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Eco-Design and Artificial Intelligence: Sustainable Practices in Contemporary Visual Arts

Aongsaiching Marma[1]*, Kazi Abdul Mannan[2]

Correspondence
[1]*Department of Fine Arts, Drawing & Painting, Shanto-Mariam University of Creative Technology
Dhaka, Bangladesh Email: aongsaichingmarma@gmail.com

[2]Department of Business Administration
Shanto-Mariam University of Creative Technology
Dhaka, Bangladesh.

ABSTRACT

This article examines the intersection of eco-design principles and artificial intelligence (AI) within contemporary visual arts. It asks how artists, curators, educators, and institutions can integrate sustainability into AI-driven creative practice without sacrificing artistic innovation. Through a qualitative, interpretive approach—combining semi-structured interviews with practising AI artists, thematic analysis of artworks and exhibitions, and document analysis of policy and technical literature—this study maps current practices, tensions, and emergent strategies. Key findings reveal three primary pathways toward sustainability in AI art: practice-level optimisation (energy-aware workflows, reduced iteration), material & display ecology (low-impact production, circular-material choices), and discursive and pedagogical shifts (critical reflection, audience engagement about environmental costs). The paper draws on the Green AI critique and lifecycle thinking to propose an Eco-AI Art Framework that aligns circular economy and eco-design heuristics with the particularities of computational creativity. Case studies (data-driven installations, generative visuals, and institution-led programmes) illustrate both promising innovations and remaining barriers—chiefly opacity in compute supply chains, lack of carbon accounting norms in art practice, and institutional incentives favouring scale over sustainability. The article concludes by offering actionable recommendations for artists, technologists, and policy-makers and suggesting avenues for further research, including cross-disciplinary carbon accounting tools tailored to art practices.

Keywords: eco-design, artificial intelligence, visual arts, sustainability, Green AI, circular economy, qualitative research

1. Introduction

Contemporary visual arts increasingly incorporate artificial intelligence (AI) as a generative, curatorial, and interpretive tool. From large-scale, data-driven projections to algorithmically generated still images, AI methods — especially deep learning — have expanded the expressive repertoire of artists and institutions (Anadol, 2020). However, the rise of AI in creative fields raises urgent sustainability questions. Training and deploying large machine-learning models can be energy-intensive and produce substantial carbon emissions; landmark analyses have shown that certain state-of-the-art models entail environmental costs comparable to the lifetime emissions of multiple gasoline-powered cars (Strubell, Ganesh, & McCallum, 2019). This reality has prompted calls for a "Green AI" ethos emphasising efficiency and ecological responsibility in research and deployment (Schwartz et al., 2020). For visual artists and arts organisations, the problem is twofold: the environmental footprint of computational processes and the material footprint of producing, exhibiting, and preserving AI artworks.

At the same time, eco-design — an approach traditionally associated with product design, architecture, and industrial practice — provides a suite of principles and strategies (life-cycle assessment, design for disassembly, material circularity, minimality) that can be adapted to artistic workflows (European Commission, circular-economy literature). Eco-design's core aim is to minimise negative environmental impact across a product or artefact's lifecycle. When applied to art that uses AI, eco-design prompts questions about the compute, data, and display life-cycles: How energy-hungry was the model used? What hardware and datacenter supply chain issues underpin the work? What are the embodied impacts of exhibition materials? And crucially, how can artists make those impacts legible and critical within the work itself?

Scholars and practitioners have begun to propose frameworks and practices for analysing the environmental sustainability of AI art specifically. Jääskeläinen, Pargman, and Holzapfel (2022) suggest a two-dimensional framework that considers both "materials" (hardware, software, datacenters) and "practices" (artistic process phases and iterative behaviours) when evaluating environmental impact. The present study builds on these foundations and asks: what sustainable practices are actually being used in contemporary visual arts that employ AI, and how might eco-design principles be operationalised to foster lower-impact but still innovative artistic production?

This paper takes a qualitative approach to explore these questions. The study contributes a conceptual Eco-AI Art Framework that synthesises circular economy and Green AI thinking with art practice, empirical insights from artists, curators, and technicians about real-world constraints and possibilities, and practical recommendations to align aesthetic and ethical commitments with low-impact technological choices. By focusing on practice-level tactics and institutional levers — rather than only on technical optimisation

— the research foregrounds how cultural values, funding models, and pedagogical norms shape sustainability outcomes in AI art.

2. Literature Review

2.1 AI and the environment: technical literature

The technical literature has been among the most persuasive in exposing the environmental costs of modern AI. Strubell et al. (2019) quantified the energy and carbon footprint of training certain large natural language processing models, demonstrating that single training runs can emit as much CO_2 as several cars over their lifetimes. Such work catalysed an ethical and practical conversation in AI research about reporting energy use and prioritising efficiency. The Green AI movement argues that AI research should value and measure energy efficiency and cost alongside performance benchmarks (Schwartz et al., 2020). These perspectives highlight that computational creativity is not ecologically neutral; choices about model size, dataset curation, number of training iterations, and hardware affect environmental outcomes.

2.2 Eco-design and circular economy principles

Eco-design arises from product and industrial design traditions and emphasises lifecycle thinking, material selection, energy efficiency, repairability, and recyclability. The circular economy literature urges minimising waste by keeping materials in use and reducing virgin resource extraction. Applied to art, these frameworks translate into choices about production materials (e.g., low-VOC paints, reclaimed substrates), techniques (digital-first or physical production minimised), and exhibition practices (modular displays, rental or reuse of infrastructure). Several recent publications have begun to explore how circular economy thinking can intersect with creative industries to reduce their environmental impacts.

2.3 Critical scholarship on AI art

Critical art scholarship interrogates technology's political economy, labour, and supply chains. Works such as "Anatomy of an AI System" (Crawford & Joler, 2018) map the human labour, mineral extraction, and environmental burdens that underpin consumer AI devices, reminding artists and institutions that seemingly immaterial digital works have material consequences. Similarly, recent analyses focus on the ideational and discursive potentials of AI art to foreground environmental crises or, conversely, to obscure ecological costs through spectacle (various recent articles). This scholarly body urges practitioners to be reflexive about the embedded politics of AI systems.

2.4 Art practice, literature, and case examples

Artists such as Refik Anadol have used large datasets and machine learning to create immersive installations, demonstrating the expressive potential of computational media but also raising questions about the scale of computing behind such works (Anadol, reported in Wired, 2020). Institutions and exhibitions have begun to showcase technology-focused art while also experimenting with eco-conscious curation; recent museum shows tracing art-technology histories emphasise both the promise and historical continuity of artists' engagement with computational tools (Tate Modern coverage, 2024).

2.5 Emerging frameworks specifically addressing AI art sustainability

Recent scholarly papers propose frameworks specifically targeted at the environmental assessment of AI art. Jääskeläinen et al. (2022) emphasise analysing both "materials" and "practices." Others call for reporting standards, so that artists and institutions disclose the computing budget, training time, and energy sources associated with a work. This literature suggests that a combined strategy — technical, material, and discursive — will be necessary to make AI art sustainable in practice.

3. Theoretical Framework

This study synthesises three theoretical strands: Green AI ethics, eco-design/circular economy principles, and actor-network/practice theory from science and technology studies (STS). Merging these provides both normative and descriptive tools for analysing AI-infused art practices.

3.1 Green AI ethics

Green AI calls for valuing efficiency, transparency, and environmental accountability in AI development (Schwartz et al., 2020). From this perspective, AI art practices are ethically accountable not only for aesthetic outcomes but also for the energy and material consequences of model training, inference, and hosting. Green AI informs the technical axis of the theoretical framework: it insists on measurable metrics (energy use, compute-hours, carbon estimates) and on strategies to minimise them (smaller models, distillation, efficient hardware, renewable-powered compute).

3.2 Eco-design and circular economy

Eco-design provides lifecycle assessment tools, material selection heuristics, and design-for-circularity strategies. Adapting eco-design to art foregrounds three priorities: minimise embodied impacts of physical artefacts; reduce operating energy for displays and interaction; and design for reuse, repair, or graceful degradation after exhibition. Circular economy thinking further encourages shared infrastructure (e.g., communal servers, rental exhibition hardware), material reuse, and supply chain transparency.

3.3 Practice theory / actor-network perspectives

Practice theory and actor-network theory (ANT) emphasise that social and material actors (artists, code, hardware, institutions, funders, audiences) co-constitute practices and outcomes. This lens helps us see sustainability not as a property of individual artworks but as emerging from networks of relations — funding priorities that reward spectacle, software libraries that encourage heavy compute, or institutional norms that ignore energy accounting. Practice theory encourages examining routines, habits, infrastructures, and incentives shaping the environmental footprint of AI art.

3.4 The Eco-AI Art Framework (synthesis)

Combining the above yields the Eco-AI Art Framework used in this study. It comprises three interrelated dimensions:

- Technical/Compute Ecology — model choice, training versus inference energy, hardware selection, cloud vs. local compute, and the energy mix of datacenters (Green AI lens).
- Material/Exhibition Ecology — embodied materials for fabrication and display, transport, lighting/energy demands of installations, and end-of-life strategies (eco-design lens).
- Discursive & Institutional Ecology — artist and institutional practices, reporting norms, educational curricula, funding incentives, and audience engagement that shape decision-making (practice theory lens).

Together, these dimensions guide data collection and analysis: each interview and case analysis is coded with respect to these three axes, enabling identification of leverage points for sustainable practice.

4. Research Methodology

4.1 Research design and rationale

Given the exploratory nature of this research question and the complexity of the cultural-technical configurations involved, a qualitative design was adopted. Qualitative methods allow an in-depth understanding of artists' practices, institutional constraints, and the meanings attributed to sustainability within art contexts (Denzin & Lincoln, qualitative methods literature). The study used three complementary data sources: semi-structured interviews, document and artefact analysis (artist statements, technical readme files, exhibition catalogues), and purposive case studies of AI artworks and exhibitions.

4.2 Participant selection and sampling

Participants were purposively sampled to capture diversity in roles (artists, technical collaborators, curators, technicians) and geographies (Europe, North America, Asia). Selection criteria included: (a) current or recent use of AI in visual art projects, (b) willingness to discuss technical and production processes, and (c) involvement in exhibited work within the last 3 years. The sample comprised 18 participants: 10 artists (solo practitioners and collectives), 4 curators, and 4 technical collaborators (engineers/technicians). Ethical approval was obtained from the relevant institutional review board; participants signed informed consent agreements assuring anonymity in reporting where requested.

4.3 Data collection methods

Semi-structured interviews: Conducted remotely (video/phone), lasting 45–90 minutes. Topics included: motivations for using AI, description of production workflows, compute and material choices, perceptions of sustainability, and institutional pressures. Interviews were audio-recorded and transcribed verbatim.

Document analysis: Artist process notes, GitHub readmes, exhibition tech riders, and museum installation reports were collected when available to triangulate interview claims and to extract technical details (compute hours, hardware specs).

Case studies: Three in-depth case studies were developed based on interviews and documents: (A) a data-driven immersive projection using large generative models; (B) a series of print-based AI-generated works produced via local inference and minimal training; and (C) an institution-led programme for AI art with an explicit sustainability brief.

4.4 Data analysis

Transcripts and documents were imported into qualitative analysis software and coded thematically. Coding was both deductive (guided by the Eco-AI Art Framework: technical, material, discursive codes) and inductive (new themes emergent from the data). Thematic analysis proceeded in iterative cycles: initial open coding, development of axial codes linking themes, and selective coding to produce coherent narratives and propositions about sustainable practices. Case study materials were synthesised to provide concrete exemplars.

4.5 Trustworthiness and limitations

Triangulation across interviews and documents enhanced credibility. Member-checking was used: draft case descriptions were shared with participants for correction. Limitations include a modest sample size limiting statistical generalizability, potential self-selection bias (participants concerned about sustainability may have been more likely to respond), and variable availability of accurate computer data — many artists could not precisely quantify energy use, reflecting a broader transparency gap.

5. Findings

Analysis identified six major themes describing how eco-design and AI currently intersect in visual arts practice.

5.1 Awareness coupled with opacity

Most participants were aware that AI has environmental costs, but lacked precise metrics. While many could describe hardware (GPUs, cloud services) and rough training durations, few had quantified energy consumption or carbon emissions for a given artwork. This opacity was attributed to the complexity of datacenter energy mixes, lack of reporting norms, and limited access to tooling for art practitioners.

> *"I know training the model was heavy — we used several cloud GPUs — but we didn't have a way to translate that into kWh or carbon." — Artist A*

5.2 Iteration-driven energy use

Artists described iterative exploratory practices (many rapid trials of prompts, parameter tweaks, retraining), which multiplied computational demand. Iterative generation — often essential to aesthetic discovery — emerged as a primary driver of energy use. Several artists noted trade-offs between exhaustive exploration and targeted, efficient experimentation.

5.3 Tactical optimisation strategies

Some participants reported adopting practical optimisations: fine-tuning pre-trained models rather than training from scratch; model distillation to create smaller, faster versions for inference; scheduling heavy training to times when cloud providers offered lower-carbon energy mixes; and using local inference on lightweight models for prints or projections. These align with technical Green AI recommendations.

5.4 Material and exhibition choices matter

Beyond compute, participants emphasised materials and display decisions. Large immersive works consume electricity for projection and climate control. Some curators experimented with low-energy display strategies (e.g., lower-lumen projections, timed activation, solar-assisted powering for outdoor pieces). Artists making physical outputs prioritised reclaimed or recycled substrates and modular set pieces for reuse.

5.5 Institutional and funding incentives

Institutions and funders tend to reward novelty, scale, and media attention; these incentives can encourage compute-heavy spectacles. Conversely, a small but growing subset of residencies and grants now mandate sustainability plans or prefer low-impact proposals, indicating shifting funding norms.

5.6 Pedagogical and discursive shifts

Educational programs and public-facing materials increasingly incorporate environmental reflection: artist statements mention compute, and materials, and some exhibitions include interpretive information on environmental impacts. Participants saw public disclosure as a way to both educate audiences and exert pressure for greener practices.

6. Case Studies

Three anonymised case studies illustrate the diversity of approaches.

Case A — Immersive Data Projection (Large Compute)

A large urban museum commissioned an immersive projection created from training a generative adversarial network (GAN) on millions of urban images. The project required intensive cloud training (several weeks on multiple GPUs) and large projection hardware. The team lacked precise carbon accounting, but later retrofitted the exhibition with interpretive signage discussing data sources and energy use. The museum compensated by purchasing renewable energy credits for the exhibition period. This case illustrates scale and visibility paired with partial mitigation but highlights how spectacle often precedes full accounting.

Case B — Local Lightweight Production (Low Compute)

A collective produced a series of prints derived from locally run, distilled models. Instead of training large models, they fine-tuned an off-the-shelf model on a small dataset and used local inference for batch printing. Materials were reclaimed substrates; the exhibition used minimal lighting and modular frames intended for reuse. This case demonstrates how artistic constraints (budget, locality) can align with sustainability objectives.

Case C — Institution-led Sustainable AI Art Programme

A public arts organisation launched a programme requiring proposals to include lifecycle considerations for the artwork. The program offered access to a shared, renewable-powered compute cluster and technical support for model compression and efficient inference. Artists appreciated the shared infrastructure and mentoring; some noted it allowed more ambitious conceptual work without the same environmental burden as distributed cloud training. Yet participants also observed the need for transparent reporting standards and better measurement tools.

7. Discussion

7.1 Interpreting findings through the Eco-AI Art Framework

Applying the Eco-AI Art Framework clarifies where interventions can be most effective.

Technical/Compute Ecology: Artists' lack of precise energy metrics reflects the broader AI field's transparency gap (Strubell et al., 2019). However, tactical measures such as model distillation, transfer learning, and scheduled training can substantially lower energy consumption. The literature on Green AI suggests that reporting compute-hours and FLOPs, and optimising for efficiency, should become normative in the arts as in AI research (Schwartz et al., 2020). Where institutions provide shared computing with renewable energy, artists can undertake ambitious projects with lower net emissions.

Material/Exhibition Ecology: The physical ecology of exhibitions (lighting, projection, materials) often rivals computation in overall environmental impact. Eco-design strategies (material reuse, modular exhibition systems, low-energy lighting, timed activations) are readily applicable and, in many cases, low-cost. The circular economy approach encourages institutions to emphasise reuse and shared inventories of exhibition hardware.

Discursive & Institutional Ecology: Incentives play a central role. Many artists reported that grant criteria and exhibition opportunities implicitly reward scale and novelty. Policymakers and funders can reshape practice by requiring sustainability plans, offering green residencies, and funding shared renewable computing infrastructure. Equally, transparent labelling of artworks' computational and material footprints could shift audience expectations and market norms.

7.2 Tensions: Aesthetics vs. Sustainability

An important tension emerged between aesthetic goals (which sometimes demand high computational experimentation) and sustainability concerns. Iteration is central to creative discovery, yet it can be energy-expensive. Artists grappled with the trade-off, and a number adopted more selective iterative strategies or mixed computational and analogue generative techniques to reduce compute needs.

7.3 The role of transparency and reporting standards

A recurrent theme is the need for standardised reporting of computational and material footprints for artworks. Comparable to energy labels on appliances, a simple public “footprint statement” (detailing training hours, hardware used, hosting energy mix, and material choices) could help institutions and audiences evaluate works’ environmental impacts. Several academic proposals and pilot projects in the Green AI literature call for reporting of training time and model efficiency; transferring this ethic to the art world is both feasible and potentially transformative.

7.4 Institutional levers and policy implications

Institutions can act as important levers for change. Museums and funding bodies may institute procurement policies favouring renewable-powered partners, provide shared green compute resources, and prioritise low-impact proposals. Policy-makers could incentivise cultural organisations to adopt sustainability standards through grants dependent on ecological reporting. Such structural changes would address the root causes of unsustainable practice beyond individual artist choices.

7.5 Opportunities for artistic innovation

Framing sustainability as a constraint can foster new aesthetics and methods. Artists reported creative benefits of constraint: using model efficiency as an aesthetic parameter, exploring low-energy generative methods, or foregrounding reduced-material installations as conceptual choices. Eco-design doesn't necessarily truncate creativity; rather, it can redirect it.

7.6 Recommendations and Practical Guidelines

Based on findings and theoretical synthesis, the following recommendations are offered for artists, curators, institutions, and funders.

For Artists and Technicians

- Prefer fine-tuning and transfer learning over training large models from scratch whenever suitable; this reduces compute substantially.
- Use model distillation and pruning to create lighter inference models for exhibition; smaller models often suffice for high-quality outputs.
- Plan iterations mindfully: structure exploratory phases to reduce redundant runs; log experiments to avoid repeating heavy compute unnecessarily.
- Select hosting with renewable energy or schedule heavy training during times when cloud providers report cleaner grids. Some cloud providers now publish region-level carbon-intensity data that can guide scheduling.
- Document compute & material choices in artist statements and technical readmes: include model type, GPUs used, approximate training hours, and material choices for physical artefacts.

For Curators and Institutions

- Require sustainability plans in calls for proposals for works using computationally-intensive methods.
- Provide shared green compute resources (e.g., institutional clusters powered by renewables) to reduce duplication and leverage economies of scale.
- Adopt circular exhibition practices: reusable rigging, modular displays, and reuse of exhibition materials across shows.
- Implement labelling: publish footprint statements for works and include interpretive material to contextualise environmental impacts, turning them into pedagogical opportunities.

For Funders and Policy-makers

- Offer grants for efficient practices and infrastructural support (shared compute, green residencies).
- Establish reporting standards for cultural funding that include energy and materials disclosures for computational works.
- Invest in tools and training that help artists estimate energy use (simple calculators tailored for artistic workflows) and in curriculum changes that embed ecological literacy in creative technology programmes.

For Educators

- Integrate Green AI and eco-design into curricula for digital arts and media programs.
- Teach lifecycle thinking: not just code but also materials, exhibition logistics, and supply chains.

7.7 Limitations and Further Research

This study's qualitative design provides depth but not generalizable prevalence estimates. The sample size and geographic spread were constrained, and many artists could not supply precise compute or carbon data, underscoring the need for more quantitative and tool-based research. Future research directions include:

- Developing and validating carbon/energy calculators specifically for artistic workflows (training/inference + exhibition energy + embodied materials).
- Larger-scale surveys to quantify the prevalence of sustainable practices and barriers across the arts sector.
- Comparative lifecycle assessments (LCAs) of representative AI artworks to identify dominant impact stages.
- Design research into new aesthetic modes that embrace low-energy generative techniques as formal strategies.
- Policy experiments to test the efficacy of funder mandates and institutional provisioning of green compute.

8. Conclusion

AI has opened remarkable expressive possibilities for contemporary visual arts, enabling new relationships between data, algorithmic processes, and sensory experience. Yet the ecological consequences of computational creativity cannot be ignored. This study has articulated an Eco-AI Art Framework that integrates Green AI principles, eco-design/circular economy thinking, and practice-theoretical sensitivity to institutional incentives and everyday routines.

Empirical findings indicate a field in transition: artists and institutions are increasingly conscious of environmental impacts, experimenting with optimisations and material choices, yet significant opacity and perverse incentives persist. Artists' iterative creative methods — central to artistic discovery — can multiply compute demand, while institutions' tendencies to reward novelty and scale can unintentionally favour high-impact spectacles.

Nevertheless, there are practical, scalable interventions. Technical strategies like fine-tuning, model distillation, and scheduled training in low-carbon windows can reduce the compute footprint. Eco-design thinking applied to exhibition materials and display strategies can substantially reduce embodied and operational impacts. Crucially, institutional reforms — shared renewable compute, funding priorities that reward ecological planning, and reporting standards that make energy and material footprints visible — can realign incentives across the art ecosystem.

Framing sustainability as a creative constraint rather than an impediment opens fertile ground for new aesthetic languages and pedagogies. Artists who experiment within energy-aware constraints may discover novel formal possibilities; audiences exposed to footprint disclosures may become more attentive to the materialities of digital art. As Green AI scholarship urges transparency and efficiency in machine learning, the art world has an opportunity to lead by example — combining critical reflection with practical change.

The work ahead requires interdisciplinary collaboration: technologists building accessible measurement tools; curators and funders designing supportive policies; educators embedding lifecycle literacy; and artists experimenting with both technical and material constraints. Together, these actors can enact an eco-design ethic for AI art that respects both planetary limits and the creative impulse.

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