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Environmental Impact and Digital Preservation

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Memory Rising

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1 Introduction

Digital preservation infrastructure relies on often invisible and enormously complex energy systems. The daily work of digital preservation practitioners, who work with myriad files, hardware, software, servers, and storage environments, is dependent on cheap and abundant energy. Historically, this energy has been generated from fossil fuels, which underpinned the Industrial Revolution and still power most of the world's infrastructure. Fossil fuels include coal, oil, and gas. The transition away from fossil fuels to renewable energy sources is critical for mitigating greenhouse gas emissions.

Even though renewable energy sources are quickly coming online, the majority of energy used to generate electricity in OECD countries still comes from non-renewable resources. As of June 2023, renewables only counted for 33.5% of net production of electricity in OECD countries (*Monthly Electricity Statistics*, 2023). The Intergovernmental Panel on Climate Change (IPCC) has stated that in order for warming to be limited to less than 2° C, all scenarios must "involve rapid and deep and, in most cases, immediate greenhouse gas emissions reductions in all sectors this decade"(Lee *et al.*, 2023).

Digital preservation aims to preserve materials for the future when that very future is uncertain due to the disruptions of climate change. Many of the sectors that employ digital preservation practitioners such as archives, libraries, museums, government agencies, and non-governmental organizations have demonstrated an uneven record of addressing climate change. Integrating climate change into our work is a critical component of digital preservation theory and practice. Organizations that have adopted a climate action plan (a plan dedicated to identifying steps to mitigate carbon emissions and integrate climate adaptation measures) should consider how digital preservation can be made more sustainable as part of specific institutional commitments.

2 Measuring the Environmental Impact of Digital Preservation

The exact environmental impact of digital preservation across the globe is difficult to assess since there is no central registry or organization charged with monitoring or oversight of all digital preservation activities. In their 2019 article "Toward Environmentally Sustainable Digital Preservation," Keith L. Pendergrass, Walker Sampson, Tim Walsh, and Laura Alagna estimated that cultural heritage organizations across the world preserved at least 5,750 petabytes of content, not accounting for multiple copies of content (Pendergrass *et al.*, 2019). Even if an organization were able to consistently measure the entirety of preserved content, assessing the true environmental impact would require answering other questions related to storage of redundant copies, fixity check practices, and handling of electronic waste.

The Greenhouse Gas Protocol is one of the most widely recognized standards for greenhouse gas emissions accounting (*Greenhouse Gas Protocol*, 2023). This protocol distinguishes between Scope 1, 2, or 3 emissions categories. Scope 1 emissions are energy use and generation activities directly owned or controlled by an institution (e.g. on-site power generation that relies on fossil fuels). Scope 2 emissions represent energy use that is obtained from third-party sources (e.g., electricity purchased from a utility with coal-fired power plants). Scope 3 emissions are associated with other institutional activities that are difficult to control and/or quantify (e.g. employee commutes, business travel, purchased goods, and investments).

As digital preservation increasingly relies on third-party vendors and/or cloud storage, this means that the bulk of digital preservation activities likely fall under an institution's Scope 3 emissions. For institutions to accurately measure the carbon footprint of their digital preservation activities, they would need to have extensive information about their own holdings and practices, but also about the energy usage practices of wherever content is stored. Microsoft Azure, Amazon Web Services, and Google Cloud offer carbon footprint accounting tools for customers. However, it is not clear whether digital preservation vendors, who often rely on these large cloud service providers, have the capacity to translate this information for their individual customers.

3 Implicit Assumptions of Digital Preservation

There are several implicit assumptions that underlie digital preservation. The climate crisis is directly challenging some of these assumptions, whereas it indirectly impacts other aspects of digital preservation.

3.1 Affordable energy and equipment costs

Digital preservation at scale is possible because energy and equipment is relatively affordable. Fortunately the transition to renewable energy has introduced even greater affordability for electricity in many markets. On the other hand, there are increasing costs that are often invisible to consumers, such as the enormous quantities of water required to cool data centers (Monserrate, 2022).

The energy and equipment used in conjunction with digital preservation generate what economists call *negative externalities* - additional costs that are not fully accounted for by the producer or the consumer. A classic example of a negative externality is an energy utility company that prices the burning of coal or gas by production costs without accounting for the costs incurred by air pollution to public health or ecosystems.

Even in areas where renewable energy makes up a larger share of energy production, there are still negative externalities associated with computing infrastructure. Computing equipment and servers generate electronic waste, and computing depends on mining rare earth minerals.

3.2 Electric grid stability

The electric grid refers to the infrastructure that delivers electricity from producers to consumers. Electric grids are enormously complex because they must continually balance supply and demand. As climate change drives increasingly severe and frequent disasters in the form of hurricanes, wildfires, and floods, this presents greater potential disruption to electric grids. Furthermore, the increasing extreme heat days associated with climate change puts greater cooling demand pressure on grids.

Digital preservation practitioners who steward vital records that must be accessed during emergencies may need to take regional grid stability issues into account to ensure reliable alternative means of information retrieval.

3.3 Adequate staffing

Studies of digital preservation practitioners have demonstrated that most organizations lack sufficient staffing to fully implement digital preservation. The National Digital Stewardship Alliance's most recent study reported that 69% of respondents either disagreed or strongly disagreed that their organization had sufficient staffing (Work *et al.*, 2022).

If organizations must deal with more frequent and severe disasters caused by climate change against a backdrop of decreasing or flattened budgets, this may eventually cut into resources allocated for hiring and retaining staff. In addition, climate change can pose occupational hazards to workers. For example, those who report to an on-site workplace may have to contend with an increasing number of extreme heat days or unsafe weather conditions during their commute.

3.4 Organizational continuity

Climate change is reshaping the geography of where people and organizations can operate with some assurance of stability. The IPCC estimates that nearly one billion people in coastal locations around the world are at risk of displacement from sea-level rise (Pörtner *et al.*, 2022).

While electronic files have the benefit of being able to be stored in areas far from coastal hazards, this advantage may become complicated if the larger organization faces existential threats. For example, the national archives of many Pacific Island nations face serious questions about relocation and access protocols (Gordon-Clark and Shurville, 2010).

3.5 Growth and permanence

Digital preservation is often assessed by measures of linear growth, such as terabytes and petabytes. While such measures are handy for institutional comparisons and assessment of current and future storage needs, measuring linear growth conveys little about the value of preserved content. When measures of linear growth are the primary way in which value is assessed, this reinforces a "growth is good" paradigm that disregards negative externalities. An organization that preserves 1 TB of useful information regularly consulted by users versus an organization that preserves 100 TB of information that is unlikely to ever be consulted in the future shows that storage volume is a poor indicator of value.

In addition to measuring value through growth, digital preservation inherently attempts to recreate aspects of permanence to counteract the ephemerality of digital objects. Tiers of digital preservation standards generally assume that once an object has been selected for digital preservation, the goal is to maintain access to it indefinitely. Some practitioners have challenged the idea of permanence, by raising concepts of "acceptable loss" (Goldman, 2018) and "graceful degradation" (Nowviskie and Porter, 2010).

4 The Importance of Selection

Given the enormous quantities of information that digital preservation practitioners *could* preserve, they should be highly selective about what content warrants the time, resources, and energy for digital preservation. Cultural heritage professionals from various disciplines have a variety of tools (collection development guidelines, appraisal policies, curatorial philosophies, records retention schedules) to determine materials of enduring value. Digital preservation practitioners should also ensure such selection and decision frameworks are applied to the content they steward.

Even materials selected for long-term preservation do not necessarily require permanent preservation. Separating long-term preservation from permanent preservation is not a new concept. Such practices are normal within records management, in which records are sometimes scheduled for decades of retention, but may eventually be discarded after their anticipated use value has ceased.

Selection policies should be living decision making frameworks. Although computing and digital preservation seem far removed from the natural world, we have much to learn from ecosystem changes. Living, healthy, dynamic ecosystems are always in a state of flux–there is no growth without loss, and there is no endurance without ephemerality. Our approach to digital preservation would do well to embrace such characteristics.

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