International Journal of Technology, Management and Social Sciences (IJTMSS)
[ISSN: 2583-8482]
Volume 4_Issue 3 [July-Sept 2026]

AI for Sustainable & Smart Management: A Comprehensive Research Study: Opportunities, Challenges & Future Directions

Ashwiinii A. Paatil
PhD Research Scholar, Yashwantrao Mohite College of Arts Science and Commerce, Pune
Dr. Smita Vedpathak
PhD Research Guide and Librarian, Yashwantrao Mohite College of Arts Science and Commerce, Pune

Abstract:
Technology has revolutionized the workplaces, governance and societies to the great extent. This study provides a comprehensive analysis of Artificial Intelligence integration into sustainable management framework. Artificial Intelligence (AI) has emerged as a catalytic force in driving sustainable & smart management across industries. From optimizing energy systems to enabling data driven decision making in governess supply chains, healthcare & urban development. This study presents a comprehensive review dealing with the role of Artificial Intelligence (AI) in sustainable & smart management, examining opportunities challenges, real world applications & future research directions.
Keywords: *Artificial Intelligence, Smart Management, Corporate Governance, Sustainability, Technology*

Submitted: May 20, 2026 **Revised:** June 30, 2026 **Accepted:** July 10, 2026 **Published:** July 15, 2026

DOI: 10.5281/zenodo.21621790

1. Introduction
Traditional Management models are increasingly failing to handle the complexity of modern environmental & socio- economic pressures. Artificial Intelligence technologies such as Robotics & Intelligent automation enable systems capable of monitoring, forecasting & self-optimizing. This helps organizations in meeting environmental social and governance reducing waste, improving productivity. This research study explores how Artificial Intelligence contributes to smart management & sustainable development. The opportunities it creates the challenges that impede its adoption & the future directions that can inform policy & innovation.

2. Objectives of the Study
- To analyze challenges associated with AI adoption for sustainability
- To propose future research directions and an implementation roadmap for sustainable AI
- To examine the role of AI technologies in sustainable and smart management
- To identify emerging opportunities created by AI-driven systems
- To provide insights useful for conference discussions and policymaking

3. Research Methodology
This study is based on qualitative analysis of existing applications of AI in sustainability domains. Comparative assessment of challenges across sectors such as energy, agriculture, supply chain, and governance. Systematic review of scholarly articles (2018–2025), reports, and case studies. Framework development for future directions. No human subjects were involved, ensuring ethical compliance. To conduct this comprehensive review, a systematic approach was adopted to identify, select, and synthesize relevant literature following the principles of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework. The literature search was performed across major academic databases, including Scopus, Web of Science, and Google Scholar, using a combination of keywords such as “artificial intelligence”, “sustainability”, “sustainable development goals”, “AI and environment”, “Green AI”, “ethical AI”, and “smart cities”.
The selection process commenced with an initial identification of 3000 records. A rigorous set of inclusion and exclusion criteria was developed to ensure the relevance and quality of the analysis. Initially, 800 duplicate articles were removed. The remaining 2200 articles were assessed based on

their titles and abstracts, leading to the exclusion of 1800 due to a lack of direct relevance to the intersection of artificial intelligence and sustainability. The full texts of the remaining 400 articles were then evaluated in detail to verify their final eligibility. At this stage, only studies that explicitly demonstrated a direct link between the applications, challenges, or future directions of artificial intelligence and sustainability goals were included. Non-academic materials such as press articles and blog posts were also excluded. This process resulted in a final curated set of 138 relevant studies, which formed the basis of this analysis. The literature included both foundational works and recent advancements, with a strong focus on publications from 2018 onwards to reflect the latest developments. The literature search for this review was concluded on 12 August 2025. Additionally, a limited number of pre-prints were included to reflect the most recent and innovative research directions.
The risk analysis is qualitative and was based on a synthesis of key challenges identified in the literature, rather than a quantitative scoring methodology.

4. Applications of Artificial Intelligence in Sustainability

Artificial intelligence (AI) can be a powerful catalyst for sustainability, offering innovative solutions for resource optimization, emission reduction, and efficient ecosystem management. Its ability to analyze massive datasets, identify complex patterns, and automate processes makes it an indispensable tool in achieving the Sustainable Development Goals (SDGs) and carbon neutrality targets (Gaikwad, 2024). A critical perspective, however, reveals that the effectiveness of these solutions is often constrained by factors such as data quality, scalability, and implementation costs, which can create a technological divide. These limitations are addressed in detail in the following section.

4.1. AI for Efficient Resource Management and Decarbonization

One of AI's most significant areas of impact is the energy sector, which is crucial for global economic decarbonization and reducing greenhouse gas emissions. AI enables the dynamic management of modern electricity grids, using machine learning (ML) to balance energy demand and supply in real time and minimize energy losses by reducing the need to activate fossil fuel power plants. For instance, AI algorithms have been used to optimize the cooling systems of data centers, resulting in a significant reduction in total energy consumption. AI also facilitates the management of microgrids and distributed energy storage, enhancing the energy system's resilience. To address the inherent intermittency of renewable energy sources like wind and solar, AI models, fed with meteorological and historical data, can make more precise production forecasts, improving operational planning and the efficient integration of renewables. Furthermore, AI plays a transformative role in reducing energy consumption in buildings and industry, two areas with a significant energy footprint. AI systems can analyze energy consumption patterns through the continuous monitoring of sensors, dynamically adjusting the settings for heating, ventilation, and air conditioning (HVAC) systems and leading to substantial energy reductions. Similarly, in industry, AI optimizes machine and process operations, identifying inefficiencies and opportunities for saving energy and raw materials. This is also critical for energy storage management, where AI can optimize the charging and discharging strategies for batteries, maximizing the utilization of surplus clean energy.
AI also has the potential to revolutionize the agricultural sector by promoting efficiency and resilience in the face of climate change challenges. This directly contributes to achieving SDG 2 (Zero Hunger) and SDG 6 (Clean Water and Sanitation). AI-driven precision agriculture uses data from sensors and drones to determine the exact water and fertilizer requirements for each plant, reducing excessive use and minimizing pollution. Computer vision-based systems can identify weeds with remarkable accuracy, reducing chemical use by up to 90%, which has a direct impact on soil health. Deep learning algorithms can also detect early signs of diseases or pests in crops by analyzing aerial images, enabling timely interventions and reducing the reliance on widespread chemical treatments. AI models can also predict future crop yields and provide hyper-local weather forecasts, which helps with production planning and anticipating potential deficits. AI also optimizes irrigation by analyzing plant needs, and it contributes to monitoring soil erosion and waste reduction by optimizing supply chains.

4.2. AI for Environmental Resilience, Smart Cities, and the Circular Economy

AI has been proven to be a vital tool for understanding, monitoring, and protecting Earth's natural systems, contributing to SDGs such as SDG 13 (Climate Action) and SDG 15 (Life on Land). Machine learning and deep learning algorithms can process immense volumes of satellite data to track and analyze large-scale deforestation, the melting of polar ice caps, atmospheric pollution, and water quality. AI also offers powerful tools for protecting species and their habitats. Through computer vision and acoustic analysis, AI can identify animals from camera trap recordings and detect illegal activities like poaching. Algorithms can analyze disparate data sources to identify patterns and forecast high-risk areas for illegal wildlife trade, enabling preventative interventions. AI can also model how climate change will affect habitats and species distributions, informing conservation efforts. In the context of natural disaster prediction and management, AI can play a crucial role in mitigating the impact of extreme events, contributing to community resilience. AI models can integrate weather data, vegetation conditions, and topography to forecast wildfire risk and optimize intervention routes for firefighters. Similarly, AI can analyze hydrological data to forecast floods and monitor land stability to predict landslides.

AI plays an essential role in the transition to a circular economy, which aims to maximize the value and utility of products and materials, thereby eliminating waste and pollution. Robotic systems using computer vision and deep learning can quickly and accurately sort various types of waste, significantly increasing the recovery rate of recyclable materials. AI can also optimize industrial supply chains to identify inefficiencies and waste, and it can accelerate the discovery and design of new sustainable materials (Bhanot & Gaikwad, 2025). This directly contributes to the concept of "circular design". AI also underpins digital platforms that facilitate the sharing, reuse, and repair of products and, through Natural Language Processing (NLP), analyzes sustainability reports to support corporate transparency and accountability

The study selection process is detailed in the PRISMA flow diagram in Figure 1.

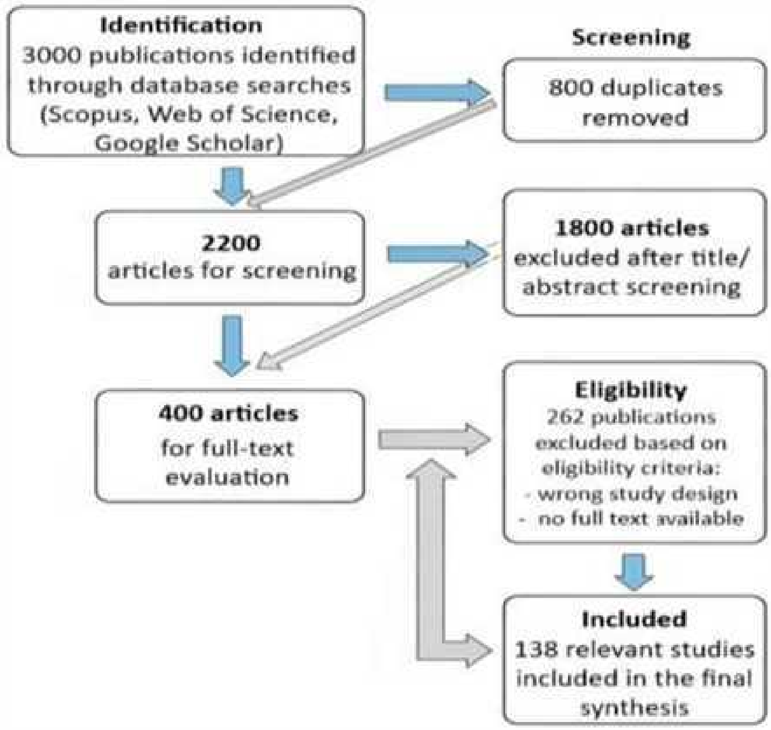

Figure 1. PRISMA flow diagram for study selection.

5. Theoretical Foundations and Key Concepts

To fully understand the intersection of artificial intelligence and sustainability, it is essential to define the fundamental concepts that underpin this complex relationship. This section will clarify the key terms and establish the necessary theoretical framework for the subsequent analysis of AI applications, challenges, and future directions in the global context of sustainable development.

5.1. Sustainability and the Sustainable Development Goals (SDGs)

Sustainability is a normative and multidimensional concept whose definition has evolved over time. The most widely accepted definition comes from the report of the World Commission on Environment and Development (known as the Brundtland Commission) titled *Our Common Future* (1987) which defines it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This definition underscores an essential intragenerational and intergenerational balance that transcends mere environmental conservation, integrating economic and social dimensions. The predominant model for analyzing sustainability is based on three interdependent pillars (Figure 2): environmental (ecological), social, and economic pillars. The environmental pillar refers to the integrity of ecosystems, the conservation of resources, the protection of biodiversity, and reducing pollution and greenhouse gas emissions. This involves the transition to a circular economy, responsible water and land management, and habitat protection. The social pillar aims for social justice, equity, inclusion, health, and education, ensuring equal access to resources and opportunities and strengthening community cohesion. Finally, the economic pillar involves creating and maintaining long-term economic prosperity that is inclusive, resilient, resource-efficient, and decoupled from environmental degradation. It is important to note that these pillars do not operate in isolation but are deeply interconnected; the most effective solutions are those that simultaneously address ecological, social, and economic aspects.

Figure 2. Three pillars of sustainability

To operationalize the concept of sustainability globally, the United Nations (UN) adopted the 2030 Agenda for Sustainable Development in September 2015, which includes 17 Sustainable Development Goals (SDGs), also known as Global Goals. These SDGs are universal, interconnected, and indivisible, representing a plan of action for peace and prosperity for people and the planet. Among the 17 SDGs, several are directly relevant to the discussion of AI's role in sustainability, particularly those related to Zero Hunger (SDG 2) Clean Water and Sanitation (SDG 6) Affordable and Clean Energy (SDG 7) Industry, Innovation, and Infrastructure (SDG 9) Sustainable Cities and Communities (SDG 11) Responsible Consumption and Production (SDG 12) Climate Action (SDG 13) Life Below Water (SDG 14) and Life on Land (SDG 15). AI, with its ability to optimize complex systems, positions itself as a vital tool in achieving these aspirations.

5.2. Carbon Neutrality (Net Zero)

Carbon Neutrality, often referred to as Net Zero, represents a crucial climate objective that refers to achieving a global balance between anthropogenic greenhouse gas (GHG) emissions released into and removed from the atmosphere. This target is not limited to carbon dioxide (CO2) and includes all greenhouse gases. The objective is fundamental for limiting global warming in accordance with the goals of the Paris Agreement (2015), which aims to keep the temperature increase below 2 °C, preferably 1.5 °C. Achieving Net Zero by mid-century requires a combination of two complementary strategies drastic emission reductions (decarbonization) and removal (offsetting) of residual emissions.

Decarbonization primarily involves a transition to renewable energy sources, increasing energy efficiency, and electrification, while the removal of emissions can be achieved through Nature-based Solutions (NbSs) like reforestation and Technological Carbon Dioxide Removal (CDR) solutions such as Carbon Capture and Storage (CCS). Carbon neutrality is not just a climate objective but a powerful engine for innovation, stimulating investment in clean technologies and fundamentally transforming industries towards a more resilient economic model.

6. Discussion:

A Critical Analysis of the Challenges and Future Directions of AI in Sustainability

The preceding sections have meticulously examined the growing role of artificial intelligence (AI) as a transformative force in the global effort to achieve sustainable development. The evidence presented from optimizing energy consumption to revolutionizing agriculture and enhancing environmental monitoring underscores AI's potential to help achieve a more efficient and resilient future. By providing unprecedented capabilities for analyzing vast and complex datasets and automating processes, AI can facilitate the transition from reactive to proactive strategies in managing our most critical resources This capacity makes AI not just a technological tool but a fundamental engine for realizing the Sustainable Development Goals (SDGs) and mitigating the challenges posed by climate change. A critical and pragmatic perspective is essential. The integration of AI to achieve sustainability is not without its limitations and risks. A central paradox emerges: on the one hand, AI promises solutions for the most pressing global problems, while on the other, its own technological lifecycle generates a significant ecological and socio-economic impact.

6.1. The "AI Green Paradox" and Key Challenges

One of the most stringent paradoxes of using AI in sustainability is the "AI green paradox," where its potential to facilitate ecological solutions is counterbalanced by its own ecological costs. The training of deep learning models, especially Large Language Models (LLMs), requires a massive amount of energy, generating a considerable carbon footprint. This paradox extends to the electronic waste (e-waste) generated by the rapid hardware replacement cycles and the water consumption of data centers for cooling, which can exacerbate local water shortages. Addressing this paradox necessitates a fundamental strategic direction: the development and adoption of the "Green AI" paradigm. In this context, it is crucial to define "digital pollution" as the cumulative ecological impact of digital infrastructure, including the massive energy consumption of data centers and the carbon emissions associated with the production and disposal of electronic waste (e-waste). Furthermore, "green debt" refers to the risk that the short-term benefits of AI for sustainability are outweighed by the long-term ecological and resource costs of its development and operation, creating a net ecological deficit. The effectiveness of any AI system also depends on the quality, quantity, and ethics of its training data. A critical problem is data bias, where historical datasets can perpetuate social inequalities or may be unrepresentative of certain regions or communities. Thus, AI solutions may fail to meet the needs of marginalized communities, creating a digital and social "AI divide." Moreover, many deep learning models function as "black boxes," making it difficult to explain how they arrive at certain conclusions. This lack of transparency undermines public trust, especially in critical applications, and makes it difficult to establish algorithmic accountability in the case of erroneous decisions. To manage these risks, the development of explainable AI (XAI) is imperative, as it makes models more transparent and interpretable, allowing for human intervention and auditing. Additionally, data governance frameworks are necessary to promote the collection of diverse and equitable data, reducing bias and ensuring data ethics.

Finally, the implementation of AI also raises socio-economic risks, such as high initial costs and technological dependence, which can be prohibitive for developing countries or for small- and medium-sized enterprises (SMEs). Consequently, there is a risk that the benefits of AI for sustainability will be concentrated in the hands of a few corporations and nations, deepening the existing inequalities. To address these challenges, clear strategic recommendations are necessary. These include, first and foremost, funding and incentive policies, which should allocate dedicated funds for "Green AI" innovation and provide fiscal incentives for sustainability solutions. Another essential component is international collaboration and public–private partnerships (PPPs). These would facilitate the exchange of expertise and technology, ensuring an equitable global distribution of AI benefits. It is also crucial to promote open-source platforms through the development of open algorithms and datasets that reduce barriers to technology access. Finally, education and capacity building play a fundamental role. Through training programs, a new generation of "Green AI engineers" can be created, and skills development can be supported in developing countries.

6.2. A Critical Risk Analysis

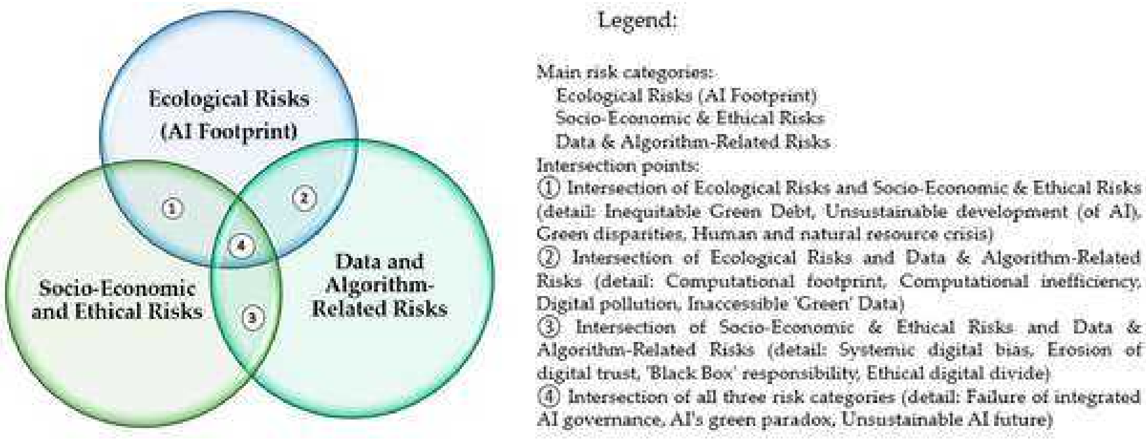

Figure 3. Intersection of artificial intelligence risk categories in the context of sustainability.

Although artificial intelligence (AI) holds transformative potential for achieving sustainability goals, its widespread implementation is not without inherent challenges and risks. A critical approach necessitates a rigorous analysis of these risks to ensure a responsible, ethical, and efficient integration of AI into global environmental and social strategies. Identifying, assessing, and prioritizing these risks are essential for developing appropriate mitigation strategies and for avoiding undesirable consequences. Risks can be classified into several main categories, as illustrated in Figure 3. The risk categories include the following: inherent ecological risks of AI data- and algorithm-related risks, and socio-economic and ethical risks The analysis of risks in the implementation of artificial intelligence for sustainability becomes particularly complex at the intersection of the main categories, revealing multifactorial challenges that require an integrated and nuanced approach. Ecological Risks and Socio-Economic and Ethical Risks: This intersection addresses the environmental impact of AI and its inherent social, economic, and ethical consequences. It gives rise to the concept of inequitable green debt, which highlights the central paradox of using AI for sustainability: while AI promises ecological solutions, its own ecological footprint (through energy consumption, e-waste, and water usage) creates a "green debt". If unaddressed or improperly managed, this debt could exacerbate social and economic inequalities, as its disproportionate impact on certain communities or unequal access to its benefits transforms it into an "inequitable" one. This dynamic also points to the risk of the unsustainable development (of AI), where the significant ecological footprint, if ignored, undermines the very idea of sustainable development. When the processes of creating and operating AI are not sustainable, they can perpetuate or aggravate existing social and ecological imbalances. Furthermore, this leads to green disparities, where the negative ecological impact is not uniformly distributed, and the most vulnerable communities may bear a disproportionate burden regarding pollution, resource depletion, or the management of electronic waste. Finally, the human and natural resource crisis perspective connects AI's dependence on intensive natural resources (rare minerals, energy, and water for data centers) with its impact on communities and the workforce, generating potential social conflicts, population displacement, or inequitable labour conditions.

Ecological and Data- and Algorithm-Related Risks: This intersection examines how the volume, quality, and management of data, along with the efficiency of algorithms, directly influence the ecological footprint of AI systems. This relationship manifests as a computational footprint, the direct ecological impact resulting from the immense computational resources needed for training and operating AI models. The massive energy and resource consumption of data centers, which is directly proportional to algorithm complexity and data volume, contributes significantly to carbon emissions and resource depletion. This issue is amplified by computational inefficiency, which arises when algorithms are sub-optimized or the data is managed poorly, leading to excessive energy and resource consumption. This inefficiency needlessly amplifies AI's ecological footprint. This effect is often referred to as digital pollution, a metaphorical expression for the negative ecological impact of the digital infrastructure whose operation depends on massive data volumes and algorithms, encompassing energy consumption, carbon emissions, and e-waste. Moreover, inaccessible "green" data poses a significant challenge; if the data required to develop effective "green" AI solutions is difficult to collect, store, or process due to technical or financial barriers, it impedes ecological progress and the adoption of sustainable AI.

Socio-Economic and Ethical Risks and Data- and Algorithm-Related Risks: This intersection is one of the most critical areas. It addresses how data and algorithm characteristics can generate inequalities, ethical problems, or threats to fundamental rights. It highlights the problem of systemic digital bias, where inherent bias in training data, once propagated and amplified by algorithms, becomes a systemic issue of social discrimination. This can lead to inequitable decisions in employment, lending, justice, or access to services, deepening the existing inequalities. The lack of algorithmic transparency (the "black box" problem), coupled with confidentiality issues, also leads to the erosion of digital trust. This erodes public confidence not only in AI systems but also in the institutions that use them, with profound social consequences. Furthermore, the "black box" responsibility expression refers to the fundamental difficulty of attributing responsibility for errors or damages generated by opaque AI systems, making it challenging to establish legal and ethical accountability. Finally, this intersection amplifies the notion of the ethical digital divide, suggesting that unequal access to advanced AI technologies and their benefits, combined with poor data governance, could deepen global socio-economic and ethical disparities.

The Complex Intersection of All Three Risk Categories: The most complex intersection is the one for all three risk categories (ecological, socio-economic/ethical, and data/algorithm-related), representing situations where all risks manifest simultaneously. This highlights the potential for the failure of integrated AI governance, where, if regulatory mechanisms fail to address these three dimensions simultaneously, the result can be a systemic failure of sustainability. Partial benefits could be offset by negative, multidimensional consequences. This leads to what can be called AI's green paradox, which reiterates the idea that AI, despite its potential to support sustainability, can pose a threefold negative impact through its resource consumption (ecological), perpetuating biases and generating inequalities (socio-ethical), and through its challenges related to data and algorithm opacity. This culminates in a powerful warning about an unsustainable AI future, serving as a label for a trajectory where, without a holistic and proactive management of these interconnected risks, the development of AI could lead to a future that is unsustainable from all perspectives, undermining global efforts to build an equitable society and a healthy environment.

7. Conclusion

This study analyzed the dynamic and complex role of artificial intelligence (AI) in promoting global sustainability. It has been demonstrated that AI is an indispensable tool, capable of processing massive volumes of data, identifying patterns, and optimizing complex systems in crucial sectors, from energy and agriculture to environmental monitoring and smart city development. These applications highlight AI's remarkable potential to support every pillar of sustainability: ecological, social, and economic.

However, the integration of AI is not without challenges. The analysis has brought to light the "AI green paradox", issues related to data bias and the lack of transparency in "black box" models, as well as the socio-economic risks, such as the high implementation costs and technological disparities. To maximize AI's benefits and mitigate its risks, it is essential to follow clear strategic directions. These include developing research in "Green AI," creating ethical and responsible governance frameworks, fostering international collaboration, and investing in education and training. AI represents a transformative technological force with immense potential to accelerate the transition towards a sustainable future. Nevertheless, recognizing and proactively managing its limitations is just as important as celebrating its successes. Only through a conscious, ethical, and collaborative approach can we ensure that AI truly becomes a real partner in building a healthier planet and a more equitable society for present and future generations.

References

- Bhanot, S. & Gaikwad, S.R. (2025). Bridging The Generational Divide: Exploring Communication Preferences, Workplace Behaviour, And Conflict Resolution Between Generation Z And Generation Alpha. Asian And Pacific Economic Review, 18(1). 1071-1082.
- Brundtland Commission. *Our Common Future: Report of the World Commission on Environment and Development*; Oxford University Press: Oxford, UK, 1987. [Google Scholar]
- Brynjolfsson, E.; McAfee, A. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*; W. W. Norton & Company: New York, NY, USA, 2014. [Google Scholar]
- Cenek, M.; Haro, R.; Sayers, B.; Peng, J. Climate Change and Power Security: Power Load Prediction for Rural Electrical Microgrids Using Long Short-Term Memory and Artificial Neural Networks. *Appl. Sci.* 2018, *8*, 749. [Google Scholar] [CrossRef]
- Gaikwad, S. R. (2024). Role of artificial intelligence in smart manufacturing of automobile industry in India. AIP Conference Proceedings, 3178(1), 070012.
- Goodfellow, I.; Bengio, Y.; Courville, A. *Deep Learning*; MIT Press: Cambridge, MA, USA, 2016. [Google Scholar]
- IEA (International Energy Agency). *Net Zero by 2050: A Roadmap for the Global Energy Sector*; IEA Publishing: Paris, France, 2021; Available online: https://www.iea.org/reports/net-zero-by-2050 (accessed on 14 September 2024).
- Intergovernmental Panel on Climate Change. *AR6 Synthesis Report: Climate Change 2023*; IPCC: Geneva, Switzerland, 2023. [Google Scholar]
- Kates, R.W.; Clark, W.C.; Corell, R.J.; Hall, M.; Jaeger, C.C.; Lowe, I.; McCarthy, J.J.; Schellnhuber, H.J.; Bolin, B.; Dickson, N.M.; et al. Sustainability science. *Science* 2001, *292*, 641–642.
- LeCun, Y.; Bengio, Y.; Hinton, G. Deep learning. *Nature* 2015, *521*, 436–444. [Google Scholar] [CrossRef]
- Meadows, D.H.; Meadows, D.L.; Randers, J.; Behrens, W.W., III. *The Limits to Growth*; Universe Books: Los Angeles, CA, USA, 1972. [Google Scholar]
- Rockström, J.; Steffen, W.; Noone, K.; Persson, Å.; Chapin, F.S., III; Lambin, E.F.; Lenton, T.M.; Scheffer, M.; Folke, C.; Schellnhuber, H.J.; et al. A safe operating space for humanity. *Nature* 2009, *461*, 472–475. [Google Scholar] [CrossRef] [PubMed]
- Russell, S.J.; Norvig, P. *Artificial Intelligence: A Modern Approach*, 4th ed.; Pearson: London, UK, 2021. [Google Scholar]
- Sachs, J.D. *The Age of Sustainable Development*; Columbia University Press: New York, NY, USA, 2015. [Google Scholar]
- UN (United Nations). *Transforming Our World: The 2030 Agenda for Sustainable Development*; UN Publishing: New York, NY, USA, 2015. [Google Scholar]
- Vinuesa, R.; Azizpour, H.; Leite, I.; Balaam, M.; Dignum, V.; Domisch, S.; Fennell, P.; Georgieff, R.; Jacobsson, A.; Jernberg, J.; et al. The role of artificial intelligence in achieving the Sustainable Development Goals. *Nat. Commun.* 2020, *11*, 233. [Google Scholar] [CrossRef]

