Sustainability in Context: An Evidence-based (Digital) Preservation Lifecycle Investigation

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***Abstract* – The ReVerDi project is developing an evidence-based approach to sustainability optimization for cultural heritage preservation in national libraries. It uses the Life Cycle Sustainability Assessment Methodology (LCSA) to explore the environmental, economic, and social impacts of both physical and digital preservation activities. This more accurately reflects our operational contexts than those which produce recommendations on one impact aspect alone. The paper presents our research methodology, outlines how ReVerDi fills a gap in the current research literature, and summarises our progress and thinking to date.**

***Submission Type* – Full Paper**
***Keywords* – Assessment, eBooks/eJournal Content, Data Management, Sustainability,**
***Conference Topic* – Haerenga – Journey**

I. Introduction

Sustainability is the buzzword of the modern day. Much of its use can be traced back to the 1987 Brundtland report from the UN that defined sustainable development as that which 'meets the needs of the present generation without compromising the ability of the future generation to meet their own needs' [1]. The relationship between sustainable development and climate change was explicitly acknowledged a few years later, leading to international collaboration through annual UN Climate Change Conferences, the now infamous Kyoto Protocol, and the COP21 Paris Agreement to reduce global emissions [2] [3]. Spurred on by the declaration of a climate emergency in the late 2010's, many smaller organizations have since established sustainability strategies to reduce the climate impact of their environmentally harmful emissions. Their focus is often exclusively on environmental sustainability. In this way, the climate crisis has led to a shift in focus when it comes to what we commonly understand by 'sustainability'.

The cultural heritage sector is no exception. The British Library's Sustainability and Climate Change Strategy for example, like many others from the field, is focused predominantly on environmental sustainability [4]. Our internal collection management strategy however, 'Sustaining the Value, 2022 - 2030', addresses sustainability not only in environmental terms but also in relation to economic, social, and collection longevity factors [5]. The British Library's new digital preservation policy does the same [6].

This holistic perspective on sustainability recently led to a new collaborative research project on sustainable preservation: ReVerDi. This paper introduces the ReVerDi project, explains its lifecycle assessment methodology, and provides a summary

iPRES 2025: The 21st International Conference on Digital Preservation, Wellington, Aotearoa New Zealand.
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of work to date. It concludes with some observations for the field in the hope of stimulating further discussion thereafter.

II. The ReVerDi project

ReVerDi is a partnership of three European national libraries and three University research partners: British Library, Royal Library of the Netherlands, Swiss National Library, University of Surrey, Delft Technical University, and Bern University of Applied Sciences. Library partners in the project all have substantial digital collections in their holdings, alongside more established holdings of physical content. As collections have grown however, questions about the impact of maintaining a hybrid print/digital collection have started to become more pressing. Many relate to the environmental impact of collecting, asking how the climate impact of maintaining both print and digital collections can be reduced. These have led to wider, contextual questions about the social and economic impact of hybrid collecting, to ensure sustainability decisions are balanced against core Library roles, mandates, and services.

ReVerDi was established to explore these questions and produce evidence-based recommendations on the '*Re*al *Ver*sus *Di*gital' conundrum. Taking a holistic perspective to ensure balance and viability of its recommendations, it addresses the triple bottom line of sustainability: environmental, social, and economic impacts alike. Work started in July 2024 and will conclude by mid-2027.

III. Methodology

Library partners provide research partners with operational data relating to each of the three impact types listed above. Data is gathered and analyzed in line with the Life Cycle Sustainability Assessment (LCSA) methodology [7], a well-established interdisciplinary technique borne from the more widely known environmental Life Cycle Assessment (LCA) method. In essence, LCSA combines three tools: Environmental Life Cycle Assessment, Social Life Cycle Assessment and Life Cycle Costing. It is particularly suitable for identifying trade-offs between our three sustainability perspectives and developing solutions to resolve them.

The core unit of measurement in LCSA is the *functional unit,* i.e. a quantifiable unit of library products or services used to measure environmental, social and economic impacts. Selection of appropriately consistent functional units allows comparison of different alternatives for delivering the product or service, such as physical papers or a digital file.

Functional units in LCSAs are considered in the context of *system boundaries*, which define the processes or stages of the lifecycle that are in scope for the assessment. The lifecycle model developed by the LIFE3 project for economic costing [8] provides a generic framework and terminology set for system boundaries, stages, and activities in the project. It is also a reference point around which we can determine where print and digital workflows may or may not vary. The social indicators used in the project meanwhile, are based on those developed in the United Nations Environment Programme, specifically for social lifecycle assessments of products and organizations [9].

Aligning the lifecycle scope of the LCSA methodology with the lifecycle-based definitions of preservation that abound in library literature, the project applies the term 'preservation' to encompass many of the collecting activities undertaken by partner libraries, including access. This latter inclusion ensures analysis can incorporate the social impact of preservation, most meaningfully imparted by the access and use of content by end users. In national institutions with exceedingly large-scale hybrid print/digital collections, this holistic perspective is essential to identify efficiencies and opportunities overall.

IV. LCSAs and Digital Preservation

Our background research for the project indicated that whilst sustainability is a hot topic, the library and preservation sectors have relatively little LCSA experience. We have nonetheless identified several other relevant studies to inform our research, typically focused on one distinct aspect of the LCSA framework.

Much of the published digital preservation research on sustainability is focused on the environmental aspect, the earliest and most highly cited example being a comprehensive discussion from Pendergrass *et al* in 2019 [10]. A small number of operational carbon footprint calculations and/or methodologies for digital preservation services have also recently appeared, largely from Europe and the U.S. [11] [12] [13] [14]. These consider, for example, technological storage and preservation action infrastructure emissions, alongside employee footprints for administering, developing, and managing a preservation service.

Prior to this environmental focus, digital preservation sustainability research often took a more economic perspective [15] [16] [17]. Several different cost models were produced, identifying a wide array of economic factors to consider. Wheatley observes however that lifecycles are incredibly complex things that depend on a whole host of variables [18]. There are lessons there for ReVerDi to learn from, not least that simplicity and clear scoping is key.

Outside of the field and from the publishing sector, numerous environmental LCAs have been conducted that compare the per-unit greenhouse gas (GHG) impacts of paper and e-books [19]. Their scope however is relatively limited - they do not, for example, factor in the type of processing operations typically conducted in national libraries. Moreover, our analysis found that they vary significantly in the functional units and system boundaries that form the basis or scope of their analysis. As a result, this makes it challenging to develop an overall and joined up 'whole of lifecycle' assessment from these various studies, particularly from a library perspective.

Finally, we also approached other national collecting institutions to ask about experiences with LCSAs and functional units. No affirmative responses were received to our enquiries. Together with our background research, this indicates that ReVerDi addresses a gap in sectoral understanding and knowledge about the bigger picture of sustainability in libraries, despite the widespread interest in sustainability in general.

V. Progress to Date

At the time of writing, the project had been underway for nine months. Initial discussions explored Library workflows and appropriate functional units for the project. Each Library has a different operational context so time was taken to also explore this with University partners, demonstrating the scales at which we each work and presenting our sustainability strategies. This section represents the most salient aspects of those discussions.

A. Timeframes for an assessment

Memory institutions, including national libraries, have a uniquely long-term mandate, to preserve 'for the future'. Incorporating this 'forever' perspective into a functional unit is likely to make the overall calculations less reliable, given the inevitability of change over time. We therefore take a pragmatic and parsimonious approach to establishing the timeframes in scope for assessment and have agreed to focus on time periods up to ten years. This is, we believe, the point at which significant technological development will sufficiently change workflows and systems, for both physical and digital processing, to the degree that the reliability of longer-term calculations becomes questionable.

B. Variations in 'Print versus Digital'

The processing and use of collection content has changed in the past few decades, driven in part by improvements to the search, extraction, and discovery capabilities provided in a digital environment. This suggests that simple functional units for 'print versus digital', such as 'one hour spent accessing a print or digital newspaper' or 'acquisition of a single print or digital journal article', may not accurately reflect variations in usage or processing patterns. Such variations may have negligible impact on a small scale but are exacerbated when scaling up to the degree required to represent practices in a very large national collection. Until we have developed a deeper understanding of the individual processes to be assessed, we therefore expect to avoid highly granular, single intellectual item units.

Moreover, the intangibility of electronic content separates the so-called 'medium from the message'

in a way that the physical artefact cannot. In print, the written word is wholly reliant on the publisher's choice of paper and bound to it from that point on: together, the intellectual content and its carrier form a distinct and measurable unit. That unit is not so consistently formed in the digital world, particularly when it comes to access on end-user devices, making it more difficult to establish the 'item' as a consistently comparable functional unit between the two worlds. One resolution to this might be to focus the functional unit on an accessible form of the content, though this may produce misleading data when assessing the impact of certain preservation and processing activities. We have addressed this in the project to date by focusing on specific stages of the lifecycle, though we acknowledge that a generic access environment may need to be stipulated for direct comparisons further down the line.

C. Preservation Lifecycle Stages

Preservation is more than storage: it is an ongoing activity and series of processes that occur throughout the lifecycle. Initial lifecycle stages at each of the national libraries vary according to their general workflow design and established data reporting processes. At the Swiss National Library for example, there are three main stages: acquisition and cataloguing, preservation, and access. The British Library on the other hand, has broken them down into more detail and identified six. These are based on the LIFE model with modifications to support both print and digital collecting:

- *Acquisition:* in some cases, this may also include creation, e.g. if a newspaper is digitised for preservation purposes.
- *Processing*: includes basic metadata generation/extraction/allocation though excludes full cataloguing, which is considered a distinct user service that supports findability rather than preservation.
- *Ingest:* includes the process of transport/transfer into the repository location and any validation checks
- *Long term storage and management*: includes preservation and conservation interventions over the specified period and infrastructure security
- *Retrieval*: includes extraction of content from storage so it is available for users
- *Access*: includes resources provided by the Library to use and interact with the content.

Different representations of units may be used at different stages or parts of the lifecycle. For storage alone, for example, it may be more helpful to think in terms of storage units rather than intellectual items: kilometers of shelf space for physical items and terabytes for digital. Both are affected by format decisions, e.g. hardback/paperback and TIFF/JP2, though these may disproportionately alter the resulting measurement for digital. Such variations must therefore also must be acknowledged in and documented in the assessment description.

More than one stage may be represented in the system boundaries for a single functional unit, if appropriate to the relevance of a measurement outcome. Examples of this can be seen in the next section. The scope of the functional unit and system boundaries for each assessment also must be carefully stipulated each time. This will not only identify areas of potential overlap or inconsistency when the total sum of stage values is calculated for a given Library, but also enable more accurate comparisons of assessments between each different Library for the project's final reports.

D. Initial sets of functional units

We have taken a layered approach to defining our functional units, in order to explore sustainability at different levels of granularity. Our primary focus is our collections and factors relating to the preservation of our collections. The first set of functional units focuses on two significant collection content types that all three libraries acquire and preserve, albeit in different ways: newspapers, and journal content. To illustrate the bigger picture and wider context for those assessments, however, we each begin with a top-level assessment for our collections in general.

There is some disparity in the initial sets of functional units used at each Library, as we are each

dependent on the data we can readily collect and have available. To facilitate comparability nonetheless, we therefore define and describe what is in scope at each one very carefully. The initial set for the British Library, for example, is as follows:

1: Long term storage and management of the national collection of published content, digital vs physical, for one year.

2. Long term storage & management of all newspaper titles from a given publisher (representing a tbc number of issues/articles OR represented in storage units), digital vs physical, for one year.

3. Long term storage and management of all journal titles from a given publisher (representing a tbc number of issues/articles OR represented in storage units), digital vs physical, for one year.

4. Acquisition and processing of all newspaper titles from a given publisher (representing a tbc number of issues/articles), digital vs physical, for one year

5. Acquisition and processing of all journal titles from a given publisher (representing a tbc number of issues/articles), digital vs physical, for one year

6. Reader access to six journal articles, digital versus physical, in a single day (six being the maximum number of physical journal items that can be ordered in a BL reading room for a single day).

7. Reader access to six newspaper issues, digital versus physical, in a single day.

These will be refined as the project gains more experience. The varying operational and legislative contexts represented in the cumulative set of units is expected to widen the overall project impact and provide insight relevant to many other GLAM organisations with similar long-term mandates and sustainability aspirations.

E. Environmental factors

Several categories of factors have so far been identified to assess the environmental impact of print and digital preservation: utility services, off-site data storage, transport, consumables, book and journal purchases additional to legal deposit copies received, capital equipment, buildings, and waste.

Energy consumption is often considered the prime culprit in environmental sustainability discussions, in both digital and physical preservation. This is represented, for the most part, in the utility services category. Digital preservation discussions often focus on server usage and storage, whilst physical discussions focus on high density storage and climate control. Environmental LCAs seek to quantify the full environmental impacts across all life cycle stages of a product or service. Our LCAs therefore include direct GHG emissions on site (scope 1 emissions in the Kyoto Protocol), emissions occurring off site resulting from the supply of electricity and other energy (scope 2 emissions) and indirect emissions from the wider supply chain (scope 3 emissions). Thus, the GHG emissions resulting from use of a third-party vendor to undertake preservation work offsite on our behalf are also included.[1]

The capital equipment category includes data about GHG emissions and other environmental impacts associated with the hardware and machinery we use, not just for storage but also for collection processing. The transport category on the other hand includes staff travel for work purposes, including not only travel into work for activities that must be conducted onsite, but also travel to other sites, business meetings, and conferences elsewhere, as well as physical transportation of collection content where necessary. The waste category meanwhile includes data about the electronic and physical items that we dispose of, including hardware and electronic handheld media as well as physical inserts and cases.

As our experience of undertaking assessments grows, we will review and refine our initial list of factors to identify those which are most relevant and share them with the wider community. This open and transparent way of working should enable reproducible reuse of our methodology, growing the

[1] Full descriptions of different emission types can be found in the Greenhouse Gas Protocol, p. 25 [20]

overall evidence-base to better support informed decision-making for good preservation practice in the future.

F. Economic and social factors

In addition to the environmental impact assessments, work has also begun on social impact identifiers. The project team has developed a core set of social indicator categories, divided across three major social groupings: workers, society, and readers/service users. These are consistent with the original 2009 social lifecycle assessment guidelines from UNEP, and the revised 2020 version [9]. Our core set is comprised of thirteen indicator categories, (e.g. service accessibility, engagement with local community, and workplace health and safety), and will be populated with data for approximately thirty quantifiable criteria such as access to services for alternatively abled users, number of local people participating in services, and recorded health and safety incidents.

Social indicators from the top-level organisational assessment will provide a rich picture of overall social impact. The detail of the print-versus-digital question is expected to feature mainly in subsequent, lower-level collection-specific assessments, utilizing subsets of social indicators relevant to particular functional units or lifecycle stages.

Work to identify economic factors remains in its early stages. We expect to incorporate not only factors to represent internal expenditure but also to explore the wider socio-economic impact. Examples of such are seen in previous 'return on investment' reports such as that from the British Library [21]. Defining more nuanced economic indicators may allow us to assess cultural heritage institutions in terms of both private and social value, for example, by tracking downstream reuse of openly licensed items to explore how collections generate cultural capital and knowledge diffusion [22]. Similarly, open licensing models in the heritage sector can yield indirect economic benefits through enhanced fundraising, audience development and new partnership opportunities [23]. Integrating these approaches into our LCSA framework would ensure that economic indicators reflect both cost recovery and broader social returns.

G. The (literal) scale of the challenge

ReVerDi is an ambitious project with a relatively small budget and staffing complement. Many of the challenges we describe above are as relevant to small organizations as they are to national libraries. The one great difference however is the scale of our operations, which manifests in different ways.

Operations at scale require significant amounts of organizational resource that do not always or consistently map to specific collections. As a result, one of the more challenging aspects to collection-level assessments is extrapolating representative organizational data from the overall datasets. For example, equal opportunities data often exists at an organisational or departmental level, yet collection processing or preservation work is commonly undertaken in several different departments and across multiple lifecycle stages. To count only those staff who work in a department on a given collection would require additional data collection and may present a misleading overall picture.

A similar observation may be made in relation to usage data for a collection, particularly given the long-term nature of national libraries and the inevitable 'peaks and troughs' of collection content use over time. This too is a scale issue, but a longitudinal one. Assessment timeframe horizons of ten years, whilst justifiable, and practical for the project, may lead to misleading conclusions if considered without the context of our long-term role. This will be borne in mind as the project proceeds and explored in further depth to ensure results appropriately represent both the scale and the long-term nature of our collection and preservation mandates.

VI. Conclusion

The ambition of the ReVerDi challenge is comparable with our mandates, not only as long-term memory organisations but also our national roles and the national relevance of our collections. The uniqueness of ReVerDi for our sector is the new perspective it brings to sustainability discussions, not only in digital preservation but in the cultural

heritage field in general. For organizations with a long-term mission, this tripartite perspective is essential: environmental sustainability balanced with economic sustainability for societal sustainability. It is a new form of the three-legged stool metaphor, with a holistic vision to underpin the longevity of our collections and our institutions, as well as our planet. Its evidence and data-driven approach will help inform a shift to more evidence-based decision-making for the future. By sharing our approach even in this early stage, we hope to involve more of the digital preservation and collecting community in our work as we move forwards.

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Acknowledgments

ReVerDi is funded through the Belmont Forum in conjunction with national funders in the Netherlands, UK and Switzerland. The main partners are the British Library (UK), the Koninklijke Bibliotheek (Royal Library of the Netherlands), the Schweizerische Nationalbibliothek (Swiss National Library), the University of Surrey, Technische Universiteit Delft (TU Delft), and Berner Fachhochschule (Bern University of Applied Sciences).

We are grateful to the following staff for their input to the discussions in this paper: Jan Bieser (BFH), Michael Day (BL), Emeline Lin (TUDelft), Jeffrey Love, (TUDelft), Nick Ilott (UoS) Marco Martens (KB), Richard Murphy (UoS), Matthias Nepfer, (NB), Uta Pottgiesser (TUDelft), Oliver Sievi, (NB), and James Suckling (UoS).