

Editorial

AI Meets Sustainability: A Special Issue on Real-World Applications

Dhiya Al-Jumeily OBE ¹, Jamila Mustafina ^{2,*}  and Manoj Jayabalan ³ 

¹ School of Computer Science and Mathematics, Liverpool John Moores University, Liverpool L3 5AH, UK; d.aljumeily@ljmu.ac.uk

² Naberezhnye Chelny Institute, Kazan Federal University, 420008 Kazan, Russia

³ Bath School of Design, Bath Spa University, Bath BA2 9BN, UK; m.jayabalan@bathspa.ac.uk

* Correspondence: dnmustafina@kpfu.ru

Dear colleagues, researchers, practitioners, professionals, students, and all those sincerely committed to exploring pathways toward a harmonious future, to all who observe with both enthusiasm and thoughtful reflection the ways in which artificial intelligence increasingly permeates the fabric of our daily lives and shapes the trajectory of societal development. We are pleased to present a Special Issue of *Sustainability* dedicated to a theme that only a few decades ago many regarded as belonging to the realm of science fiction: the integration of artificial intelligence into applied practices for advancing sustainable development. Today, we stand at the threshold of an era in which the analytical, predictive, and cognitive capacities of machine intelligence are no longer experimental tools confined to specialized laboratories, but rather a systemic factor influencing the economy, social sphere, environmental management, and culture. We live in a time when technologies are becoming an inseparable part of every aspect of life—from climate monitoring and the optimization of urban systems to the management of production and natural resources. At the same time, AI generates unprecedented challenges—ethical, legal, and humanitarian. This is why it is now essential to discuss not only what kinds of problems algorithms can solve, but also how they operate, whom they serve, and according to which principles they evolve.

The aim of this issue is to bring together cutting-edge scientific research devoted to the application of AI in addressing concrete, practical challenges within the context of sustainable development. Each contribution presented here not only demonstrates scholarly novelty but also illustrates how machine learning, big data, and contemporary computational approaches are helping to shape a future in which comfort, safety, environmental integrity, and social justice are prioritized. The articles assembled in this volume (see List of Contributions) showcase real-world applications of AI: in crop yield forecasting, ecological risk management, greenhouse gas emissions monitoring, and the assessment of the hydro-chemical state of water bodies. Although these topics differ in scale and domain, they are united by a common philosophy: artificial intelligence is becoming a key instrument in the realization of the global goals of sustainable development [1–3].

As editors, we recognize that artificial intelligence has the potential not only to resolve specific technical problems but also to serve as a global resource for enhancing quality of life, equity, and sustainability. For this reason, we believe it is crucial to frame any discussion of AI within the context of ethics, human rights, and the fundamental values of contemporary society. Our task as a scholarly community is to ensure that this integration proceeds not only effectively but also ethically, fairly, transparently, and with due respect for the rights of individuals and society at large [4–6].



Received: 7 October 2025

Accepted: 8 October 2025

Published: 15 October 2025

Citation: Al-Jumeily OBE, D.; Mustafina, J.; Jayabalan, M. AI Meets Sustainability: A Special Issue on Real-World Applications. *Sustainability* **2025**, *17*, 9148. <https://doi.org/10.3390/su17209148>

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

I would like to draw particular attention to the values that underpin any responsible work in the field of artificial intelligence. The ethics of algorithm design and deployment, transparency in decision-making, protection of personal and confidential data, and the accessibility of technologies across diverse social groups—these principles cannot be optional. They constitute the foundation of trust between science and society [7–10].

Sustainable development is impossible without the integration of advanced digital tools. Equally, it cannot be achieved without commitment to the values of Society 5.0—an envisioned society in which humans, technologies, and nature form a respectful, ethical, and safe unity. Society 5.0 affirms that technologies must not displace human beings but rather augment their capacities and create conditions for a dignified and meaningful life [11,12]. This principle is particularly relevant when it comes to artificial intelligence—systems capable of transforming the structure of entire industries and regions.

Artificial Intelligence as a Driver of Sustainable Development

Historically, the concept of sustainability has been linked primarily to natural resources, economic growth, and social stability. However, since the mid-2010s, international academic and policy discourse has increasingly emphasized that sustainable development is unattainable without digital transformation. The nature of contemporary challenges is complex, dynamic, and interconnected. Climate change, ecosystem degradation, soil depletion, freshwater scarcity, demographic transitions, and globalized markets do not merely coexist; they amplify one another. In such conditions, linear and routine approaches are insufficient for effective planning and adaptation [13–16].

Artificial intelligence demonstrates a unique capacity to process vast datasets, identify hidden correlations, forecast risks, and support decision-making under uncertainty. For this reason, AI is increasingly viewed as the core of the “Fourth Industrial Revolution”—a transformation that reshapes not only industry but also the models of human–nature interaction.

From agricultural monitoring to urban planning, AI helps render processes more environmentally responsible, manageable, and adaptive.

This issue brings together five articles that exemplify both the intellectual boldness and the social responsibility of their authors. Each contribution illustrates, in its own way, that AI is not only a powerful predictive tool but also a technology that can be made understandable, controllable, and safe.

- “Predicting Sustainable Crop Yields: Deep Learning and Explainable AI Tools” (Contribution 1) addresses the critical theme of food security—a cornerstone of sustainable development. Its significance lies in moving beyond abstract machine learning models toward practical scenarios where decision transparency is essential for effective policy and management.
- “Digital Visualization of Environmental Risk Indicators in the Territory of the Urban Industrial Zone” (Contribution 2) explores the challenges of assessing and communicating environmental risks in complex urbanized landscapes. The study demonstrates how AI systems can collect and analyze data on air, soil, and water pollution and represent these findings through digital maps and risk indices.
- “Statistics Using Neural Networks in the Context of Sustainable Development Goal 9.5” (Contribution 3) focuses on the application of neural networks to monitor and evaluate progress toward Sustainable Development Goal 9.5, which emphasizes strengthening scientific research, modernizing industrial technologies, and expanding access to innovation. This article illustrates how AI contributes to more precise and evidence-based decision-making in public and sectoral policy.
- “Assessment of Water Hydrochemical Parameters Using Machine Learning Tools” (Contribution 4) concentrates on water quality control—a cornerstone of ecological

sustainability. The study highlights how AI can be deployed to safeguard natural ecosystems. In the context of accelerating climate change and anthropogenic pressures, such monitoring systems are becoming indispensable elements of adaptive water resource management.

- “An Enhanced Particle Swarm Optimization Long Short-Term Memory Network Hybrid Model for Predicting Residential Daily CO₂ Emissions” (Contribution 5) presents an example of research into processes where AI can serve as the foundation of climate-responsible urban policy. The study demonstrates how the technological integration of advanced AI methods with practical applications can directly support the fulfillment of climate commitments.

Ethics and Responsibility in the Application of Artificial Intelligences

Across all the contributions in this issue, a central idea emerges clearly: artificial intelligence is not merely a collection of algorithms. It is a tool that directly affects human rights, safety, dignity, and the health of the environment. The ethics of AI design and application are not optional supplements but an integral component of sustainable development. This consideration is especially vital in the era of Society 5.0, where technologies are envisioned as extensions of human intelligence and as pillars of new forms of solidarity and responsibility. Society 5.0 asserts that AI must reinforce human rights, create conditions for safe and meaningful living, and promote equal access to opportunities. Values of justice, transparency, and inclusivity must be embedded into every line of code and every model architecture [4,10].

If AI is to become a genuine resource for sustainability, we must clearly articulate the guiding principles:

- **Transparency:** Algorithms must be accountable. People have the right to know how forecasts or managerial decisions are generated and on what grounds [8,14].
- **Explainability:** AI outcomes cannot remain a “black box,” especially when they pertain to human health, safety, or well-being [4].
- **Fairness:** Systems must not discriminate based on gender, age, ethnicity, or socioeconomic status.
- **Data protection and privacy:** Reliable safeguards must be in place when collecting and analyzing large datasets, including personal and biometric information [5].
- **Inclusivity:** Access to technologies and their benefits must be ensured for all stakeholders, regardless of income level or country of residence.

These ethical imperatives define the framework within which artificial intelligence can and must evolve as an instrument of genuine public good.

Society 5.0: A Humanistic Model of the Technological Future

An important theoretical and practical foundation for conceptualizing AI in the context of sustainable development is the model of Society 5.0—a vision first proposed in Japan and later adapted in several European and Asian countries.

Society 5.0 is not merely an information or industrial society, but a holistic paradigm in which technologies are not an end in themselves, but a means of realizing human potential. At its core lies the conviction that data and artificial intelligence should create the conditions for a comfortable, just, and ecologically sustainable life.

Within this model, AI is regarded as a decision-support system that helps humans better understand reality and manage complex processes, rather than replacing human will or responsibility [10,11].

The five fundamental values of Society 5.0, which we consider highly relevant for the development and deployment of AI algorithms, are:

- Human-centeredness: all digital solutions must be designed for the benefit of people.
- Ethics and trust: technologies should inspire confidence through transparency and predictability.
- Environmental balance: AI should contribute to reducing anthropogenic pressures on nature.
- Inclusivity: access to tools and knowledge must be available to all.
- Innovativeness: a readiness for continuous learning and the revision of solutions as new data emerge [10,11].

Artificial Intelligence for Real Life: Potential and Examples

What does the phrase “real-world application of AI” mean? It goes beyond laboratory research. It refers to practical scenarios where algorithms help address challenges that directly affect human health, nutrition, safety, and the future of entire regions.

One of the central themes of this issue is the shift of AI from being a field of purely academic experimentation to becoming a domain of concrete solutions. Crop yield forecasting, water quality management, CO₂ emissions assessment, and environmental risk monitoring are all tasks directly tied to people’s quality of life.

Modern deep learning systems, for example, make it possible to forecast crop yields with an accuracy unattainable for classical agronomic models. This reduces the risks of hunger and food-price inflation. Algorithms for analyzing hydrochemical data enable the rapid detection of water pollution. Predictive models for CO₂ emissions monitoring provide critical support for urban climate strategies.

Each of these cases illustrates that artificial intelligence need not remain an abstract technology, but can function as a tool that enhances human comfort and safety. The essential mission of science and engineering is to employ AI as a resource for strengthening comfort, safety, and sustainability. At the same time, it is vital to remember that trust in new technologies is impossible without ethical responsibility, accountability, and transparency.

This issue demonstrates that such approaches are not only possible but are already being realized in leading scientific projects today [3,9].

Challenges and Prospects

Despite impressive achievements, the integration of AI into real life faces a number of challenges, including:

- Limitations of data and risks of bias [4,13];
- Insufficient preparedness of specialists [3,10];
- The need to harmonize ethical standards and regulatory frameworks [4];
- Issues of long-term data storage and the energy efficiency of AI infrastructures [16].

These challenges, however, should not halt progress. Rather, they call upon us to act responsibly, to formulate principles and standards that unite diverse industries, states, and scientific communities.

Conclusions and Outlook

We stand at the threshold of a unique historical opportunity: to create systems in which machine intelligence operates in alliance with human wisdom and ethics. Artificial intelligence has the potential to become an instrument of profound transformation—not only in business or industry, but also in ecology, healthcare, and social justice.

For this transformation to be genuinely sustainable, we must cultivate trust, ensure transparency, and uphold the shared values of Society 5.0. AI for sustainability is a field that still has a long road ahead. From early experiments to mature solutions integrated

into governmental and sectoral strategies, numerous scientific and organizational tasks remain to be addressed. Yet it is already evident that the potential of these technologies is immense. We are witnessing the birth of a new era: one in which algorithms begin to shape models of resource management, threat forecasting, and urban development—where data becomes an instrument of transparency rather than merely a tool of control.

Looking ahead, it will be crucial not only to expand computational capacities and data volumes but also to safeguard the principles of openness, interdisciplinary collaboration, and equitable access to the benefits of AI. Only in this way can sustainable development become a truly global project—one in which technologies serve humanity and nature, rather than the reverse.

May this Special Issue serve as an example that technologies and values can advance hand in hand, helping us to build a more sustainable, just, and livable world.

Sincerely,
Editors of the Special Issue
Journal of Sustainability

Author Contributions: Conceptualization, D.A.-J.O. and J.M.; methodology, D.A.-J.O. and J.M.; formal analysis, M.J. and J.M.; investigation, M.J. and J.M.; writing—original draft preparation, J.M.; writing—review and editing, D.A.-J.O., J.M. and M.J.; supervision, D.A.-J.O. All authors have read and agreed to the published version of the manuscript.

Acknowledgments: We wish to extend our gratitude to all contributing authors for their high level of professionalism and their steadfast commitment to the principles of sustainable development. We also thank the reviewers, whose insightful comments have helped make the articles more precise and accessible.

Conflicts of Interest: The authors declare no conflicts of interest.

List of Contributions

1. Malashin, I.; Tynchenko, V.; Gantimurov, A.; Nelyub, V.; Borodulin, A.; Tynchenko, Y. Predicting Sustainable Crop Yields: Deep Learning and Explainable AI Tools. *Sustainability* **2024**, *16*, 9437. <https://doi.org/10.3390/su16219437>.
2. Safarov, R.; Shomanova, Z.; Nossenkov, Y.; Mussayev, Z.; Shomanova, A. Digital Visualization of Environmental Risk Indicators in the Territory of the Urban Industrial Zone. *Sustainability* **2024**, *16*, 5190. <https://doi.org/10.3390/su16125190>.
3. Okulich-Kazarin, V. Statistics Using Neural Networks in the Context of Sustainable Development Goal 9.5. *Sustainability* **2024**, *16*, 8395. <https://doi.org/10.3390/su16198395>.
4. Malashin, I.; Nelyub, V.; Borodulin, A.; Gantimurov, A.; Tynchenko, V. Assessment of Water Hydrochemical Parameters Using Machine Learning Tools. *Sustainability* **2025**, *17*, 497. <https://doi.org/10.3390/su17020497>.
5. Hu, Y.; Wang, B.; Yang, Y.; Yang, L. An Enhanced Particle Swarm Optimization Long Short-Term Memory Network Hybrid Model for Predicting Residential Daily CO₂ Emissions. *Sustainability* **2024**, *16*, 8790. <https://doi.org/10.3390/su16208790>.

References

1. Aslan, M.F.; Sabanci, K.; Aslan, B. Artificial intelligence techniques in crop yield estimation based on Sentinel-2 data: A comprehensive survey. *Sustainability* **2024**, *16*, 8277. [\[CrossRef\]](#)
2. Ashraf, H.; Akanbi, M.T. Sustainable agriculture in the digital age: Crop management and yield forecasting with IoT, cloud, and AI. *Tensorgate J. Sustain. Technol. Infrastruct. Dev. Ctries.* **2023**, *6*, 64–71.
3. Toderas, M. Artificial intelligence for sustainability: A systematic review and critical analysis of AI applications, challenges, and future directions. *Sustainability* **2025**, *17*, 8049. [\[CrossRef\]](#)
4. Rohde, F.; Wagner, J.; Meyer, A.; Reinhard, P.; Voss, M.; Petschow, U.; Mollen, A. Broadening the perspective for sustainable AI: Comprehensive sustainability criteria and indicators for AI systems. *arXiv* **2023**, arXiv:2306.13686. [\[CrossRef\]](#)

5. Wright, D.; Igel, C.; Samuel, G.; Selvan, R. Efficiency is not enough: A critical perspective of environmentally sustainable AI. *arXiv* **2023**, arXiv:2309.02065. [[CrossRef](#)]
6. Martin, K.D.; Zimmermann, J. Artificial intelligence and its implications for data privacy. *Curr. Opin. Psychol.* **2024**, *58*, 101829. [[CrossRef](#)] [[PubMed](#)]
7. Nguyen, T.; Sun, K.; Wang, S.; Guitton, F.; Guo, Y. Privacy preservation in federated learning: An insightful survey from the GDPR perspective. *arXiv* **2020**, arXiv:2011.05411. [[CrossRef](#)]
8. Doshi-Velez, F.; Kortz, M.; Budish, R.; Bavitz, C.; Gershman, S.; O'Brien, D.; Scott, K.; Schieber, S.; Waldo, J.; Weinberger, D.; et al. Accountability of AI under the law: The role of explanation. *arXiv* **2017**, arXiv:1711.01134. [[CrossRef](#)]
9. Hacker, P.; Cordes, J.; Rochon, J. Regulating gatekeeper AI and data: Transparency, access, and fairness under the DMA, the GDPR, and beyond. *arXiv* **2022**, arXiv:2212.04997. [[CrossRef](#)]
10. European Parliament. *The Impact of the General Data Protection Regulation (GDPR) on Artificial Intelligence*; Study STOA/EPRS; European Parliament: Brussels, Belgium, 2020. Available online: https://www.europarl.europa.eu/stoa/en/document/EPRS_STU%282020%29641530 (accessed on 2 October 2025).
11. Cao, J.; Meng, T. Ethics and governance of artificial intelligence in digital China: Evidence from online survey and social media data. *Chin. J. Sociol.* **2025**, *11*, 58–89. [[CrossRef](#)]
12. Paal, B. Artificial intelligence as a challenge for data protection law. In *The Cambridge Handbook of Responsible Artificial Intelligence*; Cambridge University Press: Cambridge, UK, 2022; pp. 178–192.
13. Meszaros, J.; Ho, C.-H. Artificial intelligence research & data protection: Can the same rules apply for commercial and academic research under the GDPR? *Comput. Law Secur. Rev.* **2021**, *41*, 105532. [[CrossRef](#)]
14. UNESCO. *The UNESCO Recommendation on the Ethics of Artificial Intelligence*; UNESCO: Paris, France, 2021. Available online: <https://www.soroptimistinternational.org/2024/07/18/the-unesco-recommendation-on-the-ethics-of-artificial-intelligence/#:~:text=The%20UNESCO%20Recommendation%20on%20the%20Ethics%20of%20AI%20adopted%20in,%E2%80%8Bsystem%20to%20ensure%20the> (accessed on 2 October 2025).
15. Jobin, A.; Ienca, M.; Vayena, E. Artificial intelligence: The global landscape of ethics guidelines. *Nat. Mach. Intell.* **2019**, *1*, 389–399. [[CrossRef](#)]
16. Kumar, A.N.P.; Bogner, J.; Funke, M.; Lago, P. Balancing progress and responsibility: A synthesis of sustainability trade-offs of AI-based systems. *arXiv* **2024**, arXiv:2404.03995. [[CrossRef](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.