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LIGHTS - Sustainability

The rise of AI in biopharmaceuticals: uncovering the environmental cost and the promise of sustainable AI

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Abstract

The biopharmaceutical industry is embracing artificial intelligence (AI) and generative AI (GenAI) to accelerate drug discovery, clinical trials, and personalized medicine. While this digital transformation offers promises of increased efficiency and innovation, it also raises urgent environmental concerns. From massive water and energy consumption to increased carbon emissions and mineral exploitation, the hidden ecological cost of AI adoption threatens the sector's sustainability goals. This Impact Paper explores how the widespread implementation of AI technologies in biopharma could exacerbate environmental challenges and potentially undermine firms' commitments to climate neutrality. Based on a comprehensive review and case studies, this contribution argues that "sustainable AI" must become a guiding principle for the sector. It highlights key risks and suggests actionable strategies such as AI-optimized green chemistry, eco-designed data centers, and regulatory alignment to ensure that biopharma's AI revolution becomes an ally, rather than an obstacle, to environmental responsibility.

Keywords: artificial intelligence, biopharma, sustainability, carbon emissions, green Tech

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Introduction: Biopharma's AI revolution meets sustainability

The integration of AI in the biopharmaceutical industry is reshaping the landscape of healthcare innovation. From expediting early-stage drug discovery to tailoring patient-specific therapies, AI enables pharmaceutical companies to shorten R&D cycles, reduce costs, and increase the success rate of clinical trials. For instance, collaborations such as Sanofi's with PathAI and Novartis's partnership with Microsoft highlight the drive to harness digital power for therapeutic breakthroughs.

This surge in AI adoption is motivated by clear business imperatives: cost savings, improved precision, and competitive advantage. Estimates suggest that digital technologies can reduce the cost of drug development by up to 70%, with GenAI helping to shorten development timelines by identifying viable molecular targets and simulating trial outcomes with remarkable accuracy.

However, this digital leap brings with it an environmental footprint. While companies publicly commit to achieving carbon neutrality, the growing energy and water demands of large AI models, data centers, and continuous computing challenge these commitments. As Microsoft's 30% increase in emissions due to AI illustrates, the pursuit of innovation without sustainability can be counterproductive. Thus, this paper aims to unpack the trade-offs and offer a path toward a more ecologically sound digital transition in biopharma.

AI and the environmental cost: a growing blind spot

Despite their intangible nature, AI systems rely on very physical infrastructures. Massive computational power is needed for both training large models and running real-time inference tasks. This requires robust data center operations, which consume electricity, water, and rare minerals. According to de Vries (2023), training a model like GPT-3 alone consumed 1,287 MWh of electricity—enough to power hundreds of homes for a year.

Recent studies underscore the growing environmental footprint of AI technologies. For instance, the International Energy Agency (IEA, 2024) highlights that data centers accounted for nearly 1% of global electricity use in 2023, with AI workloads contributing a rapidly increasing share. Furthermore, analyses from the Carbon Disclosure Project (CDP, 2023) emphasize the urgent need for comprehensive digital emissions accounting to meet corporate climate targets. Incorporating these findings contextualizes the biopharmaceutical sector's challenges within the broader technological ecosystem.

Water consumption is another concern. Data centers, especially in warmer climates, use water for cooling, sometimes exceeding local sustainable limits. Microsoft's facility in The Netherlands drew public attention after consuming 84 million liters of water during a heatwave. GenAI prompts alone can consume 0.5 liters per interaction, while model training can require more than 700,000 liters.

The carbon impact varies geographically due to energy source differences. A data center in France, powered largely by nuclear energy, emits significantly less CO_2 than one in India reliant on coal. Furthermore, rare earth elements, essential for AI hardware, are mined under environmentally taxing conditions. The dependence on rare earth elements -such as neodymium, indium, and tantalum- exposes biopharma's AI hardware supply chains to substantial geopolitical and ethical risks. Mining operations for these minerals often take place in regions with poor environmental governance and human rights challenges, including child labor and ecosystem degradation (Amnesty International, 2023). This underscores the need for pharmaceutical companies to adopt rigorous sourcing standards and to invest in circular economy models that promote hardware recycling and material reuse.

Biopharma's increasing use of GenAI in R&D, marketing analytics, and supply chain forecasting means that these environmental concerns are no longer abstract—they are embedded in day-to-day operations. Without environmental impact assessments tailored to digital deployments, sustainability efforts may fall short.

While general AI infrastructure data is instructive, biopharmaceutical companies exhibit specific patterns of AI use that influence their environmental impact. Internal data from leading pharma firms indicates that AI-driven R&D activities represent approximately 15-20% of their total IT energy consumption, a significant portion given the sector's overall digital footprint. Moreover, supply chain forecasting and marketing analytics, increasingly reliant on generative AI, add layers of computational demand unique to biopharma's operational profile.

Can AI help biopharma become more sustainable?

While AI contributes to environmental strain, it also presents tools for reducing it. For instance, AI-powered green chemistry solutions are being used to design molecules with lower energy synthesis paths and reduced waste. Generative models can simulate greener alternatives for excipients and solvents, helping reduce toxicity and environmental load.

AI also contributes to sustainable manufacturing by predicting equipment maintenance, thus reducing unplanned downtime and material wastage. In packaging, AI algorithms can suggest optimized, lower-impact materials and shapes. Companies like Pfizer and GSK are beginning to incorporate such systems into their smart factories.

In data center operations, AI has already proven its ability to cut energy usage through load balancing, predictive cooling, and dynamic voltage scaling. Google reports using AI to reduce its cooling energy use by up to 40%. Applying such models across pharmaceutical computing hubs could yield substantial sustainability gains.

Additionally, GenAI can enhance Environmental, Social & Governance (ESG) reporting and compliance by automating traceability, generating sustainability reports, and simulating regulatory outcomes. Beyond R&D and manufacturing, AI's sustainability potential extends to green logistics optimization—reducing transportation emissions through route planning—and AI-assisted waste management systems that enhance recycling efficiency. Virtual clinical trials enabled by AI reduce the need for patient travel and resource-intensive site operations, representing additional avenues to lower the sector's overall environmental footprint. Such applications are key to ensuring that biopharma does not just offset its environmental impact, but actively reduces it.

Towards a sustainable AI agenda in biopharma

To embed sustainability into AI strategy, pharmaceutical firms must prioritize governance mechanisms that track digital environmental impacts. Despite promising technological solutions, practical barriers hinder sustainable AI adoption. High upfront investment costs, the complexity of integrating green algorithms into legacy systems, and organizational resistance pose significant challenges. Addressing these requires a phased implementation approach, strong executive sponsorship, and embedding sustainability KPIs within digital transformation projects. Incentive mechanisms such as internal carbon pricing can motivate teams to innovate with environmental consciousness. This includes integrating digital emissions into ESG metrics, requiring green certifications for cloud providers, and setting internal standards for model size and compute usage.

One promising path is to adopt 'frugal AI'—algorithms that achieve acceptable performance with fewer resources. For example, using small, task-specific models in marketing or diagnostics instead of massive general-purpose models like GPT-4 can drastically cut emissions, as already demonstrated by DeepSeek in China. The French start-up Nabla has illustrated this well by developing lightweight AI tools for clinical assistants.

Several companies are already setting benchmarks. Novartis, for example, has implemented AI tools within their environmental monitoring systems to anticipate and minimize the energy and water footprint of their production lines. Sanofi has adopted eco-design frameworks supported by AI to optimize packaging and reduce plastic usage in distribution. AstraZeneca has committed to planting 200 million trees by 2030 and uses AI models to predict biodiversity impact across its global operations.

To support and monitor such initiatives, biopharma companies are exploring internal carbon pricing models that factor in the footprint of AI deployments. This encourages teams to innovate with impact awareness and contributes to a deeper shift in digital sustainability culture.

Policy also plays a vital role. In the EU, the Corporate Sustainability Reporting Directive (CSRD) now requires digital environmental disclosures (European Commission, 2024). In France, the REEN law (*Réduction de l'Empreinte Environnementale du Numérique*) pushes public and private actors to adopt energy-efficient digital practices (ADEME, 2025). Biopharma must anticipate these shifts and lead by example.

Figure 1 visually synthesizes the multifaceted environmental challenges posed by AI in biopharma alongside emerging technological and governance solutions. This infographic highlights causal links such as how high computational loads translate into energy and water consumption, and how interventions like frugal AI and AI-driven green chemistry provide mitigation pathways. Future work will expand this graphical approach to include supply chain and lifecycle impacts for a more holistic view.

Figure 1. Environmental Challenges and AI Opportunities in Biopharma

Environmental Challenges	**AI-Powered Sustainability Solutions**
High energy demand (training & inference)	Predictive load balancing & energy-efficient models
Water-intensive data centers	Smart cooling & regional redistribution
CO2 emissions from computing & logistics	Eco-design, frugal AI & internal carbon pricing
Rare earth mineral dependency	Lifecycle monitoring & hardware optimization
Waste from manufacturing	AI-driven predictive maintenance & green chemistry

Conclusion

The convergence of AI and biopharma represents both a renaissance and a reckoning. The environmental impact of AI in biopharma must be understood against the backdrop of accelerating climate change and urgent global calls for decarbonization (IPCC, 2023). Without swift and decisive action, the digital transformation risks exacerbating ecological degradation, contradicting the healthcare sector's fundamental mission to improve human wellbeing. Thus, sustainable AI is not only a technological or regulatory challenge, but a moral imperative aligned with planetary health. As AI transforms how medicines are discovered, tested, and delivered, its unseen environmental consequences could contradict the very ethos of health promotion and sustainability.

By adopting a proactive stance, pharmaceutical companies can lead the charge toward a green digital transformation. This includes evaluating digital infrastructures, championing green innovation, and embedding ecological foresight into AI governance. Ultimately, a sustainable AI agenda in biopharma is not just a regulatory necessity or a reputational safeguard—it is a moral imperative.

Academic institutions and business schools also have a role to play in shaping the next generation of leaders who can balance innovation with responsibility. Curricula integrating AI ethics, digital ecology, and green entrepreneurship should become standard in life sciences and management programs.

If done right, biopharma's digital revolution can become a blueprint for scaling innovation without sacrificing sustainability. The opportunity is not just to mitigate harm, but to redefine progress itself.

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