The Longevity and Sustainability of AI in Research Infrastructure and Cultural Heritage

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Infrastructure development in the cultural heritage (CH) sector has accelerated alongside the growth of digital humanities (DH). Although new projects emerge frequently, the longevity of their results is often limited. Large-scale DH initiatives have even been criticized as a "dead end" (Van Zundert, 2012). However, we argue that the primary challenge is not the utility of these initiatives but their sustainability: the capacity to continuously improve and adapt to evolving needs while balancing economic, social, and environmental costs (Toti and Cina, 2024; Waelen and van Wynsberghe, 2025). Recent research has increasingly examined the role of artificial intelligence (AI) in the CH domain, focusing on topics such as preservation, innovation, and ethical concerns (Harmanda et al., 2026; Fu et al., 2025; Pansoni et al., 2023). At the same time, scholars have begun to investigate the sustainability implications of AI deployment, both in general and within cultural heritage contexts (Bansal, 2025; Wang et al., 2025; Waelen and van Wynsberghe, 2025). While a growing body of literature offers frameworks, guidelines, and recommendations for sustainable AI practices, evidence of how these principles are applied in real-world cultural heritage projects remains fragmented and difficult to locate. This literature review addresses that gap by identifying and analyzing documented cases where sustainability considerations have been incorporated into AI-enabled cultural heritage initiatives.

Making economically and environmentally sound decisions requires a more critical assessment of the suitability of AI models for specific tasks. In an era of rapid AI advancement, balancing technical performance with economic, environmental, and social considerations has become increasingly important. However, the current AI landscape is largely driven by competition for state-of-the-art (SOTA) performance rather than task-specific efficiency, often overlooking broader sustainability concerns. This trend has intensified with the widespread adoption of large language models (LLMs), such as GPT and Google Gemini. Consequently, this review focuses on AI infrastructure development from 2022 onwards, reflecting the period in which LLMs became a central component of digital research ecosystems. While initiatives, such as Google's 2025 sustainability reporting and instructions for Gemini models (Google Sustainability, 2026), suggest a growing commitment to transparency, the dominant business model of frontier AI systems remains primarily subscription-based. Such dependency on proprietary services may pose challenges to the long-term economic sustainability, autonomy, and strategic resilience of organisations operating in the cultural heritage sector.

International organisations, policymakers and researchers have increasingly emphasised sustainability and responsible deployment as key considerations in the development of AI-supported infrastructures. In a recent UNESCO report (UNESCO and University College London, 2025), resource-wise solutions and collective responsibility are called for action across the world. The environmental costs of the AI usage for tasks that could be done adequately with simpler and smaller solutions (Sundaram et al., 2025; Cielen et al., 2026; Sistla, 2024) should be considered while making decisions of the employed models also in developing infrastructure for cultural heritage and research. Additionally, when it comes to choices of open or proprietary systems, it might be feasible to consider the higher initial cost of development for future sovereignty and decision-power. A great example of this has been the handwritten text recognition (HTR) development in the National Archives of Finland (Kansallisarkisto, 2025). Rather than relying only on platforms

such as Transkribus (Kahle et al., 2017), they developed their own open-source model to be used in their archival processes.

In addition to economic and environmental resource use, it is imperative to contemplate social sustainability. Various institutions, such as UNESCO and EU, have given their guidelines to responsible AI use (UNESCO, 2022; Council of Europe, 2024). In addition to advocating for preservation and cultural sensitivity, the guidelines by the Council of Europe suggest that AI should augment and not substitute the fundamental role of scholarly expertise (Council of Europe, 2024). Even though newer "System 2" (Li et al., 2025) thinking models demonstrate improved reasoning capabilities and have evolved in solving complex real-world problems (Zhang et al., 2024), AI should still be positioned as a collaborator rather than it replacing scholarly expertise. Scaling human-in-the-loop frameworks in these workflows is, thus, critical for sustainable development. By keeping the human scholar at the center of the interpretive loop, we ensure that the infrastructure remains socially relevant and methodologically sound over longer periods.

Focusing on these key elements, we conduct a systematic literature review of AI-enabled research infrastructures in the cultural heritage domain following the PRISMA framework (Page et al., 2021). Our objective is not to benchmark AI systems according to their performance, but to investigate the methodological approaches through which customized AI models are incorporated into research infrastructures and to assess the extent to which sustainability considerations are addressed. Specifically, we analyze how economic, environmental, and social factors are considered in model selection and customization for infrastructure development in the cultural heritage sector.

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