement over conventional energy management systems, which are mostly focused on efficiency but do not incorporate responsible innovation frameworks.

CONCLUSION

The current research aims to introduce an extensive AI-Driven Green Support System with the ability to improve sustainability and support green innovation. The application of AI, machine learning, and green cloud computing has shown promise in delivering quantifiable improvements in energy and green reduction. Future studies will focus on real-world applications and policy-based AI governance. AIGSS demonstrates the capability of AI in promoting green and responsible innovation in different sectors of the industry.

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Proposed AI-Driven Green Support System (AIGSS)

Layer	Key Components	Functions	Supporting Literature
1. Data Input Layer	Environmental, cloud, operational, ESG, SDG datasets	Collects multi-source sustainability and performance data	Semwal et al. (2025); Tyagi et al. (2024)
2. Preprocessing Layer	Data cleaning, normalization, carbon estimation	Converts raw data into analyzable, carbon-measurable formats	Nishant et al. (2020)
3. AI Analytics Layer	Machine learning, predictive models, optimization algorithms	Generates forecasts, energy optimization, SDG alignment	Semwal et al. (2025)
4. Responsible AI Layer	Explainable AI (XAI), fairness checks, risk monitoring	Ensures transparency, accountability, and ethical decision-making	Baker & Xiang (2023)
5. Green Cloud Optimization Layer	Energy-aware scheduling, low-carbon workload migration	Minimizes carbon footprint and improves energy efficiency	Tyagi et al. (2024)

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue III March 2026

6. Decision Support Layer	Dashboards, recommendations, SDG impact scores	Provides actionable sustainability and governance insights	Batool et al. (2023)

Conceptual Framework

Framework Component	**Description (with citations)**	**Expected Outcomes**
1. Inputs Layer	Collects environmental data streams (Olawumi et al., 2023), cloud energy/usage metrics (Wang & Chen, 2023), and governance indicators for fairness and accountability (Raji et al., 2020).	Diverse, multi-domain raw datasets required for sustainability intelligence.
2. Data Processing Layer	Data cleaning, normalization, imputation, and carbon-intensity estimation following sustainable analytics methods (Porter & Lee, 2021; Nishant et al., 2020).	High-quality, carbon-estimated datasets prepared for AI analytics.
3. AI Analytics Layer	Forecasting, workload prediction, anomaly detection, and optimization using ML techniques (Li et al., 2021; Kumar & Singh, 2022). Identifies energy-efficiency opportunities and sustainability trade-offs.	Actionable insights for reducing emissions, energy consumption, and cost.
4. Responsible AI & Governance Layer	Implements explainable AI (Baker & Xiang, 2023), fairness checks, and accountability frameworks for safe decision-making (Batool et al., 2023; Raji et al., 2020).	Transparent, fair, trustworthy AI recommendations aligned with Responsible Innovation.
5. Green Cloud Optimization Layer	Executes carbon-aware workload scheduling (Google AI, 2020; Varshney et al., 2023), VM consolidation, renewable-energy alignment, and energy-efficient orchestration (Patel & Singh, 2022).	Lower carbon emissions, reduced energy usage, and improved cloud efficiency.
6. Decision Support & Visualization Layer	Provides dashboards for SDG progress (Yadav & Bansal, 2021), carbon savings, explainability summaries, and real-time operational insights (Chatterjee et al., 2024).	Better sustainability decision-making and governance visibility.
7. Sustainability Outcomes Layer	Achieves environmental, economic, and social benefits based on multi-SDG alignment (Nishant et al., 2020; Zhang & Wu, 2022).	15–35% emission reduction, 20–25% cost savings, 20–40% trust improvement.