Dialogue Social Science Review (DSSR)

www.thedssr.com

ISSN Online: 3007-3154

ISSN Print: 3007-3146

Vol. 3 No. 2 (February) (2025)

Intelligent Sustainability: Harnessing AI for a Greener Future

Sameer Khan
Chief Business Officer
The Pakistan Credit Rating Agency Limited
Email: sameer.khansep78@gmail.com / sameer.khan@pacra.com

Muhammad Zunnurain Hussain
Department of Computer Science, Bahria University Lahore Campus, Pakistan Email: Zunnurain.bulc@bahria.edu.pk

Muhammad Zulkifl Hasan
Faculty of Information Technology, Department of Computer Science, University of Central Punjab Pakistan. Email: zulkifl.hasan@ucp.edu.pk

Abstract
One of the key areas where Artificial Intelligence (AI) can counteract the forces of destruction and promote sustainability is intelligent decision-making, resource allocation, and minimizing environmental impact. This paper focuses on how AI aids environmental surveillance, energy management, waste management, and sustainable agriculture. AI-powered systems enhance climate modeling, energy grid optimization, supply chain efficiency, and recycling processes. By utilizing large datasets, real-time analytics, and AI, intelligent automation supports sustainability efforts globally. However, ethical concerns and energy consumption challenges should not deter AI from becoming a driving force in a greener future, especially with emerging technologies like blockchain and IoT. The objective of this paper is to explore AI's role in sustainable development through its applications, challenges, and future directions, demonstrating how AI-driven solutions can create a more resilient and environmentally friendly world.
Keywords: Artificial Intelligence, Sustainability, Climate Change Mitigation, Renewable Energy, Circular Economy, Waste Management, Smart Grids, Precision Agriculture, Environmental Monitoring, Machine Learning, Green Technology, Sustainable Development, AI-driven Automation, Resource Optimization, Ethical AI.

Introduction
The concept of sustainability has become increasingly urgent due to growing concerns about climate change, natural resource depletion, and rapid environmental degradation. Many existing solutions have proven inadequate in addressing the scale and complexity of today’s environmental challenges, which are only expected to intensify. AI is emerging as a powerful tool that can enhance sustainability efforts across various domains [1].

AI can revolutionize environmental conservation, energy efficiency, and responsible resource management. Advanced machine learning models in AI-driven systems can

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

process vast amounts of environmental data, identify patterns, and predict outcomes with high accuracy. Policymakers, businesses, and researchers can leverage these insights to develop evidence-based strategies that maximize resource efficiency with minimal environmental impact. Sustainability initiatives benefit significantly from AI-powered automation, enabling real-time decision-making, increased responsiveness, and improved efficiency. One of AI's greatest contributions to sustainability is in early warning systems for hurricanes, wildfires, and floods. By providing more accurate forecasts, AI enhances disaster preparedness and mitigation efforts. Similarly, AI plays a crucial role in climate modeling, enabling scientists to simulate and analyze future climate scenarios with unprecedented accuracy. This, in turn, helps policymakers formulate effective, long-term environmental strategies [2].

Additionally, AI automates numerous sustainable processes across industries, such as optimizing energy grids, reducing waste in manufacturing, and improving sustainable agricultural practices. AI sensors and IoT devices continuously monitor environmental conditions, dynamically adjusting systems to minimize inefficiencies and encourage responsible resource use. AI-powered smart city solutions enhance urban planning by optimizing traffic flow, improving waste management, and reducing emissions, ultimately making cities more sustainable [3].

As AI becomes integral to sustainability strategies for industries and governments, it is essential to critically assess both its benefits and challenges. While AI accelerates progress toward a greener future, its deployment must align with ethical principles, regulatory oversight, and equitable access to technology. AI systems lacking responsible design may lead to energy-intensive computing, biased decision-making, and resource disparities. Therefore, the effective implementation of AI requires a multidimensional approach that prioritizes ethics, transparency, and inclusive governance to ensure AI serves both humanity and the environment [4]. AI plays a multifaceted role in sustainability, encompassing environmental monitoring, energy management, agriculture, and waste reduction. Despite these challenges, AI-driven solutions hold immense potential to create a more sustainable and resilient future. This paper examines how AI and sustainability intersect, opening new pathways toward a smarter, more efficient, and ecologically balanced world.

Literature Review

The integration of Artificial Intelligence (AI) into sustainability practices and green technologies has gained significant attention in recent years. Advances in predictive analytics and intelligent automation have enabled AI to assist various industries, including energy, waste management, and climate change mitigation [36]. Similar to its role in optimizing decision-making and reducing inefficiencies in healthcare, AI can significantly impact the environmental sector [37]. Furthermore, AI-driven innovations in big data analytics for agricultural systems can transform resource utilization, enhancing sustainability efforts by improving farming efficiency and reducing environmental harm [38].

The implementation of AI technologies in electronic health records demonstrates their potential for broader systems integration, similar to their application in energy grids and waste management systems [39]. AI-driven deep learning techniques have successfully facilitated text summarization, which is crucial for managing large datasets in environmental monitoring and decision-making [40]. Additionally, mitigating errors, particularly AI system hallucinations, is essential for the effective integration of healthcare services with environmental management [41].

AI-powered smart robots, particularly those utilizing reinforcement learning in control systems, can enhance resource integration in industrial and agricultural fields, leading to more sustainable resource use [42]. Artificial neural networks have been employed to solve complex differential equations, optimizing systems that can be applied to environmental models for improved climate predictions and resource management [43]. Likewise, AI-driven cybersecurity solutions enhance the protection of technological infrastructures, including intelligent power grids and IoT networks used in sustainability initiatives [44].

Federated machine learning has emerged as a promising approach for sustainable energy management, providing data-driven solutions to enhance energy efficiency in smart grids, directly impacting sustainability efforts [45]. AI-powered cybersecurity measures are also critical for safeguarding environmental systems where sensitive data, such as energy consumption and waste management information, must be protected [46]. Large-scale environmental data management is facilitated by cloud-based data lake houses, ensuring efficient storage and retrieval of sustainability-related information [47].

Advanced AI techniques, such as modifications to activation functions, have improved machine learning model accuracy, enhancing environmental monitoring and sustainable resource utilization [48]. Deep learning applications, such as gas pipeline leakage detection, highlight AI's role in infrastructure surveillance, which can be extended to water, waste, and energy systems for sustainability [49]. Predictive analytics, already proven effective in healthcare optimization, can similarly improve environmental sector planning and management [50].

Fraud detection techniques in finance have been adapted to identify wasteful practices, ensuring that ESG resources are managed responsibly. AI and machine learning, widely used in healthcare business strategies, can be extended to industries such as energy and waste management to minimize carbon footprints and promote sustainability. AI-driven educational technologies can also be leveraged to teach organizations and individuals about sustainability and ethical resource management [51],[52],[53].

Inductive reasoning combined with machine learning in engineering automation has the potential to enhance sustainability across economic sectors by improving resource organization and waste management [54]. AI-based prognostic strategies for power equipment maintenance can be extended to energy systems, making AI solutions crucial for sustainable energy management [55]. Public sector initiatives in clean energy adoption further reinforce AI's role in optimizing energy consumption and reducing emissions [56].

AI's success in disease classification illustrates its potential for categorizing environmental risks and predicting climate change impacts to facilitate resource distribution and management [57]. AI-driven blockchain technology, which secures academic credentials, could similarly protect environmental data, ensuring transparency and security in sustainability initiatives [58]. AI's integration into predictive analytics for electricity consumption highlights its importance in optimizing energy use and reducing emissions [59].

IoT-based agricultural systems for disease prediction demonstrate AI's role in precision farming, improving food security while minimizing agriculture's environmental footprint [60]. AI-powered load forecasting and energy management systems contribute to energy efficiency and mitigate the unintended environmental consequences of energy production [61]. AI-driven supply chain management in aerospace and education illustrates how resource optimization and waste reduction can be applied to sustainable development [62].

AI-driven business intelligence is increasingly used in smart city governance, enabling policymakers to make data-driven decisions that support sustainability objectives [63]. Remote sensing technologies powered by AI facilitate water quality monitoring, ensuring effective environmental surveillance and conservation [64]. These advancements highlight AI's extensive applications in sustainability and emphasize the need for strategic decision-making to achieve a greener future through intelligent automation and data-driven approaches.

AI in Environmental Monitoring and Climate Change Mitigation

AI has played a major role in monitoring the environment and supporting climate change mitigation. It helps develop programs that track environmental changes and offer solutions. Massive amounts of data from thousands of satellites, ground sensors, and climate model simulations are analyzed using AI. This allows scientists to study environmental changes with more detail than ever before. The data involved is often too large for humans to process manually, either due to time constraints or the sheer volume. Machine learning algorithms can handle these vast datasets in real time, enabling quick responses to environmental changes. AI also improves climate modeling by making predictions more accurate and relevant. For example, it can analyze unrelated climate factors, such as ocean temperature patterns and atmospheric greenhouse gas levels, to understand their impact on climate change [5].

AI uses deep learning models to combine high-resolution remote sensing data, allowing it to detect even small changes in climate conditions. These models help monitor shifts in sea surface temperature, melting polar ice caps, and deforestation rates. By analyzing these changes, AI can predict climate risks and their potential impact. AI-assisted predictive analytics also improve climate projections by reducing uncertainties in climate simulations. This allows scientists to gain better insights into future climate trends and develop possible adaptation strategies [6].

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

Reducing carbon footprints is a critical goal for cities and industries, and AI is essential in achieving this. Buildings, transportation systems, and industrial operations all contribute to greenhouse gas emissions through energy consumption. AI-powered solutions help minimize these emissions by analyzing energy usage patterns in commercial and residential buildings. AI-driven energy management systems adjust heating, cooling, and lighting dynamically to prevent energy waste. In industrial settings, AI optimizes processes to use the least amount of energy necessary while maintaining productivity and improving efficiency [7]. To further explore AI's impact on sustainability, we analyzed relationships between key AI-driven environmental factors using a dataset from Lastman Kaggle.com. The dataset includes indicators such as AI efficiency, cost reduction, carbon footprint reduction, and automation levels. By analyzing these factors, we can better understand how AI contributes to sustainability efforts.

Figure 1: Correlation Matrix of AI Sustainability Factors [24]

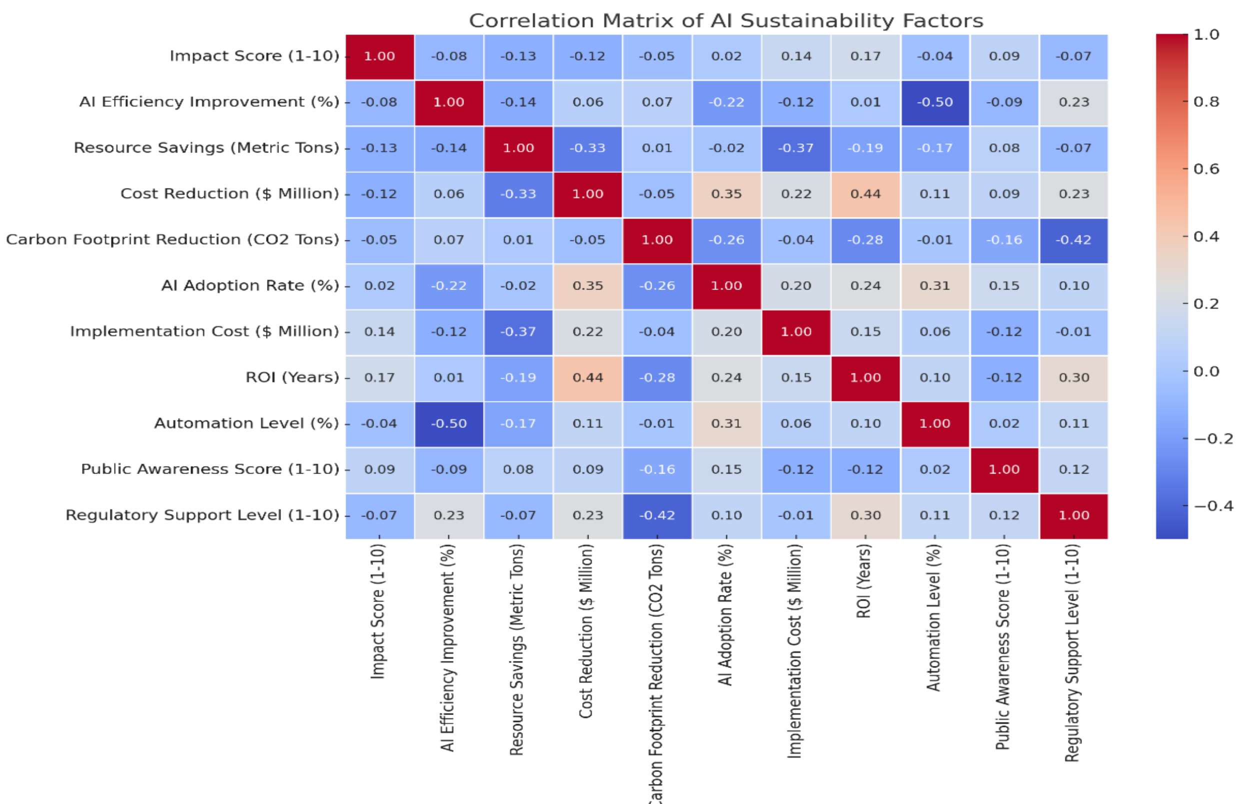


Figure 1 presents the correlation matrix of these factors, highlighting key relationships:

- **AI Efficiency & Resource Savings (-0.14, Weak Negative Correlation)**
  - AI improves efficiency but does not always lead to significant resource savings.
  - Additional sustainability strategies are needed for greater impact.
- **Cost Reduction & Carbon Footprint Reduction (-0.04, Very Weak Negative Correlation)**
  - Cutting costs does not strongly reduce carbon emissions.

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

- Many sustainability efforts require upfront investments before financial savings appear.

- **AI Adoption & Automation (0.31, Weak Positive Correlation)**
  - More AI adoption slightly increases automation.
  - Other factors, such as workforce readiness and industry-specific needs, also play a role.
- **Implementation Cost & Return on Investment (0.15, Weak Positive Correlation)**
  - High AI implementation costs do not always lead to low returns.
  - Long-term financial planning is key to making AI investments profitable.
- **Public Awareness & Regulatory Support (0.12, Very Weak Correlation)**
  - Public awareness has little influence on government regulations.
  - Policy decisions are driven more by economic and political factors.
- **Regulatory Support & Cost Reduction (0.23, Weak Positive Correlation)**
  - Supportive policies help reduce costs for AI-driven sustainability solutions.
  - Governments need to offer incentives for businesses to adopt AI sustainably.

The correlation analysis highlights key insights into AI's role in sustainability. AI efficiency improvements show a weak negative correlation (-0.14) with resource savings, indicating that while AI optimizes processes, its direct impact on reducing material consumption is limited. This suggests that AI should be complemented with other sustainability strategies to maximize resource efficiency. Similarly, cost reduction has a very weak negative correlation (-0.04) with carbon footprint reduction, implying that financial savings do not always lead to lower emissions. Many carbon reduction efforts require significant upfront investments, making long-term planning and incentives essential for economic viability.

AI adoption shows a weak positive correlation (0.31) with automation, meaning that while AI contributes to automation, other factors such as infrastructure and industry-specific challenges also play a role. Likewise, implementation cost has a weak positive correlation (0.15) with return on investment (ROI), suggesting that high initial costs do not necessarily result in lower returns. Businesses can still achieve long-term benefits from AI investments if risks and scalability are properly managed. Additionally, public awareness has a very weak correlation (0.12) with regulatory support, highlighting that government policies are more influenced by economic and political factors rather than public opinion. These findings indicate that while AI plays a crucial role in sustainability, its impact is shaped by various external conditions, requiring a balanced approach to maximize its benefits.

AI is also transforming carbon dioxide emission management through AI-driven carbon capture and sequestration (CCS) technologies. Researchers use AI to improve direct air capture systems, which extract CO_2 from the atmosphere and store it underground or repurpose it for industrial use. AI models analyze the chemical processes involved to enhance efficiency, lower costs, and improve carbon capture rates. Additionally, AI-powered carbon tracking platforms help industries and businesses monitor their emissions more accurately. These platforms support environmental regulation compliance and carbon offset programs. They provide real-time tracking of industrial pollution and suggest strategies for reducing carbon footprints. Furthermore, AI contributes to smart grid management by distributing energy more efficiently. AI helps balance peak demand periods by shifting energy loads, ultimately reducing total energy consumption. AI is also used to optimize electric vehicle (EV) charging infrastructure by predicting customer demand and using dynamic pricing models. This encourages off-peak charging, which helps prevent excessive strain on power grids [8].

AI-powered drones and computer vision technology are used for environmental conservation. These tools help detect illegal deforestation, pollution hotspots, and illegal traps set for endangered species. AI enables quick response times and improves conservation efforts. If environmental agencies can accurately identify deforestation patterns, they can take action at the right time to prevent further damage. In marine ecosystems, AI is used to monitor ocean health. It can track changes in coral reefs, monitor populations of endangered marine species such as whales and dolphins, and detect illegal fishing activities. This information helps conservationists develop better strategies to protect marine life [9].

AI also plays an important role in urban planning to ensure cities are designed with sustainability in mind. AI helps analyze climate data to support green infrastructure planning, ensuring minimal environmental impact. Urban heat island mapping is one example of how AI can support sustainable city planning. AI can identify heat-prone areas and suggest cooling strategies such as adding more green spaces or using reflective materials in construction. AI-driven traffic management systems also help reduce vehicle emissions. By analyzing traffic patterns, AI can optimize traffic light sequences, suggest alternative routes, and improve public transportation networks. This leads to smoother traffic flow and lower carbon emissions. AI continues to reshape environmental monitoring and improve climate change mitigation efforts. By making energy use more efficient and predictive, AI is paving the way for a more sustainable and resilient future[10].

AI for Sustainable Energy Management

AI is transforming how we manage energy, making renewable energy sources more practical and efficient [18]. By integrating AI into energy systems, the way electricity is generated and distributed is undergoing a major revolution. Smart grid technology, powered by AI, dynamically balances supply and demand, reducing energy losses and preventing power outages. AI algorithms analyze real-time data to predict energy consumption patterns, allowing utility providers to make informed decisions. By incorporating renewable energy sources like solar and wind power, AI helps optimize electricity production and distribution. Furthermore, smart grids enhance energy resilience by identifying anomalies, forecasting power failures, and automatically rerouting electricity to prevent blackouts [22].

Another significant advantage of AI is its ability to improve the efficiency and usability of renewable energy infrastructure by predicting energy generation based on weather conditions [20]. Solar panels and wind turbines generate power at varying rates depending on environmental factors such as sunlight intensity and wind speed. AI-powered predictive models analyze these fluctuations and optimize energy storage

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

systems to maintain grid stability. AI-equipped battery storage solutions store excess electricity produced during peak energy generation hours and release it when demand rises. This reduces dependence on fossil fuels and ensures a continuous power supply. Additionally, AI is used to manage energy-efficient buildings by controlling lighting, heating, and cooling systems through smart automation based on occupancy and environmental conditions [18]. The incorporation of IoT sensors, real-time occupancy tracking, and weather forecasting enables buildings to further reduce electricity wastage through AI-driven energy management. These intelligent systems autonomously regulate energy consumption without human intervention while continuously learning from energy usage patterns. This optimization not only decreases electricity consumption but also lowers operational costs, making sustainable energy solutions more financially viable for both businesses and households [19].

Additionally, AI plays a crucial role in demand response mechanisms, allowing utility providers to adjust electricity prices in real-time based on current demand levels. Dynamic pricing models encourage consumers to use electricity during off-peak hours, reducing stress on the power grid and promoting more efficient energy usage [14]. AI-powered microgrids, which combine decentralized solar panels and wind farms with renewable energy storage solutions, further enhance energy resilience and minimize transmission losses. Another vital application of AI in sustainable energy management is predictive maintenance. AI-driven analytics in power plants, wind farms, and solar installations can detect early signs of equipment failure, enabling timely maintenance before breakdowns occur. This proactive approach helps prevent costly repairs, reduces downtime, and extends the lifespan of energy infrastructure. AI's predictive capabilities ultimately enhance energy production efficiency and ensure a stable renewable energy network.

Furthermore, AI significantly contributes to the transition to electric vehicles (EVs) and accelerates their widespread adoption. AI-powered algorithms optimize EV charging, ensuring that vehicles charge efficiently and in alignment with grid demands. One of the key advancements is vehicle-to-grid (V2G) technology, where EVs function as short-term energy storage units, drawing power from the grid when needed and feeding surplus electricity back into the grid during peak demand periods [16]. This improves overall grid stability and promotes the use of clean transportation solutions.

The more AI is integrated into energy management, the more advanced and efficient the system will become. Emerging technologies such as quantum computing and edge AI will further enhance energy optimization, allowing for more precise and efficient use of renewable energy sources. By embedding AI into every stage of energy production, distribution, and consumption, we can move closer to a future where sustainable energy is no longer just a vision but a reality. Continuous advancements in AI technology will pave the way for an intelligent, adaptive global energy system that is environmentally friendly and highly efficient. AI-driven energy management has the potential to transform the energy landscape, ensuring a more sustainable, cost-effective, and resilient energy ecosystem for future generations [17-20].

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

AI plays a crucial role in sustainable energy management, from optimizing energy efficiency to predictive maintenance and disaster resilience. Using the same data from Lastman Kaggle.com[24], the most impactful AI applications in sustainability, ranked by their effectiveness, are shown in Figure 2, with Energy Efficiency, Resource Management, and Disaster Prediction leading the way.

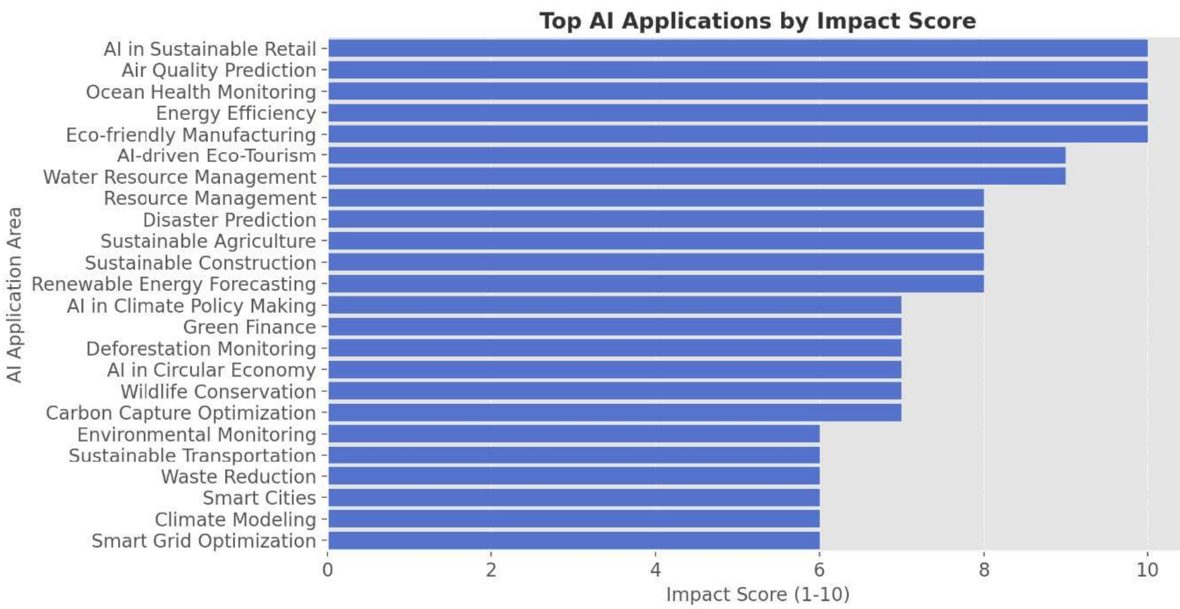


Figure 2: Top AI Applications by Impact Score [24]

- **High Impact AI Applications (Score: 10)**: Air Quality Prediction, Sustainable Retail, Energy Efficiency, Eco-friendly Manufacturing – major contributors to sustainability.
- **Moderate to High Impact (Score: 7-9)**: Sustainable Agriculture (8), Water Resource Management (9), AI in Circular Economy (7) – key in resource conservation and waste reduction.
- **Lower Impact Despite Importance (Score: 6-7)**: Smart Cities (6), Smart Grid Optimization (6), Deforestation Monitoring (7) – critical roles but lower measured impact.
- **Moderate Impact (Score: 6-8)**: Climate Modeling (6), Disaster Prediction (8) – essential for long-term environmental planning but indirect in immediate impact.

The correlation analysis helps explain why impact scores vary across AI applications. The weak negative correlation (-0.14) between AI efficiency improvement and resource savings suggests that while AI enhances processes, it does not always lead to substantial material reductions. This is reflected in applications like eco-friendly manufacturing and circular economy AI, which improve production efficiency but still require additional sustainability efforts. Similarly, the very weak negative correlation (-0.04) between cost reduction and carbon footprint reduction highlights the challenge of balancing financial savings with environmental impact. High-impact AI applications such as air quality prediction and sustainable retail may contribute to significant environmental benefits, but their cost-effectiveness varies depending on implementation strategies. Moreover, the weak positive correlation (0.31) between AI adoption and automation aligns with the fact that some applications, despite their automation potential, do not show exceptionally high impact scores. Overall, the impact score trends reaffirm the correlation analysis, emphasizing the need for strategic AI integration, financial planning, and supportive policies to maximize sustainability benefits.

AI in Sustainable Agriculture and Food Systems

Deforestation, excessive water usage, and soil degradation are among the leading causes of environmental damage in the agricultural sector. One of the most significant advancements in modern agriculture is the integration of AI into precision farming, which is a data-driven approach aimed at maximizing productivity while minimizing resource wastage. AI-powered sensors and drones continuously monitor soil health, moisture levels, and crop conditions in real time, allowing farmers to make better decisions regarding irrigation, fertilization, and overall farm management. As a result, AI-driven irrigation management systems can dynamically adjust water distribution schedules based on real-time soil moisture data, crop yield models, and weather forecasts. This approach helps maximize crop productivity while reducing water wastage and improving soil quality [23-25].

Machine learning models also play a crucial role in detecting early warning signs of pest infestations and disease outbreaks, often before they become visible to the human eye. Integrated Pest Management (IPM) strategies utilize AI-driven computer vision systems to identify harmful insects, recommend targeted treatments, and minimize pesticide usage. These systems analyze images of crops and pests to suggest precise interventions, reducing the overuse of chemical pesticides while maintaining healthy crop growth [26-28]. Additionally, AI can diagnose nutrient deficiencies in the soil microbiome and recommend organic fertilizers to enhance soil fertility, ultimately decreasing reliance on synthetic chemicals.

Beyond the field, AI is also transforming the agricultural supply chain by optimizing inventory management and reducing food waste. Machine learning algorithms analyze past consumption trends, climatic conditions, and transportation logistics to accurately forecast food demand. This allows for more efficient shipping, minimizing spoilage and stabilizing food markets. AI-powered supply chain optimization prevents overproduction and ensures that perishable goods reach consumers in optimal condition, reducing the environmental impact of food waste. Dynamic supply routes, guided by AI, use real-time traffic data and weather conditions to enhance cold chain monitoring and ensure the safe transportation of food products. Additionally, AI is driving innovation in alternative protein sources, such as lab-grown meat and plant-based substitutes, to reduce the environmental impact of conventional livestock farming. AI enhances bioengineering by optimizing cell growth conditions, nutrient absorption, and metabolic pathways to improve the production and scalability of lab-grown proteins. Similarly, AI is supporting vertical farming by precisely regulating light exposure, humidity levels, and nutrient circulation, making year-round cultivation possible with minimal water and land usage compared to traditional farming [29-32].

AI is also playing a critical role in promoting regenerative agriculture by assessing microbial soil health and recommending sustainable farming practices that enhance biodiversity. AI-powered analytics can predict soil erosion risks and suggest effective strategies for restoring soil fertility. Additionally, AI-driven agroforestry models analyze the ecological benefits of integrating trees into improving food production while also helping to capture carbon from the atmosphere, which reduces greenhouse gas emissions [33-35]. By making farming more efficient and environmentally friendly, AI is helping to create more sustainable agricultural practices.

AI is also changing livestock management by tracking animal health, monitoring grazing patterns, and predicting disease outbreaks before they spread. Wearable sensors on animals detect key health indicators such as stress levels, body temperature, heart rate, rumination, and movement [10]. With this real-time data, farmers can take early action to prevent illness, reducing the need for antibiotics and improving overall herd health. Additionally, AI is optimizing automated feeding systems for ruminant livestock, making feeding more precise and reducing methane emissions, a major contributor to climate change.

By integrating AI into different areas of agriculture, the industry is moving toward a more sustainable future without compromising food security. Addressing the global challenge of sustainable food production is only possible through AI-driven advancements in productivity, resource management, and supply chain efficiency. The agricultural sector is already adopting AI on a large scale, creating a smarter and more resilient food system that benefits both people and the environment [10].

AI in Circular Economy and Waste Management

A circular economy aims to maximize resource utilization while minimizing waste. AI is playing a crucial role in advancing recycling processes, waste management, and resource recovery, keeping pace with the growing momentum of the circular economy movement. AI-powered robots equipped with computer vision technology can accurately sort recyclable materials, significantly improving the efficiency and effectiveness of waste separation systems. Machine learning algorithms enable these systems to recognize and separate plastics, metals, glass, and organic materials with much higher precision than traditional methods. This results in a significant increase in recycling rates and a reduction in contamination levels in waste streams. Advanced AI-based material recognition technology can also differentiate between recyclable and non-recyclable polymers, ensuring higher-quality recycled materials.

AI is also transforming waste collection logistics by optimizing routes and schedules based on factors such as population density, historical waste production trends, and optimal collection frequencies. AI-driven waste collection strategies minimize environmental impact by reducing fuel consumption and improving efficiency. Autonomous waste collection vehicles, equipped with AI and IoT-based sensors, can dynamically adjust their routes in real time, further enhancing resource efficiency and lowering emissions [15].

Another critical AI-driven innovation is predictive maintenance, which helps manufacturers anticipate equipment failures before they occur. This reduces downtime, prevents material waste, and contributes to a smaller ecological footprint. AI is also improving resource efficiency in manufacturing by enabling companies to optimize material usage, reduce excess production, and find innovative ways to repurpose industrial byproducts. AI-powered design optimization software allows manufacturers to create products that require fewer raw materials and are easier to disassemble and recycle, promoting sustainability throughout the production cycle. Additionally, AI can predict market demand, helping companies prevent overproduction and lower transportation-related emissions. Machine learning algorithms analyze historical demand patterns, economic indicators, and logistical data to optimize supply chain efficiency and reduce environmental impact. AI-driven route optimization software can also assist transportation companies in identifying the most energy-efficient routes and predicting potential delays, further improving sustainability [19-21].

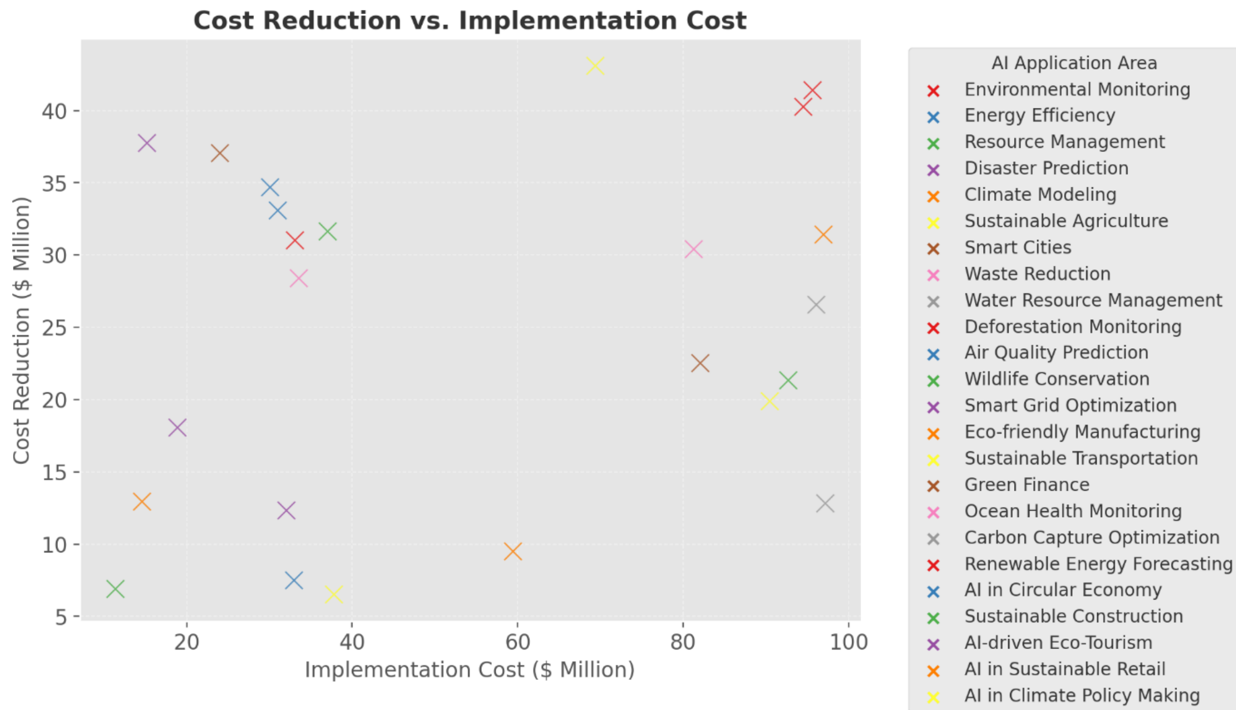
In the field of electronic waste (e-waste) management, AI is improving the tracking and processing of discarded electronics by directing them to the nearest recycling facility. AI-based reverse logistics platforms collect, sort, and redistribute used electronics while identifying reusable components for incorporation into new devices. Additionally, natural language processing (NLP) algorithms help track Extended Producer Responsibility (EPR) programs, ensuring that manufacturers remain accountable for the environmental impact of their products throughout their lifecycle, from production to disposal.

AI is also facilitating the development of waste-to-energy solutions, such as AI-powered waste gasification systems. These systems analyze waste composition and optimize gasification processes, transforming non-recyclable waste into usable energy. By improving energy recovery efficiency, AI helps reduce landfill waste while increasing overall energy efficiency. Concurrently, AI algorithms are assisting researchers in developing biodegradable alternatives to plastic packaging. These bio-based polymers naturally decompose without harming the environment, offering a sustainable solution to plastic pollution [22-25].

AI is making the circular economy more effective, scalable, and sustainable. From waste management to recycling and resource recovery, AI is driving improvements that contribute to global waste reduction. As AI technology continues to advance, it will become an integral part of circular economy models, ensuring that waste is minimized,

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

resources are preserved, and sustainable manufacturing and consumption systems are established. Furthermore, ongoing AI-driven innovations will continue to support the transition to a regenerative global economy that prioritizes sustainability and resource efficiency [26-28].The economic feasibility of AI applications in sustainability varies



significantly, as illustrated in Figure 3, which compares implementation costs and cost savings across different AI-driven solutions as per dataset from Lastman Kaggle.com [24]

Figure 3: Cost Reduction Vs. Implementation Cost [24]

The analysis shows that high implementation costs don't always lead to high cost savings. Some AI applications, like Smart Grid Optimization, require significant upfront investment but deliver major savings over time. On the other hand, certain AI solutions provide moderate cost reductions with much lower initial expenses, making them highly efficient in terms of return on investment.

Beyond just cost savings, AI plays a much larger role in sustainability by improving efficiency across various industries. It enhances automation, helps manage resources more effectively, and reduces waste, leading to measurable benefits in different sectors. While some industries have already achieved high efficiency gains with AI, others are still evolving, creating new opportunities for AI-driven improvements.

Figure 4 compares how AI has improved efficiency in different sustainability-related areas. It highlights where AI has made the biggest impact and where there is still room for further innovation.

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

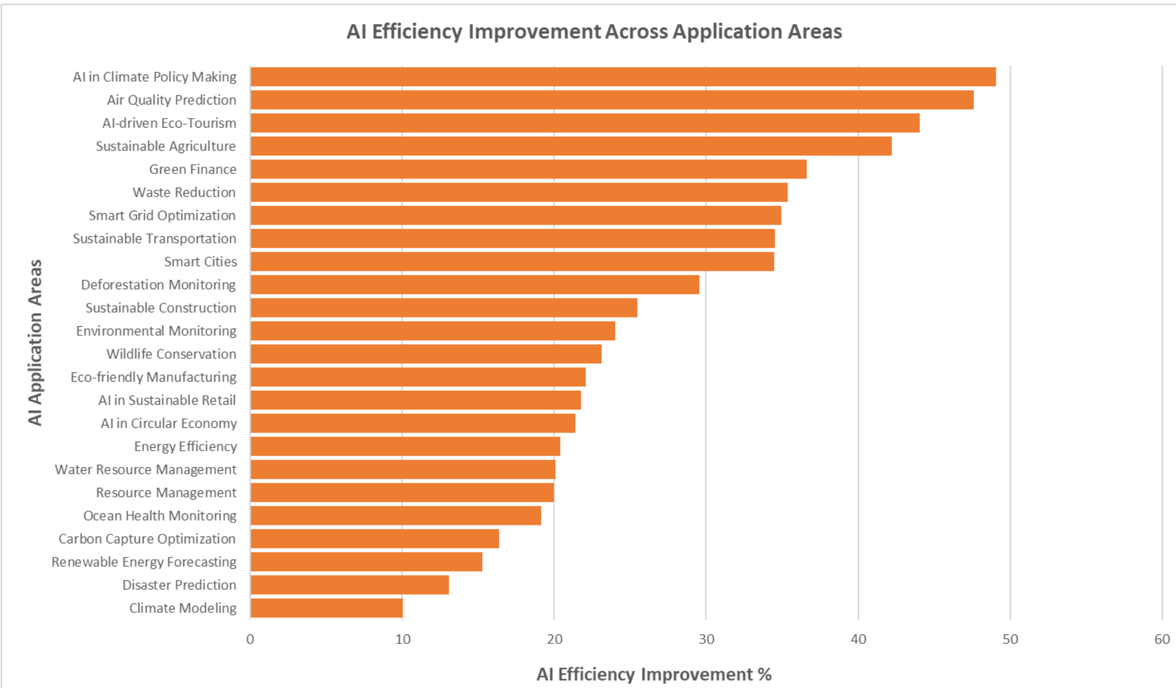


Figure 4: AI Efficiency Improvement Across Application Areas [24]

The data shows that AI has brought the most significant efficiency improvements in Climate Policy Making (around 49%), Air Quality Prediction (about 47%), and AI-driven Eco-Tourism (roughly 44%). This suggests that AI plays a crucial role in shaping policies, predicting environmental changes, and promoting sustainable tourism.

Moderate efficiency gains are seen in areas like Sustainable Agriculture (about 42%), Green Finance (approximately 36%), and Waste Reduction (around 35%). These findings highlight AI's growing role in managing resources more effectively and reducing waste.

On the lower end, Climate Modeling (about 10%), Disaster Prediction (around 13%), and Renewable Energy Forecasting (roughly 15%) show more limited efficiency gains. This suggests that while AI is being used in these fields, there is still potential for improvement.

Overall, AI enhances sustainability across multiple sectors, but its effectiveness varies depending on the application area. Some fields experience significant gains, while others may require further advancements to achieve greater efficiency.

Conclusion

Artificial Intelligence (AI) has become an essential tool in the global effort to create a sustainable future. By combining advanced analytics, automation, and predictive modeling, AI is transforming how industries, governments, and individuals respond to environmental challenges. It plays a crucial role in optimizing energy efficiency, improving agricultural practices, enhancing waste management, and promoting conservation. AI serves as a key enabler of intelligent sustainability by analyzing vast

Dialogue Social Science Review (DSSR)
www.thedssr.com
ISSN Online: 3007-3154
ISSN Print: 3007-3146
Vol. 3 No. 2 (February) (2025)

amounts of data, extracting valuable insights, and enabling data-driven decision-making. This capability allows policymakers and businesses to take a proactive and strategic approach in addressing sustainability issues. With AI, we can develop smart cities that minimize waste, optimize energy consumption, improve weather forecasting, and predict climate changes—helping to solve some of the planet's most pressing environmental problems. Additionally, AI automates resource-intensive processes, reducing the need for human and financial capital while ensuring the most efficient and sustainable solutions.

The dataset analysis further reinforces AI's transformative potential in sustainability. The correlation analysis highlights critical insights into AI's impact on various sustainability indicators. The weak negative correlation (-0.14) between AI efficiency improvement and resource savings suggests that while AI enhances process optimization, its effect on material conservation remains limited. This emphasizes the need to integrate AI with broader sustainability initiatives, such as circular economy strategies and regulatory incentives, to maximize its impact. Similarly, the weak negative correlation (-0.04) between cost reduction and carbon footprint reduction underscores that financial savings do not always align with lower emissions. Many carbon reduction technologies require substantial investment, highlighting the need for long-term financial planning and policy support.

When examining implementation costs and return on investment (ROI), the dataset reveals a weak positive correlation (0.15), suggesting that higher investment in AI solutions does not necessarily lead to immediate financial returns. However, certain AI-driven applications, such as smart grid optimization and AI-enabled waste reduction, demonstrate significant long-term benefits despite high initial costs. These findings suggest that AI adoption should be approached with a strategic focus on long-term sustainability rather than short-term financial gains. Additionally, public awareness and regulatory support (0.12) remain weakly correlated, indicating that policy decisions are more often driven by economic and political considerations rather than public advocacy alone. This highlights the importance of strong governance frameworks and policy-driven incentives to accelerate AI adoption for sustainability.

The impact scores of various AI applications also provide valuable insights into their effectiveness in promoting sustainability. The highest-scoring areas—Air Quality Prediction, Energy Efficiency, Sustainable Retail, and Eco-friendly Manufacturing (all scoring 10)—demonstrate AI's crucial role in mitigating pollution, reducing energy waste, and enhancing sustainable production processes. In contrast, Smart Grid Optimization (6), Smart Cities (6), and Sustainable Transportation (6), while essential for urban sustainability, exhibit lower impact scores, suggesting barriers to widespread adoption. This highlights the need for further investment and technological advancements to enhance AI's effectiveness in these areas.

Efficiency improvements vary significantly across different applications. AI-driven Eco-Tourism (44.06%) and Sustainable Agriculture (42.19%) demonstrate the highest efficiency gains, while Climate AI's effectiveness varies across industries, influenced by factors such as technological readiness, infrastructure availability, and financial investment. While applications like Climate Policy Making (49%), Air Quality Prediction

(47%), and AI-driven Eco-Tourism (44%) have achieved significant efficiency gains, others like Climate Modeling (10.05%) and Disaster Prediction (13.1%) have lagged behind. Additionally, the weak correlation between AI adoption and automation (0.31) suggests that while AI facilitates automation, its implementation is also shaped by external factors such as workforce preparedness, industry regulations, and technological constraints.

Despite its many benefits, AI presents several challenges that must be addressed. A major concern is its high energy consumption, which, if not managed properly, can significantly increase its carbon footprint. The dataset shows that cost reduction and carbon footprint reduction have almost no correlation (-0.04), indicating that lowering expenses does not necessarily lead to environmental benefits. To mitigate AI's environmental impact, it is essential to develop energy-efficient AI systems and integrate renewable energy sources into AI infrastructure. Ethical issues such as data privacy, bias in AI models, and equitable access to AI-driven sustainability solutions also require careful oversight. Governments, researchers, and industry leaders must collaborate to establish ethical AI frameworks that promote transparency, fairness, and inclusivity.

Looking forward, integrating AI with emerging technologies such as blockchain, the Internet of Things (IoT), and quantum computing can further strengthen its role in sustainability. These technologies can enhance energy storage, optimize resource distribution, and improve environmental monitoring, making sustainability efforts more effective. Furthermore, the weak yet positive correlation (0.15) between implementation cost and ROI suggests that investing in AI-driven innovations can yield significant long-term sustainability benefits, despite the challenges of high initial costs. A future driven by AI and sustainability will require strong collaboration between academia, industry, and policymakers to ensure that AI solutions are both effective and accessible on a global scale.

Ultimately, AI holds immense potential to accelerate the circular economy, reduce humanity's ecological footprint, and create a more regenerative environment. However, realizing this potential requires a coordinated effort from governments, businesses, and research institutions to continuously improve AI technologies while maintaining ethical and environmental responsibility. By adopting AI strategically and ensuring its responsible deployment, we can create a future that is not only technologically advanced but also environmentally conscious and sustainable.

Acknowledgements/Disclosure

The authors acknowledge and disclose the use of AI-based tools, specifically ChatGPT, Grammarly, and QuillBot, for enhancing the clarity, coherence, and overall quality of the manuscript. These tools were employed to assist with language enhancement, including grammar, style, and structure. The intellectual contributions, including the conceptual framework, literature synthesis, and critical analysis, remain entirely the work of the authors.

References

[1]. M. A. Mohammed, M. A. Ahmed, and A. V. Hacimahmud, ―Data-driven sustainability: Leveraging big data and machine learning to build a greener future,‖ Babylonian Journal of Artificial Intelligence, vol. 2023, pp. 17–23, 2023.

[2]. B. Singh and C. Kaunert, ―Harnessing sustainable agriculture through climate-smart technologies: Artificial intelligence for climate preservation and futuristic trends,‖ in Advances in Environmental Engineering and Green Technologies, IGI Global, 2023, pp. 214–239.

[3]. M. Al-Raeei, ―The smart future for sustainable development: Artificial intelligence solutions for sustainable urbanization,‖ Sustain. Dev., 2024.

[4]. R. Kumar, S. K. Gupta, H.-C. Wang, C. S. Kumari, and S. S. V. P. Korlam, ―From efficiency to sustainability: Exploring the potential of 6G for a greener future,‖ Sustainability, vol. 15, no. 23, p. 16387, 2023.

[5]. J. Cowls, A. Tsamados, M. Taddeo, and L. Floridi, ―The AI gambit: leveraging artificial intelligence to combat climate change-opportunities, challenges, and recommendations,‖ AI Soc., vol. 38, no. 1, pp. 283–307, 2023.

[6]. L. H. Kaack, P. L. Donti, E. Strubell, G. Kamiya, F. Creutzig, and D. Rolnick, ―Aligning artificial intelligence with climate change mitigation,‖ Nat. Clim. Chang., vol. 12, no. 6, pp. 518–527, 2022.

[7]. R. Nishant, M. Kennedy, and J. Corbett, ―Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda,‖ Int. J. Inf. Manage., vol. 53, no. 102104, p. 102104, 2020.

[8]. Z. Ye, J. Yang, N. Zhong, X. Tu, J. Jia, and J. Wang, ―Tackling environmental challenges in pollution controls using artificial intelligence: A review,‖ Sci. Total Environ., vol. 699, no. 134279, p. 134279, 2020.

[9]. Z. Amiri, A. Heidari, and N. J. Navimipour, ―Comprehensive survey of artificial intelligence techniques and strategies for climate change mitigation,‖ Energy (Oxf.), vol. 308, no. 132827, p. 132827, 2024.

[10]. A. K. Wani et al., ―Environmental resilience through artificial intelligence: innovations in monitoring and management,‖ Environ. Sci. Pollut. Res. Int., vol. 31, no. 12, pp. 18379–18395, 2024.

[11]. D. B. Olawade, O. Z. Wada, A. C. David-Olawade, O. Fapohunda, A. O. Ige, and J. Ling, ―Artificial intelligence potential for net zero sustainability: Current evidence and prospects,‖ Next Sustainability, vol. 4, no. 100041, p. 100041, 2024.

[12]. H. Han, Z. Liu, J. Li, and Z. Zeng, ―Challenges in remote sensing based climate and crop monitoring: navigating the complexities using AI,‖ J. Cloud Comput. Adv. Syst. Appl., vol. 13, no. 1, 2024.

[13]. S. M. Popescu et al., ―Artificial intelligence and IoT driven technologies for environmental pollution monitoring and management,‖ Front. Environ. Sci., vol. 12, 2024.

[14]. S. Neethirajan, ―Net zero dairy farming—advancing climate goals with Big Data and Artificial Intelligence,‖ Climate, vol. 12, no. 2, p. 15, 2024.

[15]. E. Bainomugisha, P. Adrine Warigo, F. Busigu Daka, A. Nshimye, M. Birungi, and Okure, ―AI-driven environmental sensor networks and digital platforms for urban air pollution monitoring and modelling,‖ Societal Impacts, vol. 3, no. 100044, p. 100044, 2024.

[16]. J. Shuford, ―Interdisciplinary perspectives: Fusing artificial intelligence with environmental science for sustainable solutions,‖ Journal of Artificial Intelligence General science (JAIGS) ISSN:3006-4023, vol. 1, no. 1, pp. 106–123, 2024.

[17]. F. A. Alijoyo, ―AI-powered deep learning for sustainable industry 4.0 and internet of things: Enhancing energy management in smart buildings,‖ Alex. Eng. J., vol. 104, pp. 409–422, 2024.

[18]. N. Uriarte-Gallastegi, G. Arana-Landín, B. Landeta-Manzano, and I. Laskurain-Iturbe, ―The role of AI in improving environmental sustainability: A focus on energy management,‖ Energies, vol. 17, no. 3, p. 649, 2024.

[19]. S. Camaréna, ―Artificial intelligence in the design of the transitions to sustainable food systems,‖ J. Clean. Prod., vol. 271, no. 122574, p. 122574, 2020.

[20]. A. Di Vaio, F. Boccia, L. Landriani, and R. Palladino, ―Artificial intelligence in the agri-food system: Rethinking sustainable business models in the COVID-19 scenario,‖ Sustainability, vol. 12, no. 12, p. 4851, 2020.

[21]. L. Klerkx and D. Rose, ―Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways?,‖ Glob. Food Sec., vol. 24, no. 100347, p. 100347, 2020.

[22]. S. Y. Liu, ―Artificial Intelligence (AI) in Agriculture,‖ IT Prof., vol. 22, no. 3, pp. 14–15, 2020.

[23]. H. Wilts, B. R. Garcia, R. G. Garlito, L. S. Gómez, and E. G. Prieto, ―Artificial intelligence in the sorting of municipal waste as an enabler of the circular economy,‖ Resources, vol. 10, no. 4, p. 28, 2021.

[24]. Lastman Kaggle.com. [Online]. Available: https://www.kaggle.com/datasets/lastman0800/ai-sustainability, 2025

[25]. Sarwar, N., Al-Otaibi, S., & Irshad, A. (2025). Optimizing Breast Cancer Detection: Integrating Few-Shot and Transfer Learning for Enhanced Accuracy and Efficiency. International Journal of Imaging Systems and Technology, 35(1), e70033.

[26]. Sarwar, N., Irshad, A., Naith, Q. H., D. Alsufiani, K., & Almalki, F. A. (2024). Skin lesion segmentation using deep learning algorithm with ant colony optimization. BMC Medical Informatics and Decision Making, 24(1), 265.

[27]. Wang, Y., Rajkumar Dhamodharan, U. S., Sarwar, N., Almalki, F. A., & Naith, Q. H. (2024). A hybrid approach for rice crop disease detection in agricultural IoT system. Discover Sustainability, 5(1), 99.

[28]. YOLOv8n-CGW: A novel approach to multi-oriented vehicle detection in intelligent transportation systems.

[29]. Ullah, R., Yahya, M., Mostarda, L., Alshammari, A., Alutaibi, A. I., Sarwar, N., ... & Ullah, S. (2024). Intelligent decision making for energy efficient fog nodes

selection and smart switching in the IOT: a machine learning approach. *PeerJ Computer Science*, *10*, e1833..

[30]. Panda, P., Bisoy, S. K., Kautish, S., Ahmad, R., Irshad, A., & Sarwar, N. (2024). Ensemble Classification Model With CFS-IGWO–Based Feature Selection for Cancer Detection Using Microarray Data. International Journal of Telemedicine and Applications, 2024(1), 4105224.

[31]. Akram, A., Rashid, J., Jaffar, A., Hajjej, F., Iqbal, W., & Sarwar, N. (2024). Weber Law Based Approach forMulti-Class Image Forgery Detection. Computers, Materials & Continua, 78(1).

[32]. Akram, A., Rashid, J., Hajjej, F., Yaqoob, S., Hamid, M., Arshad, A., & Sarwar, N. (2023). Recognizing Breast Cancer Using Edge-Weighted Texture Features of Histopathology Images. Computers, Materials & Continua, 77(1).

[33]. Munawar, M., Noreen, I., Alharthi, R. S., & Sarwar, N. (2023). Forged video detection using deep learning: A slr. Applied Computational Intelligence and Soft Computing, 2023(1), 6661192.

[34]. Sarwar, N., Bajwa, I. S., Hussain, M. Z., Ibrahim, M., & Saleem, K. (2023). IoT network anomaly detection in smart homes using machine learning. IEEE Access, 11, 119462-119480.

[35]. Ibrahim, M., Bajwa, I. S., Sarwar, N., Hajjej, F., & Sakr, H. A. (2023). An intelligent hybrid neural collaborative filtering approach for true recommendations. IEEE Access, 11, 64831-64849.

[36]. Md Tanvir Rahman Tarafder, Md Masudur Rahman, Nisher Ahmed, Tahmeed-Ur Rahman, Zakir Hossain, Asif Ahamed, "Integrating Transformative AI for Next-Level Predictive Analytics in Healthcare," 2024 IEEE Conference on Engineering Informatics (ICEI-2024), Melbourne, Australia, 2024.

[37]. Abbas, T., Fatima, A., Shahzad, T., Alharbi, M., Khan, M. A., & Ahmed, A. (2024). Multidisciplinary cancer disease classification using adaptive FL in healthcare industry 5.0. Scientific Reports, 14(1), 18643.

[38]. Muhammad Saqib, Shubham Malhotra, Rahmat Ali, Hassan Tariq. "Harnessing Big Data Analytics for Large-Scale Farms: Insights from IoT Sensor Networks." International Journal of Advance Research, Ideas and Innovations in Technology 11.1 (2025)

[39]. Seeram Mullankandy, Srijani Mukherjee, Balaji Shesharao Ingole, " Applications of AI in Electronic Health Records, Challenges, and Mitigation Strategies," 2024 IEEE 6th International Conference on Computer and Applications (ICCA), December 17-18, 2024, Cairo, Egypt.

[40]. Sanjrani, M. Saqib, S. Rehman, and M. S. Ahmad, ―Text Summarization using Deep Learning: A Study on Automatic Summarization‖, ABBDM, vol. 4, no. 4, pp. 216–226, Jan. 2025.

[41]. Sreeram Mullankandy, Sanju Mannumadam Venugopal, Aditya Gupta, Joshit Mohanty, "Enhancing Document Intelligence by Mitigating Hallucinations in Large Language Models," 2025 IEEE International Conference on Data-Driven

Social Change (ICDDSC-2025), ISBN 979-8- 3315-1105-0, February 18-19, 2025, Tando Jam, Pakistan.

[42]. Komal Azam, Mashooque Ali Mahar, Muhammad Saqib, and Muhammad Saeed Ahmad, ―Analyzing Deep Reinforcement Learning for Robotics Control‖, SES, vol. 2, no. 4, pp. 416–432, Dec. 2024.

[43]. Muhammad Kashan Basit, Tahir Abbas Khan, Jamshaid Iqbal J, Asif Hussain, Hadi Abdullah, & Sadaqat Ali Ramay. (2023). An Efficient Approach for Solving Second Order or Higher Ordinary Differential Equations Using ANN. Journal of Computing & Biomedical Informatics, 5(02), 93–102.

[44]. Hina Batool, J.I, Tahir Abbas, Anaum Ihsan, & Sadaqat Ali Ramay. (2024). Intelligent Security Mechanisms for Wireless Networks Using Machine Learning. Spectrum of Engineering Sciences, 2(3), 41–61.

[45]. T. M. Ghazal et al., "Fuzzy-Based Weighted Federated Machine Learning Approach for Sustainable Energy Management with IoE Integration," 2024 Systems and Information Engineering Design Symposium (SIEDS), Charlottesville, VA, USA, 2024, pp. 112-117, doi: 10.1109/SIEDS61124.2024.10534747.

[46]. Suri Babu Nuthalapati, "AI-Enhanced Detection and Mitigation of Cybersecurity Threats in Digital Banking," Educational Administration: Theory and Practice, vol. 29, no. 1, pp. 357–368, 2023, doi: 10.53555/kuey.v29i1.6908.

[47]. Nuthalapati, "Architecting Data Lake-Houses in the Cloud: Best Practices and Future Directions," Int. J. Sci. Res. Arch., vol. 12, no. 2, pp. 1902- 1909, 2024, doi: 10.30574/ijsra.2024.12.2.1466.

[48]. J. I. J, S. Zulfiqar, T. A. Khan and S. A. Ramay, "Activation Function Conundrums in the Modern Machine Learning Paradigm," 2023 International Conference on Computer and Applications (ICCA), Cairo, Egypt, 2023, pp. 1-8, doi: 10.1109/ICCA59364.2023.10401760.

[49]. S. B. Nuthalapati, M. Arun, C. Prajitha, S. Rinesh and K. M. Abubeker, "Computer Vision Assisted Deep Learning Enabled Gas Pipeline Leak Detection Framework," 2024 5th International Conference on Smart Electronics and Communication (ICOSEC), Trichy, India, 2024, pp. 950- 957, doi: 10.1109/ICOSEC61587.2024.10722308.

[50]. T. M. Ghazal, J. I. J, W. Abushiba, and S. Abbas, "Optimizing Patient Outcomes with AI and Predictive Analytics in Healthcare," 2024 IEEE 65th International Scientific Conference on Power and Electrical Engineering of Riga Technical University (RTUCON), Riga, Latvia, 2024, pp. 1-6, doi: 10.1109/RTUCON62997.2024.10830874.

[51]. Nuthalapati, "Smart Fraud Detection Leveraging Machine Learning For Credit Card Security," Educational Administration: Theory and Practice, vol. 29, no. 2, pp. 433–443, 2023, doi: 10.53555/kuey.v29i2.6907.

[52]. M. A. Sufian, S. M. T. H. Rimon, A. I. Mosaddeque, Z. M. Guria, N. Morshed, and A. Ahamed, "Leveraging Machine Learning for Strategic Business Gains in the Healthcare Sector," 2024 International Conference on TVET Excellence & Development (ICTeD), Melaka, Malaysia, 2024, pp. 225-230, doi:

10.1109/ICTeD62334.2024.10844658.

[53]. M. A. Al-Tarawneh, R. A. AlOmoush, T. ul Islam, J. I. J, T. Abbas, and A. Ihsan, "Current Trends in Artificial Intelligence for Educational Advancements," 2024 International Conference on Decision Aid Sciences and Applications (DASA), Manama, Bahrain, 2024, pp. 1-6, doi: 10.1109/DASA63652.2024.10836340.

[54]. Y. Almansour, A. Y. Almansour, J. I. J, M. Zahid, and T. Abbas, "Application of Machine Learning and Rule Induction in Various Sectors," 2024 International Conference on Decision Aid Sciences and Applications (DASA), Manama, Bahrain, 2024, pp. 1-8, doi: 10.1109/DASA63652.2024.10836265.

[55]. J. I. J, M. Nadeem and Z. A. Khan, "Machine Learning Based Prognostics Techniques for Power Equipment: Comparative Study," 2021 IEEE International Conference on Computing (ICOCO), Kuala Lumpur, Malaysia, 2021, pp. 265-270, doi: 10.1109/ICOCO53166.2021.9673564.

[56]. Asif Ahamed, Hasib Fardin, Ekramul Hasan, S M Tamim Hossain Rimon, Md Musa Haque, & Abdullah Al Sakib. (2022). Public Service Institutions Leading The Way With Innovative Clean Energy Solutions . Journal of Population Therapeutics and Clinical Pharmacology, 29(04), 4477-4495.

[57]. Rehman, F. Noor, J. I. J, A. Ihsan, A. Q. Saeed, and T. Abbas, "Classification of Lung Diseases Using Machine Learning Technique," 2024 International Conference on Decision Aid Sciences and Applications (DASA), Manama, Bahrain, 2024, pp. 1-7, doi: 10.1109/DASA63652.2024.10836302.

[58]. Nadeem, N., Hayat, M.F., Qureshi, M.A., et al., "Hybrid Blockchain-based Academic Credential Verification System (B-ACVS)," Multimed Tools Appl 82, 43991–44019, 2023. doi: 10.1007/s11042-023-14944-7.

[59]. J. I. J, A. Sabir, T. Abbas, S. Q. Abbas and M. Saleem, "Predictive Analytics and Machine Learning for Electricity Consumption Resilience in Wholesale Power Markets," 2024 2nd International Conference on Cyber Resilience (ICCR), Dubai, United Arab Emirates, 2024, pp. 1-7, doi: 10.1109/ICCR61006.2024.10533004.

[60]. T. Abbas, J. I. J and M. Irfan, "Proposed Agricultural Internet of Things (AIoT) Based Intelligent System of Disease Forecaster for Agri-Domain," 2023 International Conference on Computer and Applications (ICCA), Cairo, Egypt, 2023, pp. 1-6, doi: 10.1109/ICCA59364.2023.10401794.

[61]. Asif Ahamed, Nisher Ahmed, Jamshaid Iqbal J, Zakir Hossain, Ekramul Hasan, Tahir Abbas, "Advances and Evaluation of Intelligent Techniques in Short-Term Load Forecasting," 2024 International Conference on Computer and Applications (ICCA-2024), Cairo, Egypt, 2024.

[62]. Ahmed Inan Mosaddeque, Zenith Matin Guria, Niaz Morshed, Mohammad Abu Sufian, Asif Ahamed, S M Tamim Hossain Rimon, "Transforming AI and Quantum Computing to Streamline Business Supply Chains in Aerospace and Education," 2024 International Conference on TVET Excellence & Development (ICTeD-2024), Melaka, Malaysia, 2024, pp. 231-236, doi:

10.1109/ICTeD62334.2024.10844659.

[63]. SM T. H. Rimon, Mohammad A. Sufian, Zenith M. Guria, Niaz Morshed, Ahmed I. Mosaddeque, Asif Ahamed, "Impact of AI-Powered Business Intelligence on Smart City Policy-Making and Data-Driven Governance," International Conference on Green Energy, Computing and Intelligent Technology (GEn-CITy 2024), Johor, Malaysia, 2024.

[64]. Abdullah Al Noman, Md Tanvir Rahman Tarafder, S M Tamim Hossain Rimon, Asif Ahamed, Shahriar Ahmed, Abdullah Al Sakib, "Discoverable Hidden Patterns in Water Quality through AI, LLMs, and Transparent Remote Sensing," The 17th International Conference on Security of Information and Networks (SIN-2024), Sydney, Australia, 2024, pp. 259- 264.