IIIEE Theses 2021:06

Environmental Sustainability in Digital Preservation of Cultural Heritage

Advancing a sufficiency approach for Cultural Heritage Organisations;
A case study of the Finnish Heritage Agency

Evangelia Paschalidou

Supervisor

Naoko Tojo

Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, May 2021

Published in 2015 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

ISSN 1401-9191

Acknowledgements

This thesis would have not become a reality without the contribution of a number of scholars and friends whose continuous support and counsel are difficult to put in words and contain within a page.

First of all, I am especially grateful to my supervisor Naoko Tojo, who read this study at various stages and offered tirelessly her valuable commnets on questions of contents and style. But is mostly of her inexhaustible understanding, reassurance and calming energy that this thesis actually came into life through a process that I really enjoyed. ありがとうございました Naoko!

I would like to express my deepest gratitude to Pirjo Hamari and Ismo Malinen from the Archives and Information Services of the Finnish Heritage Agency for their willingness to get involved from the beginning as the case study organisation in this project. Your genuine care and passion for the field fueled your excitement and finding the time, under these difficult conditions, to accommodate for the needs of the research.

And of course, sincere appreciations are going to all the interviewees from the Finnish network and abroad, who took the time to participate in the research, and for constantly seeking to enrich and serve the Cultural Heritage field, despite all the challenges.

To all the IIIEE teachers and staff for their direct and indirect encouragement, support and precious advice and guidance (academic and beyond), not just during the past thesis semester, but throughout the past two years, deserves a big special thank you! And, it wouldn't have been the same without my beautiful Batch26, and the joy to share this whole journey with you! For creating an amazing diverse family away from home, thank you! (Including my extensive B24, B25 and Mespom families as well. Can't wait to reunite soon, in Cologne, Brussels or Thessaloniki!)

I would also like to thank all of my friends in Greece, especially Ntina, Alex and Eleni, for being by my side in all my years of physical absence and making any distance disappear.

And lastly, but by no means least, I would like to thank my family, especially my mother Maria, my sister Theodora and my brothers Achilleas and Anastasios for their lifelong inspiration and continuous encouragement during all the period of my studies and for giving me always new internal motives for continuing and fulfilling my effort. A special thank you to my brother Christos and my father Symeon who have uniquely accompanied me in my academic path all these years! This is for you.

Abstract

Starting from the human and societal need to safeguard cultural heritage (CH) in order to connect to past generations' knowledge and human experience, digital preservation (DP) is a common practice undertaken by cultural heritage organisations (CHOs). DP is heavily relying on the use of information and communication technology (ICT) as the fundamental enabling equipment. However, ICT is coming with its own considerable environmental impacts, that are only expected to multiple due to the ongoing digital transformation in general, and of the CH sector in particular, that has been accelerated by the Covid-19 pandemic. The debate on the environmental sustainability of ICT suggests that short-term technological fixes through efficiency are not enough. Therefore, a sufficiency approach needs also to be taken by the CHOs, that will extend beyond the equipment, to the DP process as well. This thesis, by taking an exploratory case study of the Finnish Heritage Agency (FHA) –and specifically their Archives and Information Services (AIS) department– delves into the current practice of the CHO and how a sufficiency approach in DP can be advanced for the FHA by the surrounding network of actors and initiatives. A sufficiency framework for DP of CH was developed, based on a literature review on sufficiency and on the Pendergrass et al. (2019) framework for environmentally sustainable DP. This was further used to analyse the data from 20 interviews in total, with FHA practitioners and actors from their surrounding Finnish network. The analysis of the case study shows that first, a common understanding of a sufficiency approach needs to be disseminated among the network. Moreover, that a qualitative function is needed for sufficiency in the DP of CH with consideration of the ICT use environmental impacts. For this, the rich interconnections and inclusive organisational structures of the network's actors were found to potentially allow for a broader public participation in order the 'enoughness' of quality to be incorporated.

Keywords: Digital Preservation (DP), Cultural Heritage (CH), Information and Communication Technology (ICT), Sufficiency, Strong Sustainability, Cultural Heritage Organisation (CHO)

Executive Summary

The human and societal need to safeguard cultural heritage (CH) in order to connect to past generations' knowledge and human experience in general, is well-recognised and legally established as a value that needs to be preserved for future generations too (UNESCO, 2020; Khan et al., 2018). For this reason, the conversion of physical or analog objects of CH into a digital form has been a common practice for decades, taken up by Cultural Heritage Organisations (CHOs) —museums, archives, libraries, galleries— in order to preserve CH from natural degradation and ensure a continued accessibility to the CH material (UNESCO, 2020). However, digital preservation is heavily relying on the use of information and communication technology (ICT) as the fundamental enabling equipment, that is entailing its own considerable environmental impact (Pendergrass et al., 2019; Goldman, 2019).

Even though, ICT, as the vehicle for digitilisation of services, is perceived to be part of the answer to climate change (Mickoleit, 2010; Hilty and Aebischer, 2015; OECD, 2015), there has been a great ongoing debate around the environmental impact of ICT itself and its raw material and high energy demands, synopsised in whether efficiency improvements only will overcome the rebound effects (Higón et al., 2017; Pohl & Finkbeiner, 2017; Hilty et al., 2011). Is argued that ICT impacts mitigation needs to go beyond efficiency (Hilty et al., 2011; Pohl et al., 2019; Lange et al., 2020; Santarius et al., 2020) and that without an ecological sufficiency framework that acknowledges the finitude of natural resources, the overall ICT environmental impacts will not be minimised.

Is in this context that a fit-for-purpose balance between the ICT and the DP of CH needs to be reached. In 2016[1], the digital CH content preserved by museums and libraries globally, corresponded to an almost 2% of the data that is stored in data centers worldwide (Pendergrass et al., 2019). And this trend is yet projected to grow rapidly. With the 94.7% of museums forced to close their doors in the breaking of the Covid-19 pandemic, a 15% of them established their digital presence for the first time after the lockdown, while an approximately 40% still has no online collections and exhibitions and is expected to proceed to their digitisation (adapted from ICOM, 2020; UNESCO, 2020d). While CHOs are currently reimagining their activities, the environmental sustainability of their practice –that has hardly been problematised (Pendergrass et al., 2019)– needs to be explicitly integrated, and a sufficiency approach to be interpreted for the ICT use in the DP of CH, in order to be aligned to the very existential purpose of CHOs and their network (Winn, 2020).

An example of a CHO on the intersection of the above issues is the Finnish Heritage Agency (FHA) that is currently undergoing a dynamic process of establishing their new digitilisation plan and sustainability strategy, while leading an EU project for evaluating museum's impact and reshaping their mission in response to the changing societal demands. The respective Archives and Information department of the FHA offered an insightful background for this research, while the rich and well-organised network of actors around the Agency, highlighted the potential of the Network's influence in advancing a sufficiency approach in the CHO.

Aim and research questions

In order to link the debate on ICT environmental impacts to the process of digital preservation, this thesis aims to explore how *sufficiency* can be understood for the digital preservation of cultural heritage and what could be the potentials, from within the CHO's context, for advancing this approach in their practices, and, thus, for integrating environmental

[1] Author's own estimation based on data of Pendergrass et al. (2019).

sustainability. In order to reach this aim, the research seeks to answer the following research questions:

- RQ1: What is the current practice of sufficiency regarding the ICT use in DP of CH by the practitioners, of the Finnish Heritage Agency?

- RQ2: How the existing network of actors and initiatives surrounding the FHA, can support the advancing of a sufficiency approach, in the CHO's context?

Research design, materials, methods

For pursuing the aim of this thesis, a single case study design (i.e the Archives and Information Services (AIS) department of the FHA) was used with an exploratory approach, and taking into consideration multiple analytical units. In order to set the context of the study a comprehensive literature review was conducted with two foci; the first block of literature review to provide a background understanding of the environmental impact of ICT equipment, its mitigation and how it is discussed in the DP of CH with the 'Environmentally Sustainable DP Framework' by Pendergrass et al. (2019), and; the second block provided the background and factors for the sufficiency approach for DP of CH. The sufficiency theoretical layer was then applied on an elaborated version of the Pendergrass et al. (2019) measures, that resulted in the development of a sufficiency framework for the DP of CH by a CHO, utilised for this thesis.

To obtain a more holistic and profound understanding of the single case, the study includes four units of analysis; for documenting the practice among the AIS department (1) seven 'self-questionnaires' of Pendergrass and (2) eleven interviews were considered and; for contextualising their analysis in the surrounding network of actors and initiatives, (3) nine interviews were held with various actors and (4) a mapping of the network's development was drawn. The data from the AIS department were structured and analysed under the according axes of the sufficiency framework in order to synthesise what is their understanding of their current practice. Then the data of the network were also coded and analysed in order to further interpret and put in context the results from the FHA. The map that was developed with document analysis around the actors, strategies and initiatives in the Finnish context, provided the background for both the aforementioned analyses.

Main Findings

Structuring the measures in the axes' framework according to; the identified hierarchy of the component strategies for a sufficiency approach in the DP of CH and; the relevant DP stages of appraisal, preservation and accessibility, allowed to extract two main findings according to the research questions.

First, that the assessment of the documented practice according to the questionnaires, suggested that all three of the component strategies for sufficiency are somehow, partially manifested. However, discrepancies were revealed between the current understanding of the measures as found in the results of the questionnaires and the on-the-ground practices as uncovered through the analysis on the interview findings. Is important to highlight that the sustainability agenda has been adopted only recently in the organisation's context, and in the CH sector, on an administrative level, in general.

Specifically, it was shown that; (1) the qualitative function for the *sufficiency strategy* is not manifesting because the engagement of the users with the content is followed up in numbers only and the value quality is not understood in that; (2) the *DP-efficiency strategy* was reported as currently being considered mostly on the Archives and Information Services' level of

preservation, but its extension is restricted due to interdependencies with the long-term preservation outsourcing service (DPS). DPS's inherent differentiation in DP preservation technical standards hinders qualitative nuances to be factored in and to decrease the resources throughput of their preservation. Also, (3) the *efficiency strategy* is perceived as the 'mainstream' sustainability approach to be taken in respect to the ICT use for DP, however it is not understood as happening from within the sufficiency strategy context (because the value quality function, needed according to the hierarchy for a sufficiency approach, is missing). Finally, an overarching observation on the above findings is the decision-making structure (e.g. for the quality standards of the digitised material) that is restricted within the CHO and the network, hindering the sufficiency uptake from the ground level of the users.

Secondly, the above analysis was put in the context of the network of actors and initiatives surrounding the FHA and the AIS department. Positively, all three of incentivising factors for the uptake of sufficiency –the long-term perspective, the need-driven nature of the organisation and an extensive application basis– are *fundamentally aligned* with the very nature of the CHO. For sufficicency to happen, though, the qualitatitve function (i.e. the level of preservation quality and the value quality extracted by the end-users, as defined in all three sufficiency-component strategies) needs to be induced further. The discussion of the opportunities and challenges presented in the network's context, with the above three factors, concluded in one overarching potential for advancing sufficiency; the *highly interconnected network* of actors and initiatives with their *inclusive organisational structures*. This could instigate the qualitative function by allowing for a broader participation of the public in the DP processes decision-making and by offering their insights of what content and preservation quality is enough to access for satisfying their respective needs in the highest value quality. Anyhow, *intentionality*, should underline any measures taken, otherwise, sufficiency is hard to manifest predominantly in the CH sector, even if there is an inherent propensity.

Conclusions and recommendations

The analysis of the case study shows that firstly, a common understanding of a sufficiency approach needs to be disseminated among the network. Moreover, that a qualitative function is needed for sufficiency in the DP of CH with consideration of the ICT use environmental impacts. For this, the rich interconnections and inclusive organisational stuctures of the network's actors were found to allow for a broader public participation in order the 'enoughness' of quality to be incorporated. Based on these remarks, recommendations for the intended audiences were made:

For the Archives and Information Services department and the Finnish Heritage Agency – The results suggest that the Agency being in the process of developing their digitisation policy, can move dynamically to the measures they have already been considering, and which are falling under the DP-Efficiency strategy of the framework. This could further influence their partners, as FHA is founding themselves in the middle of more than one initiatives (i.e. Digime and Sustainbale Agencies). They could play a key role in adopting a value quality perspective in their in-house practices, especially in the appraisal and accessibility stages, by encouraging the direct involvement of the public and their end-users. Finally, the museums' impact assessment tool that they are currently elaborating together with other CHOs and stakeholders, could also be used as a tool for capturing the value quality extracted from the public and society at large.

For the CH Actors in Finland – For integrating interdisciplinarity and creating a common understanding and language around the environmental issues of ICT and DP and the sufficiency approach, across-network working groups or smaller scale projetcs and collaborations can be launched with academia and research foundations. For advancing the qualitative function for a sufficiency approach through their already established Finna interface, surveys or new

participatory tools can be taken up as a way to involve the public actively as a key actor. This would advance the CHOs external communication with the public. Internally, within the CHOs, the organisational structure can become even more inclusive, by encouraging further the openness and bottom-up initiatives establishing transparent streams of communication. In addition, acting commonly, as a network, upon the new Climate and Environmental Strategy for the ICT Sector can be pursued on the basis of the above points.

For Finnish and EU policymakers – For ensuring sustainable public procurement, the use of environmental criteria must become mandatory in all public services, supported by the standardisation of processes, while must be extended beyond hardware, to shoftware as well. For the Finnish specific context, the Sustainability Reporting must be followed-up for funding in DP projects. Lastly, since there is a great overlapping of the ICT issues across sectors, ministries should elaborate in collaboration on the strategies implementation plans.

Table of Contents

List of Figures

List of Tables

Abbreviations

AIS – Archives and Information Services

AIP – Archival Information Packages

CH – Cultural Heritage

CHO – Cultural Heritage Organisation

CMS – Content Management System

CSC – Center for Scientific Computing

DNG – Digital Negative

DP – Digital Preservation

DPS – Digital Preservation Services

DIP – Dissemination Information Packages

EC – European Commission

EU – European Union

FADGI – Federal Agency Digitization Guidelines Initiative

FHA – Finnish Heritage Agency

GHG – Greenhouse Gas

GPP – Green Public Procurement

Hi-Res – High Resolution

HPC – high performance computing

ICH – Intangible Cultural Heritage

ICOM – International Council of Museums

ICT – Information and Communication Technology

IPCC – Intergovernmental Panel on Climate Change

ISO – International Organization for Standardization

JPEG – Joint Photographic Experts Group

JRC – Joint Research Center

LAMs – Libraries, Archives and Museums

LED – Light Emitting Diode

LCA – Life-Cycle Assessment

LTP – Long-Term Preservation

MDC – Modular Data Center

MOI – Museums of Impact

NAF – National Archives of Finland

NDL – National Digital Library

NDPS – National Digital Preservation System

NLF – National Library of Finland

OECD – Organisation for Economic Co-operation and Development

OIAS – Open Archival Information Systems

OSS – Open Source Software

PUE – power usage effectiveness

TIFF – Tag Image File Format

UNESCO – United Nations Educational Scientific and Cultural Organization

1 Introduction

The Digital Era that humanity has entered after the second half of the 20th century, is characterised by an ever-increasing technological evolution pace –from analog and mechanical to electronic– followed by an accessibility to huge amounts of information through computer and communication technology, like the Internet of Things (OECD, 1998). These advancements are radically transforming the established ways of operating businesses, organizations, institutions and societies as a whole, as well as of communication and every-day human experience in general (OECD, 1998). Indicative is that the internet users globally are counting for a 4.54 billion in 2020, presenting an increase of 7.1% compared to 2019, and a 59% penetration in the total population (We Are Social, 2020). This trend as part of the broader technological innovation is only projected to accelerate the undergoing digital transformation, while the Covid-19 pandemic has acted as an intensification catalyst, estimated to have condensed 5 years of digital innovation into just 3 months (Baig et al., 2020).

In parallel to digitilisation, anthropogenic climate change and pressure on the natural resources are also picking up pace. The current patterns of human development are threatening the stability of Earth's system by altering fundamental biophysical processes and pushing to the thresholds of the respective boundaries (Steffen et al., 2015). If human existence is to be ensured in a viable planet that will provide the necessary resources for human societies to develop, a new paradigm of meeting the needs should be pursued, based on the biophysical boundaries (Steffen et al., 2015). In this respect, a great focus has been placed on the massive energy and resources saving potentials lying in optimisation and virtualisation practices (Pohl & Finkbeiner, 2017 to; Mickoleit, 2010) that are perceived as an answer to climate change (Hilty and Aebischer, 2015; OECD, 2015) and a support to the environmental sustainability goals of various sectors (Osburg & Lohrmann, 2017; Ringenson, 2021).

In order to assess this potential, the current discourse on the intersection of digitilisation and environmental sustainability has been mainly centered on the role and impacts –both direct and indirect– of Information and Communication Technology (ICT), which is the core digitilisation-enabling technology. ICT can be perceived as the material reflection of the intangible digital content, that is being processed, stored and accessed via all the interconnected technological infrastructure, ranging from personal computers, to data centers, to satellites. This bigger picture of the ICT environmental impacts should be understood and serve as a context for discussing the environmental sustainability of any ICT-related process or activity, especially for informing more holistically any techno-fix stance.

More specifically, the sustainability debate over ICT has been mainly around; the environmental impacts of ICT itself (Higón et al., 2017) regarding raw material and high energy demands of such equipment (Pouri & Hilty, 2018); the rebound effects from improvements in the ICT technology and in the other processes as enabling technology (Pohl & Finkbeiner, 2017) and; the mitigation potential of all these impacts through efficiency improvements (Hilty et al., 2011). It is the third point that synopsises the essence of the current ICT-sustainability problematisation across multiple disciplines.

Reflecting on the above, the need for a complementary approach beyond ICT technological fixes and for incorporating a sufficiency perspective emerges in the literature with an ever-increasing frequency (Hilty et al., 2011; Pohl et al., 2019; Lange et al., 2020; Santarius et al., 2020). This means that any ICT efficiency increasing strategy should be attempted from within a sufficiency framework, that will be accounting for the finite resources (Hilty et al., 2011). The term sufficiency stands for an ecological sufficiency approach (or eco-sufficiency, used as 'sufficiency' hereafter in the text) that acknowledges the finitude of natural resources and aims

at energy and material throughput absolute reductions.[2] Additionally, it is argued that an 'active political and societal shaping of digitilisation is needed' to complement any technological efficiency strategies if they are to minimise the overall ICT environmental impacts (Santarius et al., 2020) p.20). For a sufficiency perspective to be applied, still, a different view on defining human needs should also be pursued (Barry, 2012; Cafaro, 2018; Throop, 2016).

The above becomes even more complex in the case where ICT is the enabling technology to businesses and organisations that have digitilisation in their core process. In those cases, any adoption of a sufficiency framework extents beyond the production and use of the ICT equipment itself, given that ICT equipment is so deeply entrenched in the working processes of these organisation. Therefore, the way the organisational processes are designed to make use of ICT is further determining its direct and indirect environmental impacts. If the processes are designed for efficiency or sufficiency reflects simultaneously how the organisations are choosing to fulfil their purpose and respond to their consumers' or users' needs (Heikkurinen et al., 2019; Robra et al., 2020) while the same goes for ICT-enabled businesses or organisations.

One representative example of ICT-enabled practice is the Digital Preservation (hereafter DP) of Cultural Heritage (CH). Converting physical or analog objects of tangible and intangible, movable and immovable CH into a digital form has been a common practice for decades, taken up by Cultural Heritage Organisations (CHO) —museums, archives, libraries, galleries— in order to preserve CH from natural degradation and ensure a continued accessibility to the material (UNESCO, 2020). But, since the production of this digital content is dependent on the use of ICT, it is not free from material resources and energy consumption. The environmental impact of ICT can be used as a strong indication for understanding the environmental impacts of DP of CH processes and mitigate them in order to advance the environmental sustainability of the process itself.

However, sustainability in the context of DP at the present, is mainly discussed by the practitioners as financial, staffing or organisational sustainability (Pendergrass et al., 2019). The materiality of DP environmental impacts in the CH sector has been hardly problematised since the links to the material reflections of the 'immaterial' digital CH content may not be obvious to draw or are considered an insignificant percentage of the total digital content volume (Pendergrass et al., 2019). Nevertheless, given the climate emergency and the urgency of action needed to be taken within the coming decade (IPCC, 2015; IPCC, 2018), concerns from the field of archiving and digital preservation have been raised, questioning the current mondus operandi of the field and urging the sector to consider their environmental impact too (Pendergrass et al. 2019).

Both the Covid-19 pandemic and the digital-centric strategies for climate action, are spurring DP of CH to new heights (UNESCO, 2020a). Undeniably, disseminating openly traditional knowledge and cultural reconnection to past practices is holding part of the answer in building more resilient, stronger and sustainable ways of experiencing life (Tully, 2020). However, a fit-for-purpose balance between the ICT use for DP and fulfilling the preservation and availability needs of the CH digital content must be reached, without disregarding the environmental sustainability of the practice itself, while increasing value of the CH. Based on the ICT discussion for a sufficiency approach, this thesis aims to look into how sufficiency can be understood in DP of CH along with the potentials for advancing this approach in the DP practices by delving into the real context of a CHO and its surrounding network. Linking the discussion around sufficiency in the ICT field, to the DP of CH practice and to the practitioners'

[2]As will be further explained under section 3.2.1.

empirical context in the CHO, the potential entry points for advancing sufficiency in the CHO will be also identified, in relation to the CH network too.

1.1 Background and Problem Definition in the context of Digital Preservation of Cultural Heritage

"There is no history – no interrogation of the past by the present – without archives. Without archives, there is no memory, justice or reconciliation." (Xing Qu, 2020)

As manifested by the words of UNESCO's Deputy Director-General quoted above,[3] archiving is well-recognised as a crucial element of humanity's memory and existence. Digital archives of CH are serving as evidence of the cultural identity and of the expressed perceptions of a given community at a given time and space. On another level, accessing and experiencing the historical, artistic, scientific, or other kind of such documented memory, enables the understanding of past generations, and, furthermore, by reenforcing the relatability to these generations, enhances the openness and co-existence skills of the current generations (Khan et al., 2018). In order for this value to be preserved for the future, the protection of CH is legally established in a number of UNESCO's conventions each one usually addressing or focusing on a different legal object matter, like the World Heritage Convention (UNESCO, 1975), the Convention for the Safeguarding of the Intangible Cultural Heritage (UNESCO, 2003) and the Hague Convention (UNESCO, 1954), while a number of CHOs[4], like museums, archives, libraries, galleries, are responsible for their implementation.

The variety of assets covered under the term of CH in the different pieces of legislation is rather broad and the number of actors responsible for their management matches this breadth while their operations are extending in multiple levels of the sector, private or public, national or international. According to UNESCO (2020), Cultural Heritage is defined (non-exhaustively) as "all tangible cultural heritage like: movable cultural heritage (paintings, sculptures, coins, manuscripts), immovable cultural heritage (monuments, archaeological sites, and so on), underwater cultural heritage (shipwrecks, underwater ruins and cities); all intangible cultural heritage: oral traditions, performing arts and rituals and; natural sites with cultural aspects such as cultural landscapes, physical, biological or geological formations", while it is estimated that only the museums operating globally are counting around 95,000 (UNESCO, 2020b).

This higher value that needs to be safeguarded in the great variety of assets bearing it and the vast amount of different CHOs undertaking their preservation, explains the hundreds of digitisation projects that have been launched. A rough estimation with data of 2016[5], accounts that the CH digital content preserved by only museums and libraries globally, corresponds to almost 2% of the data that is stored in data centers worldwide. And this trend is yet projected to grow rapidly. The digital transformation undergoing on the CH sector is being accelerated (1) by the harshening of climate change phenomena putting CH directly at risk and (2) by the outbreak of Covid-19 pandemic highlighting resilience as a key-feature for the future (Tully, 2020). For instance, with the 94.7% of museums forced to close their doors in the breaking of the pandemic, a 15% of them established their digital presence for the first time after the

[3] From the online dialogue "UNESCO Policy Dialogue on Safeguarding Documentary Heritage at Risk", 27th of October 2020, accessed November 19, 2020, https://www.youtube.com/watch?v=7unG4nZ-Xbs

[4] CHOs can be museums, archives, libraries, etc, focusing on the CH object management itself –as a narrower definition to the umbrella term "memory institutions" which is more broadly used to stress the common purpose of institutions "to manage cultural heritage collections in order to satisfy societies' needs to remember" (Manžuch, 2017, p.2)

[5] Author's own estimation based on data of Pendergrass et al. (2019).

lockdown, while an approximately 40% still has no online collections and exhibitions and is expected to proceed to their digitisation (adapted from ICOM, 2020; UNESCO, 2020d).

However, as mentioned above, DP is relying heavily on ICT use. Therefore, all this increased production of digital content will result proportionally in increased demands of such equipment to accommodate the processing, storage and accessing needs, which in turn are being translated into increased resources and energy consumption (Goldman, 2019; Hilty et al., 2011; Pendergrass et al., 2019). Even though environmental sustainability is greatly aligned to the very existential purpose of DP of CH and of CHO (Winn, 2020), environmental sustainability considerations are currently found to be absent from the decision-making standards for DP of CH that CHOs are following,. In order to address the mitigation of the ICT environmental impacts in the current context of DP of CH, the debate over ICT's environmental impacts mitigation –either through efficiency increases or coupled with a sufficiency approach– should be considered and operationalised proportionally for the DP processes. This, however, has not yet been discussed systematically, in the DP activities.

The current EU political momentum on the intersection of the Digital Decade Strategy (EC, 2021), the Green Deal (EC, 2019) and the soon-to-be-updated Recommendation on the DP of cultural material, suggests that the discussion of environmental sustainability of DP needs to be raised now. This opportunity is better to be seized at the present, when these policies and practices are still being formulated and before they are concretised. The above gap is also confirmed by the recently increasing interest of international organisations, like UNESCO, to build up an "international policy agenda for digital preservation of documentary history" (UNESCO, 2020e) that among others, will be considering environmental changes and resilience of the cultural heritage sector.

CHOs, who are soon to implement these developments, are the main actors defining the decision-making standards of DP of their ad hoc practice. They are the best-positioned to inform such a discussion with their practical insights on the ICT-use for fulfilling their purpose, while introducing change in the ICT-use via their decisions on the DP processes. And this is well-aligned with their constant need of reimagining and reinterpreting their core-mission and impact in order to meet the public needs, proving so already, with actions they have initiated (e.g Museums for Future, Climate Heritage Network).

An example of a quite active CHO is that of the Finnish Heritage Agency (Museovirasto-hereafter referred to as FHA or the Agency). FHA is currently undergoing a dynamic process of establishing its new digitilisation policy, while being engaged in an EU project for evaluating museum's impact and reshaping its mission in response to the changing societal demands. This case offers an insightful background for this thesis to document the current practice of ICT that could reflect some sufficiency or efficiency approaches, implemented consciously or not. Also, due to the rich and well-organised network of actors around the Agency, a holistic understanding of the Network's influence in advancing a sufficiency approach in the CHO can be offered by drawing a valuable mapping of the Network surrounding the FHA, and of the strategies already in place.

1.2 Aim and Research Questions

The aim of this thesis is to explore how *sufficiency* can be understood for the ICT use for Digital Preservation of Cultural Heritage, and the potentials, from within the Cultural Heritage Organisation's context for advancing this approach in their practices and, thus, for integrating environmental sustainability.

In order to reach this aim, the study seeks to answer the following research questions:

- RQ1: What is the current practice of sufficiency[6] regarding the ICT use in DP of CH by the practitioners, of the Finnish Heritage Agency?

- RQ2: How the existing network of actors and initiatives surrounding the FHA, can support the advancing of a sufficiency approach, in the CHO's context?

The first question intends to explore the current practice in the focus department of the FHA, with the input of the practitioners' 'self-questionnaires' and interviews in order to understand the reality of the practice and their awareness. Then the analysis of this understanding will be taken to the CH network context in order to explore how this network could support the uptake of a sufficiency approach by the FHA.

1.3 Scope and Limitations

This research project is exposed to a new complexity that Covid-19 created by uncovering interconnections among issues that, until recently, were faced separately and by individual disciplines. Environmental sustainability of ICT use is gaining ground as a more and more relevant topic in more sectors that are now hastening their digital transformation. This is why the scope of this research object lies on the nexus of ICT and Digital Preservation fields, seeking to make the links between the mitigation approaches to ICT use and their specific manifestation in the context of DP of CH. Due to the deeply interdisciplinary nature of the research problem, the further implications on a CHO's level and the sufficiency potentials would be better investigated and elucidaded in depth by taking a case-study approach (Creswell, 2014; Yin, 2014; Bryman, 2012).

Thus, a case study of a specific CHO, the Finnish Heritage Agency, was chosen. Within the boundaries of this CHO and more specifically, its department of Archives and Information Services (AIS or the Department hereafter), that is mostly engaging with the DP, a documentation of the practices among the practitioners was performed.

However, because of the great variety in the CH assets, as well as, in the nature and foci of the various CHOs dedicated to them, a more holistic understanding, deemed necessary and useful to get, by including more actors of the broader CH and DP Network. Geographically the scope remains limited in Finland. Therefore, the National Library of Finland (Kansalliskirjasto) and the National Archives of Finland (Kansallisarkisto), that are operating on the same administrative level as the FHA, enriched the research perspective. Stakeholders from the Ministry of Education and Culture of Finland, CSC –the IT Center for Science– and the Sitra Innovation Fund (Suomen itsenäisyyden juhlarahasto) provided valuable insights on the Finnish CH and DP and ICT landscape.[7] As such, it is noted that the collected data and the mapping of the network of actors are corresponding to the particular structure of the FHA, of the CHOs internal administrative structure and in general the particular Finnish landscape of actors in DP of CH and ICT.

Moreover, DP is consisted of many different, successive, decision-making stages. According to the specific purpose of DP use (meaning the produced digital content), which may be intended e.g. for preservation, for downloading by the user, for active online interaction etc, different stages and actions are to be followed for DP. This study approaches the DP stages in the way they are identified in the framework of Pendergrass et al. (2019) –that is appraisal, preservation

[6] The way it will be interpreted through the component strategies, under section 3.2.3.

[7] The whole system studied will be extensively laid out under chapter 4.

and accessibility— and maps the sufficiency approaches on these three fundamental DP stages, as explained under section 3.3.

The above two choices on the employed research method and on the framework, even though they are offering a realistic and well-defined context to explore the problem, at the same time are presenting limitations in the generalisability of the results. Studying only one specific CHO makes it hard to capture finer issues that may apply to other CHOs, of a different legal nature and purpose (private, and/or profit driven) and with different CH objects of focus. Moreover, adopting the framework by Pendergrass et al. (2019) as a tool for documenting the sustainable practices among the actors within the organisation, is unlikely to capture in detail all the practices followed in the multiple and complex various stages of DP that may be defined by different CHOs and practitioners.

Finally, a great limitation is that the understanding of the CH network in Finland unfolded along and throughout this research. Thus, it is recognised that not all the CHOs operating on the same administrative level as FHA and actively discussing the environmental sustainability of their practices, were included in this research, e.g. the Finnish Museums Association (Suomen museoliitto). Also, the number of practitioners participating from the other actors of the Network is indicative, but, still substantial according to the research design, i.e. to develop a network-understanding and not a thorough comparison with FHA. This will be further elaborated under chapter 2 of the methodology.

1.4 Ethical Considerations

For ensuring good practice in respect to the research itself and the engagement of the participants, the core ethical principles as presented by Blaikie & Priest (2019) have been adhered to, and the ones considered relevant for this research are addressed below.

The study was conducted in collaboration with and support of the Finnish Heritage Agency, which is operating under the Ministry of Education and Culture of Finland. Due to the Covid-19 pandemic the project was conducted completely remotely. No funding was agreed upon, but the FHA and the other collaborating Agencies, provided all the necessary document access and time resources for the data collection on their side. The author designed the research topic herself, taking into consideration the FHA's current mission statement and projects, but the analysis and subsequently the conclusions were not influenced in any way by the FHA. The FHA is a public organisation with strong ethical values themselves and no external interests risk research integrity since the project was autonomously pursued by the author and research integrity has been safeguarded consistently.

All the interviews and informal discussions were held voluntarily and informed consent of the interviewees and discussants was granted verbally by the beginning of the discussion. The aim of the research and the intended use of the results were communicated in written prior to the interview. Permission to record, take notes and quote their professional position was obtained along with a confidentiality statement in advance, while ensuring anonymity. Transcripts of parts of the interviews and quotes used in the analysis, were shared with the participants, in order for them to remove any information deemed sensitive or presented in an unwanted way, even though no sensitive information apart from names and professional position within the organisation was obtained. It was also communicated that they may choose not to answer or to discontinue their participation in the research. So, various arrangements were made, to ensure that all participants were feeling comfortable and may not suffer any disadvantage or get harmed from their participation in the research. Data were stored on a personal external hard drive and a duplicate will be kept on OneDrive cloud service, provided by the Lund University.

Finally, this research design has been reviewed against the criteria for research requiring an ethics board review at Lund University and has been found to not require a statement from the ethics committee.

1.5 Audience

Since this thesis has been focusing in one CHO, the intended audience is primarily consisted of the Finnish Heritage Agency and the Department of Archives and Information Services. The results of this thesis can be of relevance to the broader CH actors' Network in Finland identified into; the National Library and the National Archives of Finland, the Ministry of Education and Culture and the organisations with which they are collaborating on the DP of CH initiatives, in a national and international level.

The output of the sufficiency framework for the DP of CH by CHOs could also be of interest to policy makers, who are undergoing a process of developing a strategy integrating ICT environmental considerations into DP processes and in the CH sector in particular.

Additionally, as a Master's thesis, this research is also addressing an academic audience with an interest in ICT environmental sustainability and DP of CH. By addressing the knowledge gap of a sufficiency approach for the DP of CH sector, the sufficiency interpretation could be further developed and implemented in the broader ICT sector.

1.6 Disposition

In this *Chapter 1*, the broader issue of ICT-use and its environmental impacts and mitigation is introduced, followed by the identification of the problem for the CH sector. Then, the aim and the research questions for the research are presented, while the scope and limitations faced are clarified. Any ethical considerations and the intended audience are also described, along, finally, with an outline of the thesis.

Chapter 2 explains the methodology employed based on the conceptual and research map that is presented. It also justifies the choice of the exploratoty case study as well as of the data collection and analysis methods.

Chapter 3 initially reviews, the background literature on the ICT environmental impacts and their mitigation, to subsequently link them later to the DP of CH context by presenting the framework of reference for environmental sustainability in DP of CH. A literature review on sufficiency is additionally conducted in order to reach an interpretation to be used with the first part and develop the sufficiency framework that will be used on the following chapters.

Chapter 4 presents the findings from the case study organisation and the surrounding network of actors. The findings are divided in three parts, with the first and third one corresponding to RQ2 and the second to RQ1. The findings are further structured and analysed using the broader categories of the sufficiency framework, depending on the data presenting.

Chapter 5 interprets and further discusses on the findings, from the theoretical background and following the structure of the research questions. Additionally, the methodological choices are reflected upon, considering the related limitations.

Chapter 6 provides answers to the problem and research questions, summarizing the importance of the findings and concluding with recommendations for the distinctive audiences as well as for the future research potentials.

2 Methodology

In this chapter the methodology developed for this research is presented. First, the conceptual map of the problem along with the steps of the research process are laid out. Second, the choice of the case-study is explained. Then the selected methods for data collection and data analysis are detailed.

2.1 Conceptual and research map

This research is being guided by the aim to explore how a sufficiency approach can be advanced in the organisational level of a Cultural Heritage Organisation, in order to integrate environmental sustainability in DP of CH. The research subject by its nature is crossing several fields (Environmental Sustainability, ICT, Digital Preservation, Cultural Heritage Organisations, Sufficiency) and explores how sufficiency can be understood and implemented in the context of a CHO. In this respect, the research questions are aiming to synthesise the mosaic of the above elements by making explicit the ways they are connecting to each other.

Sufficiency can be discussed on different levels in the case of ICT in DP by a CHO; (1) on the level of production and consumption of ICT as equipment itself, (2) on the level of use of this equipment for another process (i.e. DP), and finally (3) on an organisational level of how a CHO organises the DP processes of appraisal, preservation and accessibility in respect to the ICT environmental impacts in order to fulfill its purpose and the public's needs. In particular, stricto sensu sufficiency as a strategy itself, is detected on the stages of Appraisal and Accessibility, as will be explained later, under Section 3.5. A visual representation of the conceptual map can be found under Figure 2-1.

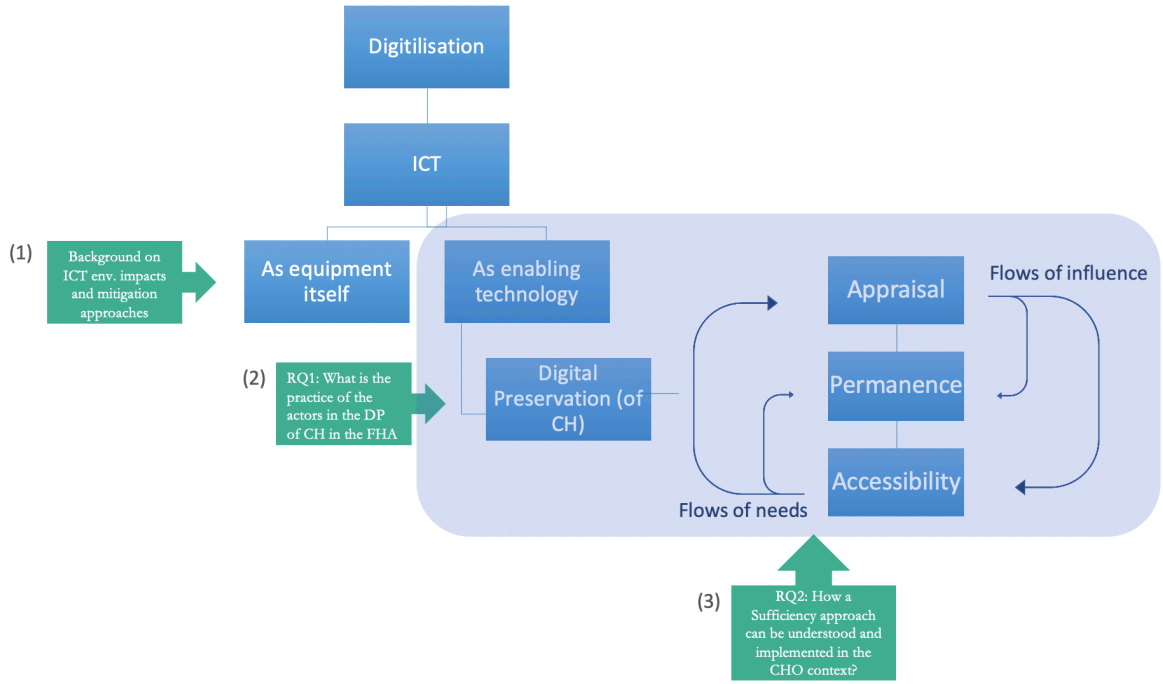

Figure 2-1. Visualisation of the concepts and RQs map

Source: Author's own creation

The area of focus in the case study lies within the light blue space, indicated on the figure above. In order to address the research questions a stepwise approach is followed, where the results of the first step are a prerequisite for providing the material basis of the second step. Also, different

methods in multiple levels were combined in the background to make up the process for answering each RQ. These steps and the materials used into each RQ are summarized in the Figure 2-2.

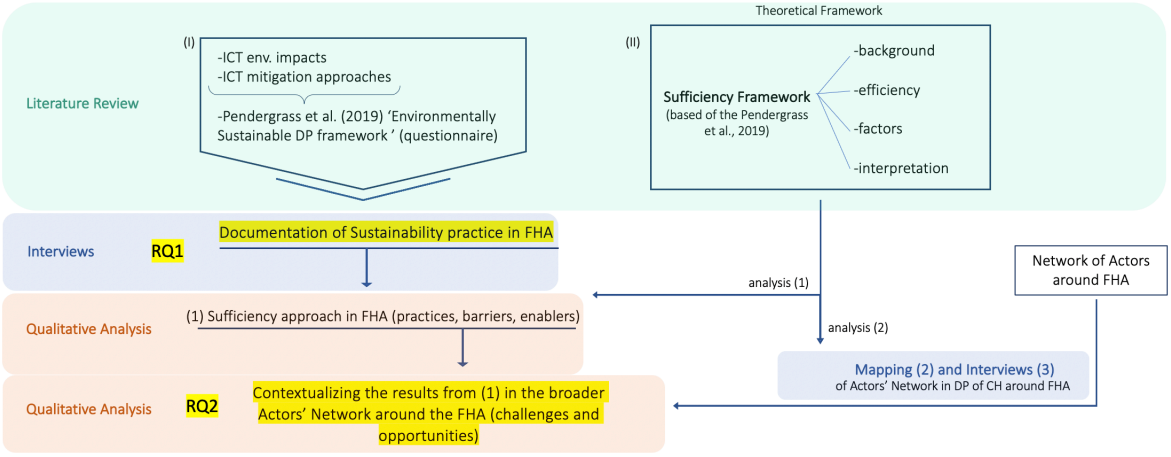

Figure 2-2. Visualisation of the research steps, materials and process map

Source: Author's own creation

First, in order to answer **RQ1- What is the current practice of sufficiency regarding the ICT use in DP of CH by the practitioners, in the case of the Finnish Heritage Agency**, the background on the environmental impacts of ICT equipment itself and the issues around their mitigation are presented (literature review n. I and under section 3.1). This first research step of the research introduces the main issues when discussing the ICT sector's environmental impact and the current understanding and mitigation approach in the DP context.

In order to take this discussion in the context of DP by CHO, the 'Environmentally Sustainable DP framework' of Pendergrass et al. (2019) with its 'self-questionnaire' for reflecting on improvements towards environmentally sustainable DP, is introduced and is utilised as a practical tool to capture and document the practices in ICT use and DP processes. The use of the basic structure of Pendergrass et al. (2019) framework for building the interviews, enabled a systematic documentation of the current state of DP sustainability practice by the actors interviewed in the FHA context. After the initial 'screening', a more detailed documentation of the practice was further conducted with the initial open-ended 'self-questionnaires' as had been developed by Pendergrass et al. (2019) (Appendix I).

The Pendergrass et al. (2019) framework and the 'self-questionnaire' were chosen for capturing the issues from the broader ICT sector as reflected into the CH DP context of interest, for two reasons; (1) it was the only existent framework, most relevant to the topic–to the best of the author's knowledge– and; (2) the questionnaire had the practical advantage to be flexible as a tool, and easy to adjust to the targeted participants. The Pendergrass et al.'s (2019) framework was also elaborated further according to the literature review around sufficiency (literature review n. II and under section 3.2) in order to serve as the basis for the theoretical framework of the study. The Sufficiency Framework for DP of CH that was developed (section 3.3), was used both for assessing the findings of the documentation through the self-questionnaires as well as for analysing the findings from the interviews qualitatively (analysis 1 and under section 4.2).

This analysis was utilised for answering **RQ2: How the existing network and initiatives surrounding the FHA, can support the advancing of a sufficiency approach in the CHO's context.** In order to understand the results of the analysis (1) to the FHA, in respect to their real context, a map of the Network of actors and initiatives around the FHA influencing the DP of CH processes was created (section 4.1). The findings from the interviews with the Network Actors (interviews 3) were also analysed with the Sufficiency Framework for DP of CH, as challenges and opportunities to the FHA practice (analysis 2 and under section 4.3). Finally, this enabled the identification of potential entry points for sufficiency.

2.2 Exploratory case study research

For pursuing the aim of this thesis, a case study method was used with an exploratory approach. According to Yin (2014) a case study research is recommended for understanding and investigating in depth the empirical occurrence of the studied material in contemporary events with no control over them. The empirical nature of such inquiry favors especially its use for answering exploratory 'what' and 'how' or 'why' questions which are approaching an under-researched phenomenon by providing descriptions along with relevant analysis (Yin, 2014). The rationale of such an exploratory approach is particularly found on the lack of data, which is usually the case for a newly developed field of study (Streb, 2010), looking to develop "pertinent hypotheses and propositions for further inquiry" (Yin, 2014, p.10).

The subject of this research is well-aligned with the above characteristics of an exploratory case study. First, the purpose is to understand in depth the occurrence of sufficiency and efficiency practices regarding the ICT use in DP of CH, in the realistic context of the Finnish Heritage Agency in order to identify how a sufficiency strategy could be advanced and implemented. A case study method has been commonly used in the literature in order to approach sufficiency from a business strategy and a business model perspective (e.g. Robra et al., 2020; Bocken & Short, 2020; Bocken & Short, 2016). As a sufficiency strategy has not been studied or discussed for the DP or for the CHO contexts, it was deemed appropriate to use a case study research method for this study. Similar to the abovementioned literature, this study is also investigating a sufficiency approach in relation to an organisation, albeit of a public nature and not a business one.

Moreover, as already presented in the previous section, the type of the two RQs provide the descriptive and contextual material needed by an exploratoty case study (Yin, 2014, Blaikie & Priest, 2019). Both RQ1 and RQ2 are consisting of a descriptive part –the documentation of sustainability practice among the involved actors of FHA, with the additional empirical perspectives of the other stakeholders and the detailed mapping of the Actors' Network– and of the relevant qualitative analysis with the sufficiency framework developed through the literature review and based off Pendergrass et al.'s (2019) original framework. The results of this first analysis are feeding partially into the material for the analysis provided under RQ2, following a stepwise design (Blaikie & Priest, 2019).

This is to be approached from within a critical realist perspective, according to which the understading of reality needs to be based mainly on insights derived from reality rather than representations or assumptions or models of reality, as it has been supported by Spash (2012) in regards to environmental economics. Adopted by Robra et al. (2020) in their research of eco-sufficiency and degrowth in economic organisations, it is argued that "data from real-life organisations reveal the operation of organisations as it unfolds rather than what is theorised, believed or imagined to be", and that "this approach helps reveal the complexity of reality" (p.4) when researching the case (for this research i.e. the potentials of sufficiency in DP of CH in the case study organisation).

And finally, the novice character of the research area and the lack of research and data in the field of environmental sustainability in DP of CH in general, and from a sufficiency theoretical perspective specifically, did not allow for the testing of any hypotheses. However, this is why, this research, as an exploratory one, seeks to develop a hypothesis on how environmental sustainability in DP of CH could be advanced by understanding and implementing a sufficiency strategy for the context of CHOs.

2.2.1 Case study organisation and selection criteria

The Finnish Heritage Agency is chosen as the case study organisation of this research. A pre-research was carried out scrutinising CH networks and EU and UNESCO projects in order to access a pool of CHOs that are active in the DP of their collections or involved in relevant projects or interested in taking up such activities. At the same time the author was reaching out to research networks on sufficiency where she is a member of. After a first round of communications with organisations willing to and interested in collaboration, two potential cases were identified. The criteria for the specific case-study organisation selection included:

1. Satisfy definitions of CHO and CH as their object of operations
2. Demonstrate active engagement in DP projects
3. Show a tendency towards environmental sustainability through its core mission strategy

However, after a more in-depth discussion, one of the two was found not to fulfil criterion n.3. This led to the selection of FHA as the only case study, given that it fits the three selection criteria outlined above. Moreover, the chosen case has the trait of being a public, not-for-profit organisation, which adds to the uniqueness of the analysis. All previous research on sufficiency strategies is focused on business or for-profit organisations, while FHA is not driven by profit, but by a higher public purpose. Most importantly, the openness and eagerness of the Finnish Heritage Agency to get further engaged in exploring the potentials of integrating environmental sustainability in their practices, highlighted their suitability for this research.

The FHA, as a public organisation, has been constantly shaping their strategy with the fulfillment of the societal needs and purpose that CH serves (Museovirasto, 2021). Their work is dedicated to promote "sustainable development and common well-being" while they strive for openness and are actively involved in the social dialogue of topical issues (Museovirasto, 2021). Moreover, the FHA has already been making the links between CH and sustainable, democratic and inclusive societies, and under their sustainability outlook, environmental (or ecological as it is referred to) sustainability is explicitly acknowledged and linked to CH and digitilisation (Mattila, 2018).

The practical involvement of FHA with sustainability, was also demonstrated on a number of their latest projects. Examples are 'The wheel chart of sustainability' (NDPC, 2019), the open access Hi-Res pictures project (Museovirasto, 2020) and the EU ongoing project of 'Museums of Impact (MOI)' that intends to develop a self-evaluation framework for EU museums, helping them to increase the societal impact by re-evaluating and re-orientating their operations (Museovirasto, 2019). Thus, there has already been a relevant background developed as well as material produced that offered a good jumping off point in this novice and forward-looking discussion. Finally, the practical advantage of having broad access to a number of willing interviewees and provision of documents, the well organized and clear structure of the FHA along with an online presence, contributed to the selection of this organisation.

2.2.2 A single-case embedded design

FHA was chosen as the case organisation, for analysing the research subject, meaning the sustainability practice of DP of CH, within its context. The single case study choice for this research is in accordance to Yin's (2014) rationale of conducting a single-case study when the case to be studied is considered to be an extreme and rather unique one. Regardless of the environmental sustainability considerations not being officially required from the decision-making criteria of the DP process of CH in EU, there is an emerging need to address such considerations by CHOs, in the context of their current digital transformation. The FHA has been –by the time the pre-research was conducted– the only public CHO considered, that has taken and was publicly communicating such environmental sustainability approaches even though they are not mandatory. So, these pro-environmental indications could imply higher potentials to have a rich investigation of sufficiency-conscious propositions. It is further emphasised by Yin (2014) that the use of a single case study can improve the likelihood of finding a case where the propositions and circumstances of the proposed research fit, as similarly argued from the critical realism's perspective (Ackroyd & Karlsson, 2014).

For obtaining a more holistic and profound understanding of the single case, the study includes more than one unit of analysis, meaning identifying and using more than one key components of human and environmental systems and, therefore, the "case is faceted and embedded in a conceptual grid" (Yin, 2014; Scholz, 2011, p. 25). This way a multi-validated understanding is achieved, since the different units of analysis, like roles, processes, environments, are implying the use of multiple sources of evidence and methods, like interviews, observations, documents. For exploring the environmental sustainability of DP of CH by CHO in this research, four units were analysed within the case study organisation, as can be seen in Figure 2-3, like; (1) 11 interviews with the Director of the Department, various hands-on and managerial employees, from two out of the four Units of the Department –the Pictures Collection and the Knowledge Management– and one participant from the National Digital Preservation System (NDPS); (2) 6 targeted Pendergrass 'self-questionnaires', from the same interviewees; (3) 9 interviews with participants from the identified Actors' Network (4) mapping of the Actors' Network.

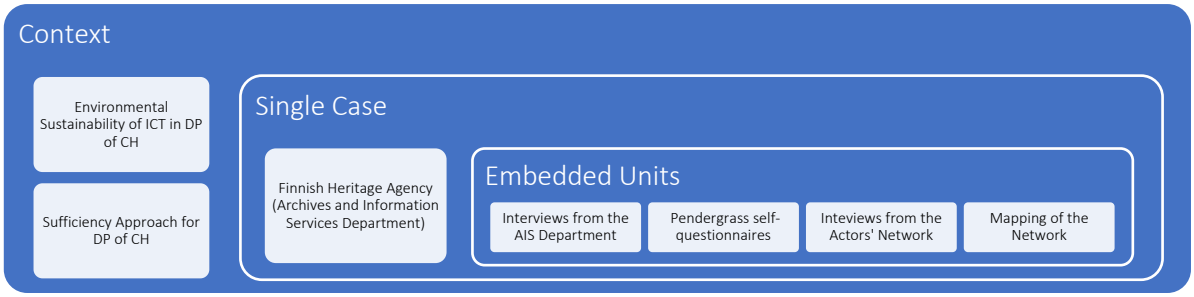

Figure 2-3. *Visualisation of the embedded single-case design for the FHA*

Source: Author's own elaboration based on Yin's original figure (2009, p.46)

2.2.3 Case study limitations and quality

As acknowledged earlier under 1.3, apart from the advantages of richness and realism of the data when opting for a case study (Creswell, 2014), this choice is open to the general criticism directed to qualitative research of being prone to subjectivity and producing hardly generalisable results (Blaikie & Priest, 2019; Yin, 2009). Even though Bryman (2012) mentions that the general limitations of validity, reliability and replication, applying in social research, are not necessarily of the same significance for a case-study, the quality criteria for social research were

considered in this research and respective validity and reliability strategies recommended by Creswell (2014) were employed, as can be seen under Table 2-1.

Table 2-1. Case study strategies to ensure quality

Quality criteria for social research	Creswell Strategies
1. Reliability & Replication	a. Document in as much detail possible the methodological steps taken for research designing, data collection and analysis b. Create a case-study database for archiving all the material collected to be available upon request c. Provide the interview and questionnaire protocols in the Appendix to allow for replication d. Create a codebook for ensuring consistency
2. Construct Validity	a. Utilise the existing Pendergrass Framework that was further elaborated transparently b. Use multiple sources of evidence (literature review and interviews)
3. Internal Validity	a. Triangulation of data sources (academic literature, CHOs documents, online sources, multi-stakeholder interviews) b. Transparent reporting with quoting and inclusion of discrepant information c. 'Member checking' parts of the final research with participants to ensure accuracy
4. External Validity (Generalisibility)	a. Theory or 'analytic generalisation'

Source: Author's own creation based on Creswell (2014)

2.3 Data collection and analysis

This research followed a qualitative approach, even though a case study research is not only restricted to such a choice (Bryman, 2012). The rationale for selecting this approach, is that a preventative environmental sustainability understanding in the processes of DP of CH is still in its nascent (Pendergrass et al. 2019), whereas the sufficiency approach hasn't been explicitly associated before. Adopting a qualitative approach in the methods chosen, allowed the author to gain, with rich and context-dependent data, a holistic perspective of the participants meanings and interactions within their Network's natural setting (Creswell, 2014). For answering both of the previously presented research questions under section 1.2., these elements were necessary, and therefore, was the use of qualitative methods (Creswell, 2014). Finally, qualitative methods are well fit for a flexible and adaptable stance during the data collection process (Creswell, 2014) which has been well suited for the unmapped research field of this study.

Due to Covid-19 and the limited travelling, which made on-site presence at FHA and the other participants' premises impossible, data collection opportunities were limited to remote only and the data collection process was entirely performed online. However, the above fact did not

diminish in the least the richness of the collected data, because the author maintained close communication with the Agency's contact person, following up and holding multiple discussions and meetings with the participants. As a result, the author managed to obtain multiple types of both primary and secondary data, compensating as much as possible the lack of in-person observation and interviewing. The data sourced and their analysis are presented in the following sections.

2.3.1 Literature Review

A literature review was conducted systematically with the dual purpose of offering an orienting background to the study and the theoretical basis for developing the analytical framework (Creswell, 2014). Academic peer-reviewed articles, monographies and reports were sourced from IIIEE's Library, Lund University scientific search engine LubSearch, the relevant redirecting online magazines or publications (e.g. Elsevier), Google Scholar and Research Gate. In the case of the latter platform some publicly unavailable items were directly shared with the author by the corresponding researchers. Search terms were gradually refined and defined, starting from different arrangements of keywords corresponding to the aim and research questions. Following a snowball technique, further literature was sourced from the bibliography of the most relevant, after the initial screening, literature as well as from some of the interviewees (Wohlin, 2014).

The content of the literature was developed around two main blocks as was presented earlier under the methodology design section and the research map (Figure 2-2), following the research conceptualisation (Figure 2-1). A list of the relevant search terms used around the two main blocks of literature review can be found under Appendix B.

The first block of literature was aiming to: 1) provide a background understanding on what the ICT environmental impact is; 2) present the debate around the current mitigating approaches the issues of ICT efficiency and an overview of the current EU policy context; 3) introduce the issues of ICT in DP of CH processes and the Pendergrass et al. (2019) framework.

Moving to the second block of literature the aim was to; 1) lay down the background and build an understanding of sufficiency in relation to efficiency; 2) distinguish the main factors influencing the inclusive interpretation of sufficiency with efficiency; 3) develop an interpretation of sufficiency for the DP of CH by CHOs.

For the analysis of the information from the collected academic literature, two different synthesis matrices were utilised where the information was arranged around; 1) ICT environmental sustainability and DP of CH and; 2) the sufficiency theoretical interpretation. The relevant information from the first block was transferred in an Excel spreadsheet, where it was reduced and rephrased, enabling to be synthesised on the side under the themes already identified, from a pre-research, for the background understanding. For the second block of literature review, the same process was followed with a more iterative approach where the themes were restructured twice after the Synthesis Matrix was enriched with new sources.

2.3.2 Semi-structured interviews

A number of semi-structured interviews, with a variety of different actors and stakeholders were conducted to gain empirical data from the DP of CH process and any related sustainability activities. This kind of semi-structured format allows for a flexible course of the discussion and gains in-depth insights from the interviewees' inputs, while remaining on track of the research aim by following-up with questions steering them to the Framework's topics (Tunn et al., 2019, Creswell, 2014).

The topic of the environmental sustainability of ICT used in the processes of DP of CH was approached differently for the interviews with the FHA participants and for the interviews with the actors of the network around FHA. The objective of the first part of interviews was to explore the understanding and practice of sustainability in DP of CH in FHA in depth and explore the reasons why they take the respective approach. This was achieved by documenting the practice itself, based on the structure of the Pendergrass et al. (2019) Framework and also by bringing up examples of their questionnaire as well. It was also aimed to outline a first mapping of the immediate Actors' Network around them.

Based on that initial network identification and with a snowball approach, specific actors were further approached. For this second part of interviews with the actors around FHA, the ojective was not as much to document their practice in the detail that happened for the FHA, rather than to further map the network and their interrelations, to identify patterns of responding to strategies and to figure out the way it could influence the potentials of sufficiency-related action to be advanced in the future.

The semi-structured nature of the interviews was well-suited for the above reasons, as well as for the varied professional backgrounds, understandings and perspectives of the large spectrum of interviewees. Even though an interview guide was developed in detail, it was then adjusted to five core questions on the DP process, which was customised according to their role and place in the DP process and in the organisations (Appendix C).

A total of twenty interviews was conducted; eleven of them with the people from the Department of Archives and Information Services of the FHA, six of which were via video-call (i.e. Zoom) and five were taken via the written interview guide (Appendix D); and nine interviews were held with the people from the identified Network (i.e. the National Library of Finland, the National Archives of Finland, the Ministry of Education and Culture, the Center for Scientific Computing, Sitra, Europeana) via video-call. In addition, a targeted number of people took the Pendergrass 'self-questionnaire' (Appendix A), five from the FHA and two partners of the Actors' Network, but closely related to parts of the DP process performed by FHA. (Appendix D).

The live interviews with the Agency and seven out of nine with the network, were audio recorded and transcribed using the transcription software Otter.ai. In order to ensure accuracy, all the transcripts were reviewed and corrected meticulously by the author, since in the initial transcript a number of mistakes were detected. Simultaneously to this reviewing of the interview data, the first steps of the 'coding process' as introduced by Tesch (1990) were performed by hand, and a 'coding list' was generated, following the categories of the developed Framework (under section 3.3). The codes were further grouped under the assessment of the 'Quality of the outcome' of the intervention measures in the DP stages, according to the sufficiency interpretation (and the three component strategies of; Sufficiency, Efficiency and Digital Preservation Efficiency) (also, under section X), and to their barriers and enablers for the discussion with FHA, whereas as opportunities and challenges on the Network's level discussion. In any case, apart from the predetermined codes, the author pursued coding with 'emerging' ones in an iterative capture of themes (Creswell, 2014). For instance, *organisational structures* kept occurring in the interviews with most participants and therefore were included in the codebook.

Finally, the Pendergrass 'self-questionnaire' with a strict format and some open-ended questions of technical measures throughout the DP stages, was taken by part of the interviewees. It was already structured under the same categorisation used for the analytical framework that was

elaborated from it. Therefore, the answers were only analysed by applying the elaborated framework with the integrated sufficiency interpretation on them.

2.3.3 Document Analysis

In order to identify the actors' network and the respective DP of CH, sustainable development and ICT strategies around the FHA, a document analysis method, meaning the use of public or private documents, that are not academic (Cresswell, 2014), was used, employing a snowball approach during the interviews. Reports, presentations, articles, organisation documents for internal or external communication and web pages were necessary since not much academic literature exist on the respective strategies and network structure in Finland.

This method is also aligned with the exploratory nature of the research design and the need for in depth and accurate understanding of the interrelations among the actors (Creswell, 2014; Bowen, 2009). However, there is also criticism raised towards the accuracy of such sources (Creswell, 2014) and this is why the data from the documents were triangulated with multiple different documents, where possible, as well as with interviewees.

Document analysis was conducted along the interviewing stage, since it was feeding back to the interview in an iterative way, with the expansion of the related actors that were revealing, while building the connections of actors and strategies around the activities of FHA. The documents collected were analysed according to the strategies around which the network has been developed.

3 Literature Review

The purpose of this chapter is threefold. The first is to provide an overview of the ICT environmental impacts (section 3.1.1), their current mitigation approaches (section 3.1.2) and to introduce the original framework used for their documentation in the case study organisation (section 3.1.3). After this first look on the current situation in the ICT and DP field, the focus is taken on interpreting sufficiency (section 3.2). Finally, a sufficiency framework applicable to DP of CH by a CHO is explored and developed and serves as an overall framework for data collection and analysis (section 3.3).

3.1 ICT environmental impacts and their mitigation

This section presents a summary of the ICT environmental impacts as they are discussed from within the ICT field. As already mentioned, DP –apart from the built environment– is heavily relying on ICT. Therefore, the environmental impacts of ICT equipment itself can be used as an environmental performance reference point for the environmental impacts of DP processes. Although the existing literature on the environmental impacts of ICT is mainly focused on the sector's energy demands and the impacts stemming from it (Arushanyan, 2016), a life-cycle perspective of the material resources is also taken in this section. Subsequently, starting from the issues of the main mitigating response –i.e. increasing technological efficiency in general– the need for a different approach is identified as needed.

3.1.1 Environmental impacts

The purpose of DP is dual; to preserve the digital content and to make it available (Pendergrass et al., 2019). ICT equipment is enabling both the preservation and the dissemination of digital content, therefore it is needed for all the essential processes of fulfilling the DP purposes; from securing a safe storage of the digitised or born-digital content to sharing and providing access to the end-user. ICT comprises the whole communication networks meaning the internet data services or core network for the electronic distribution of data (e.g. data centers' computational power and hardware), as well as the extended end-user's network (e.g. laptops and servers) in order to connect to it (Malmodin et al., 2014).

However, it is hard to perceive the full scale of this entire complex background enabling infrastructure and the considerable resources and energy consumption put into it, as well as its environmental impacts, let alone by the distant –usually– end-user. This is why the adoption of a life-cycle and broader system's approach to the DP process, is raised as a more holistic way to approach the complexity of ICT components (Pendergrass et al., 2019; Pohl & Finkbeiner, 2017; Hilty et al., 2011; Pohl et al., 2019), and to address both resources (especially scarce minerals and plastics) and energy use throughout the production, use and disposal phases.

The direct impacts from production, are mainly coming with the extraction of the raw material. Apart from resource depletion —including: scarce metals like gold, indium, palladium, silver, rare earth elements like tantalum and magnesium, fossil fuels for plastic— when looking into the resources' material rucksack which is mainly 'acquired' during the mining and refining processes (Wäger et al., 2015), biodiversity loss, land use and contamination of soil and water in the surroundings of these processing areas, must be also counted in the environmental impacts (Pohl & Finkbeiner, 2017; Wäger et al., 2015). Moreover, the 'embodied energy', as is the term for the upstream energy demand of the material composition of the product, is counting for a high percentage of the total environmental impacts of the product, since the production process and the resources' mining and refining are energy-intensive processes and most often they are taking place in areas with a high fossil fuel-sourced percentage in the energy mix (Manhart et al., 2016).

Continuing on the use phase, the direct effects are evermore shifted upstream to the ICT infrastructure and cloud-computing, due to the energy demand of the computing and networking equipment as well as the cooling needs of data centers (Pohl & Finkbeiner, 2017; Durham, 2019). Therefore, the environmental impacts of data centers, for instance, are highly determined by the strategic decisions of digital service providers, due to the energy and water intensity in conjunction with contextual factors, like the centres' architecture and type of energy source (Hintemann, 2015). But the users' behavior is still influential in this phase, as the ICT energy consumption on the user-side is quite considerable, according to a study on digital libraries environmental impact[8], and that should be taken into account in the total of GHG emission (Chowdhury, 2016).

Finally, all these ICT equipment components are forced to replacement, necessitated by either technological or software obsolescence, which in turn, in the DP context, is dictated by the digital assets' safety and secured preservation standards[9] (Durham, 2019; Prakash et al., 2017). It ia also indicative for ICT as well, that only a 17.4% of the total e-waste produced, was reported as officially collected and disposed in 2020 (International Telecommunication Union (ITU), 2020). The rest of the 50 million metric tonnes of e-waste produced, are being disposed in landfills, are burnt or are illegally traded, mainly for extracting the precious metals from ICT components —along with highly toxic substances and under hazardous conditions (Forti et al., 2020; ITU, 2020). This e-waste "recycling" ends up happening usually in the Global South, closing this way the circle of human and environmental health endangering and contamination, that initiated with the primary material extraction (Pohl et al., 2021).

3.1.2 Current mitigating approach

Embarking from the above environmental impacts, their mitigation in the context of ICT — ICT both as stand-alone and as enabling technology for other processes— is considered as a complex issue. Corresponding to this dual status of ICT, the mitigation of its impacts is discussed on two levels; of the direct effects and of the higher/second order ICT effects (Börjesson Rivera et al., 2014). Direct effects include the immediate impacts of the production, use and disposal of ICT equipment (Berkhout and Hertin, 2004). However, higher order effects, for example as direct rebound effects or to other sectors, are also created, especially where ICT is used as an enabling technology (L. Hilty et al., 2011; Pohl et al., 2019). The use of ICT as a mean for other processes can generate far-reaching implications to other sectors, therefore it can have effects that are going beyond the direct impacts and are far more complicated to be detected (Börjesson Rivera et al., 2014).

For both direct and higher-order effects, the mitigation focus has mainly been on the energy consumption of ICT and the extended energy demand implications from the optimisation, virtualisation or substitution processes on other sectors, like mobility (Pohl & Finkbeiner, 2017; L. Hilty et al., 2011). Existing studies are stressing the increased resulting CO_2 emissions (Coroama and Hilty, 2009). Thus the most considered path for mitigating the resource and environmental impacts of ICT is to increase the technological efficiency, leading to savings in

[8] In respect to CH context, the users of the digital asset, include archives, museums, national documentation organisations, etc., are usually also the ones to take the 'production process' decisions in the first place. Key aspects of user behavior need to be accounted in the total environmental impacts of CH activities (appraisal, permanence, availability), as will be discussed later under Chapter 4.

[9] According to a CH specific example cited by Durham (2019), even though a hard drive's life span may be around 8-10 years, it is a common and accepted best practice across CHOs to replace them every 3-5 years, as a proactive safety measure. That equals to almost 70,000 hard drives discarded every 10 years approximately, from the 35,000 estimated CHOs in the US. But if, as mentioned by Wanda et al. (2011, p.99), multiple copies of the same CH asset are kept 'in at least two separate drives' and a third one, ideally, in a separate geographic location, the number of discarded drives could be as high as 280,000 per decade in the US alone.

energy, in material resources and in environmental impacts (Hilty et al., 2011; Lange et al., 2020; Santarius et al., 2020). It is argued, however, that perpetual technological fixes by increasing constantly the energy and resource efficiency of ICT, cannot create 'sustainability' and are not enough on their own (Goldman, 2019; L. Hilty et al., 2011; Pendergrass et al., 2019). This is because of the complexity of ICT effects, that may roll back any efficiency gains and of the material decoupling contextual factors, as will be explained in the following section. On that note, the current EU policy context related to ICT is also outlined.

ICT Efficiency and Jevons paradox

Increasing ICT technological efficiency can be understood both in direct and indirect ICT impacts, in terms of (1) increasing efficiency in the ICT sector itself and (2) increasing efficiency in other sectors by the use of ICT. Apart from the efficiency in the context of the direct effects, the rebound effect and its interplay with decoupling are influencing factors in the discussion of the current ICT impacts mitigating approach.

In the direct effects' context, increasing the efficiency of ICT means more service/work produced per technical use of the same unit of ICT equipment, that equals to a greater material resources and energy savings in the making and running of the equipment. Therefore, saving resources by increasing the technical efficiency of the use of the resource may seem rather straightforward (Hilty et al., 2011). For example, for the same computational outcome, half of the energy is needed if the processing efficiency doubles. This has been proven by Koomey et al. (2011) to be the case since 1947, that the computations per kW/h are being doubled every 1.57 years, while the energy consumption of the data centers globally was calculated to correspond at 1.1-1.5% of the global energy consumption in 2010. However, the ICT sector as a whole, keeps growing on a global scale (Mas et al., 2018) and this translates directly to an increase of the total resources consumption. So, the final balance depends on whether the efficiency increases will outpace the sector's growth (Lange et al., 2020).

Some academic studies on energy consumption of ICT reveal stability or at least a slight increase of the sector's global energy demand, that corresponds to a 3.9% of the global electricity demand (in 2007 by Malmodin et al., 2010) to a 4.6% (in 2012, by Van Heddeghem et al., 2014). However, a report by the International Energy Agency is making an estimation of 14% in 2020 (Hoang et al., 2014) while a research organised by the European Commission estimates that the sector's global energy consumption corresponds to 7% and anticipates a raise of 13% by 2030 (Bertoldi et al., 2017). Hiekkanen, Seppälä & Ylhäinen (2021) have highlighted though, that the assumptions of some conservative academic studies that are not pointing out a significant increase in the sector's electricity consumption during the previous decade (e.g. Malmodin & Lundén, 2018; Masanet et al., 2020) have been criticised by Hintemann (2019), as not being supported by the evidence of the "dramatic global increase in the total number of data centers and information on the trends in hardware sales to data centers" (p.8).

The above suggests that besides the great technological efficiency improvements in the ICT sector, the resource consumption, undeniably, will keep increasing. The reasons for this can be better understood with insights from (1) the rebound effect and (2) the decoupling discussions.

On the one hand, the Jevons paradox is essentially arguing that an increase in technological efficiency of a process or product is not followed by a decrease in its demand, but is rather followed by the opposite —the demand bounces back up, counteracting the efficiency gains, and is widely known as the rebound effect (Jevons, 1906; L. Hilty et al., 2011 to; Polimeni et al., 2009). This is explained because of the "increases in energy efficiency foster energy consumption via various mechanisms, such as a re-spending of savings and a substitution of other production factors by energy" (Lange et al., 2020, p. 5). Consequently, an overall reduction

in energy consumption based on efficiency increases cannot be guaranteed because of the multiple rebound effects (Lange et al., 2020 to; Jevons, 1906; Khazzoom, 1980; Santarius, 2014; Sorrell, 2007).

On the other hand, understanding this decoupling of resource and negative environmental impacts per function of ICT is deeply attached to the broader economic system and behavioral dynamics within which the direct effects are embedded and thus, add a higher level of complexity (Hilty et al., 2011; Lange et al., 2020). For instance, there is a discrepancy between the current technical value of ICT growth and its economic measuring —an example of this could be the prices of smartphones that have remained on an average similar to what they were 10 years ago and they do not reflect the computational efficiency increase. Or there is an underestimation of the value of digital services, since they are not charged per data unit, but rather in flat rates (Lange et al., 2020 to; Reinsdorf et al., 2018). An example from a behavioral perspective could be that the convenience and easier access can foster demand, like in videoconferencing, where despite of the systems' improvement there is still a rising number of international conferences (i.e. total consumption increasing equals faster pace of economic growth) (Coroama et al., 2012). This is why the resource decoupling may result in a growth rate higher than the decoupling rate, and thus, counteract the resource-saving effects of efficiency increases and decoupling by driving an increase in total consumption (Hilty et al., 2011; Tainter, 2009).

Therefore, total consumption and economic growth are setting the potentials frame of the ICT environmental sustainability discussion. In this context, several researchers have supported that efficiency increases alone their own are not enough for achieving environmental sustainability of the ICT sector itself and, further, for supporting decoupling strategies (Hilty et al., 2011; Lange et al., 2020). For ICT sustainability to be supported the key themes generally recognized in the literature are suggesting that;
(1) a wider systems perspective of assessing ICT effects should be adopted, including higher order effects —e.g. rebound effects (L. Hilty et al., 2011; Pohl et al., 2019);
(2) policies that are "leading to a deeper structural change" of limitation of input resources and outputs growth are needed (Hilty et al., 2011, p.23, Lange et al. 2020) and
(3) any technological efficiency strategies in order to succeed need to be combined with and to happen from within a sufficiency framework, that is set by the ecological limits and that of finite resources (L. Hilty et al., 2011).

Policy context

Current policies related to ICT sustainability are mainly applying on the 'material' aspect of the ICT. For example, on the EU level there are already in place regulatory instruments, setting a minimum of legal criteria in respect to the electricity consumption of electrical devices and their environmental performance, like the EU Ecodesign Directive (EC, 2009) accompanied by the Energy labelling Regulation (ref the directive) focusing mostly on screens and computers –in the ICT spectrum. The Energy Star labeling scheme, as a coordinated programme with the US, or the German Blue Angel, are also assessing and communicating the energy efficiency of electronic equipment in order to facilitate more conscious decision-making by the consumers. However, on the larger scale of the data centers' energy efficiency assessment, such initiatives are still voluntary, like the "European Code of Conduct for Data Centre Energy Efficiency" run by the European Commission's Joint Research Center (JRC, 2021), due to the difficulty and complexity of the sector to be regulated (Avgerinou et al., 2017). And, even though the abovementioned Ecodesign Directive just extended its effect on servers and data storage products for "simple computational environments" (EC, 2019b), this doesn't cover the overall data center efficiency.

Immaterial aspects of sustainable software are not yet but to be addressed, since they are mutually dependent with the hardware that needs to adapt to any evolutions of the operating systems and vice versa (Pohl et., 2021). It could be said that they both have the potentials to drive each other to obsolescence, placing interoperability of software and hardware in the heart of the planned obsolescence (e.g. artificially shortened product life cycles) discussion (Manhart et al., 2016). In this respect, possible solutions are driven by transparency and openness and therefore the Free and Open Source Software has been put forward, where its licensing is free and against monopolisation that moves usually the discontinuation of software owned by private entities (Pohl et al., 2021). Relevant action has been taken by the German Environment Agency that has been researching into software sustainability criteria, and apart from the nature of licensing of the software, they are also counting in the energy efficiency per function (Blue Angel for software) (Gröger et al., 2018) and further ICT energy consumption during the use phase.

Finally, such designing and efficiency criteria for both ICT hardware and software, are not at the moment diffused as strict requirements. It was only in December of 2020, when environmental sustainability criteria for data centres, server rooms and cloud services were published in the amended EU Green Public Procurement (GPP) (EC, 2020). Even if EU GPP is a voluntary instrument, it still highlights the public sector's key role and higher potential to upgrade application of such criteria in public procurement as mandatory. And such assessments are being looked into to expand on software and applications (e.g. video-streaming) as well, that will concern their resource efficiency, longevity and transparency (Pohl et al., 2021).

3.1.3 Pendergrass et al. (2019) 'Environmentally Sustainable DP Framework'

In the area of DP of CH, the 'Environmentally Sustainable DP Framework' by Pendergrass et al. (2019) has been the only framework identified by the author linking explicitly the environmental impacts of ICT to the decisions taken during DP. The structure it uses is this of a guiding 'self-questionnaire' for the practitioners (Appendix A) and it follows the three main stages of the DP process; appraisal (that is the selection of the CH assets to be preserved digitally), preservation (the technical choices made around the digital preservation of the asset, e.g file format, storage technology, copies preserved) and finally of the availability (how the asset will become accessible by the end users).

The perspective adopted in their research is that of the practitioners of the CHO, as being well-located actors for steering environmentally sustainable DP. By that, the authors are making the case of how the DP practitioners could actively promote environmental sustainability in DP of CH by evaluating their day-to-day decisions and practices with the guiding questions of their framework and rethinking their core assumptions around their profession (Pendergrass et al., 2019). Factoring the environmental costs of ICT use in the CH field throughout the full life-cycle of the equipment and along the three main stages of DP, Pendergrass et al. are proposing the creation of 'true sustainability' within the DP practitioner's sphere of action.

This approach could be identified as being supported by two main acknowledgments. First, similarly to the rationale of the extended producer responsibility principle, the DP activities run by the CHOs are resulting in negative environmental costs that should be recognised and taken care of by the CHOs, who are designing and implementing the DP processes (most effective allocation of responsibility). Secondly, future generations are the final recipients of the CHOs' object of preservation and, consequently, CHOs' uptake of responsibility to ensure a livable natural environment is aligned to this existential purpose of theirs. This is also the reason why environmental sustainability should be consciously created and designed into the fundamental processes of DP by *reducing* volumes in general. It is argued that they need to go beyond the

technological fixes measures, that are only reducing unsustainability while the process is generally remaining inherently unsustainable (Pendergrass et al., 2019, to; Ehrenfeld, 2008).

So, apart from addressing the impacts of the current DP practicing status with efficiency and clean-tech measures as a 'stopgap' -which they are recognising as an "urgent but interim response", they are also suggesting a 'paradigm shift' in the main DP processes of appraisal, permanence and accessibility of the digital content, in order to "reduce the amount of the digital content preserved, while reducing the resource-intensity of its storage and delivery" (Pendergrass et al., 2019, p.177). Therefore, the proposed measures can be distinguished according to; (1) the medium of change, whether they are based on a technological (*Table 3-1*) or on a DP 'process' means of change (*Table 3-2*) and; (2) the nature and quality of their outcome. The latter means that they can either aim at reducing the number of objects preserved or at reducing the resource-intensity of the storage and accessibility of the digital content by altering the DP practice (Pendergrass et al., 2019).

An overview of the main measures according to the first criterion, as developed from the framework questions and further elaborated, can be found in the respective two tables, Table 3-1 and Table 3-2. A reduced version of this overview, along with a further elaboration on the general functions of measures according to the second criterion –the quality of their outcome– will follow later under section 3.3, for the development of the analytical framework.

Table 3-1. 'Stopgap' measures based on technology.

Medium of change - Technology	
Strategy	**Measures**
Efficiency	1. Acquiring new technologies in compliance with energy efficiency standards 2. Altering the use of the existing systems (stand by, turn off when not used) 3. Limiting performance characteristics of processors of local servers 4. Extending energy saving practice to collaborating IT departments 5. Efficient energy storage systems (powering one hard drive per track at a time, e.g. Facebook cold storage system)
Scheduling	1. High-energy and high-bandwidth activities scheduled to off-peak times and seasonal off-peak periods for not contributing to peak load forecast
Clean Energy	1. Producing clean energy on-site of CHO 2. Purchasing clean energy or renewable energy certificates (within the same regional electricity grid as the storage facility to ensure additionality) 3. Selecting vendor-provided facilities powered by clean energy

Source: Own elaboration of Pendergrass et al., (2019) 'Questions to guide environmentally Sustainable Digital Preservation'

Table 3-2. 'Paradigm Shift' measures based on reevaluation of DP processes.

Medium of change - Process		
Stage	**Area**	**Measures**
Appraisal	1. Contain storage size	a. Acquiring only the material falling within the CHO's collecting policy b. Digitizing material that is explicitly needed c. Generating 'lighter' file formats or in lesser quality d. Deduplicating using metadata or descriptions for the removed content e. Reevaluating the use of default choices in workflows e.g. disk images
	2. Capture and analysis	a. Make explicit the technology resources needed for capture, analyse and arrange the digital content
	3. Reappraisal	a. Regular reappraisal (including coincidental accessing of the data) and by using metrics of value

	1. Determination of acceptable loss	a. Establishing organisational policies on what constitutes "good enough" DP and an acceptable amount of loss over time b. Implementing tiered approaches to DP resources according to the value and uniqueness of material c. Allow loss-flexibility with the language used in the preservation policies and donor agreements
	2. Fixity check methods and frequency	a. Run complete fixity checks as infrequently as would be responsible by the threat management model of the collection b. Schedule fixity checks during off-peak energy and network hours c. Large and random sampling of AIPs for fixity checks, as indicative for further investigation d. Supplement file-based checksums with self-check-summing and self-healing file systems or media-level hardware checks instead of frequent file by file fixity checks
Preservation	3. Storage technologies	a. Evaluate environmental impact and energy sources of online storage vendor and cloud services provider —benefited from efficiencies of scale b. Evaluate environmental impact of manufacturing, transporting and disposing media for nearline or offline storage, as well the frequency of replacement need —benefited from no need for permanent networking infrastructure
	4. File format migration policy	a. Develop local file format policies according to specific for the CHO calculated risk assessments on format obsolescence b. Customize accordingly the file format migration policy of the digital preservation software system c. Conduct format migrations on-demand at the time of access and not during ingest to a preservation repository for some material, when appropriate d. Apply file format policies (e.g. migration at ingest) selectively on the preserved content and not in bulk
	5. Number of redundant copies	a. Preserve a necessary number of copies of AIPs according to the threat model for the AIPs conducted by the organisation b. Aim for a tiered redundancy level of AIPs copies, according to the uniqueness and value of the assets preserved c. Limit redundant surrogates for stable analog materials
Accessibility	1. Digitisation	a. Digitize according to users' demonstrated needs b. Provide access on-demand by utilizing a tiered -"track"- approach c. Articulate the on-demand digitisation policy to the user, as intending to save unnecessary trips to access analog material
	2. Access storage	a. Migrate content to an access copy upon request b. Apply a tiered storage system and retain access copies to a storage system that facilitates media power down when not in use
	3. Delivery	a. Indicate if access copies are kept on a delayed delivery system b. Bundle component files with the born digital content upon retrieval c. Provide supplemental user's documentation if necessary

Source: Own elaboration of Pendergrass et al., (2019) 'Questions to guide environmentally Sustainable Digital Preservation'

In both the immediate and the more "radical" measures, the authors are communicating the materiality of ICT-use. It is based on the fundamental acknowledgement that the digital bits to which the analog material is converted into, are, essentially, energy, plus the materials that constitute the ICT equipment, transferring it. This digital form needs energy in order to maintain stable, and it also needs infrastructure for this energy to be produced, stored and circulate into for running the respective ICT functions. The required energy and ICT infrastructure are proportional to the amount of digital content produced, its characteristics (size, format, quality) and the preservation practices followed (e.g. number of copies saved, frequency of migration). Therefore, any decisions on the previous matters correspond to energy and the respective necessary material resources for the infrastructure, affecting the demand of both energy and material throughput. For example, running energy intensive tasks in peak hours contributes to

the peak load forecast and therefore signals the need for developing more such infrastructure, while this could be mitigated, to an extent, by scheduling such tasks during off-peak hours. More discussion on concrete measures that the author selected for the purpose of this thesis will follow further under section 3.3.1.

However, scheduling of energy-thirsty tasks or more efficient use of technology is yet to address the environmental impacts of ICT use in DP in their root and is definitely not suggesting a permanent solution, but rather a temporal fix. Applying the fundamental argument of Ehrenfeld's sustainability framework that "increasing the efficiency of consumerism only reduces unsustainability", Pendergrass et al. are concluding that "greater efficiencies in the use phase do not result in sustainability" (Pendergrass et al., 2019, p.180, to; Ehrenfeld, 2008). Ehrenfeld traces the creation of true sustainability to the reconstruction of society's notion of satisfying their needs through consumption of goods and services and "towards more authentic means of satisfaction that result in physical and psychological well-being" (2008, p. 37).

Even though Ehrenfeld in his work does not use the word sufficiency per se, he recognises that 'sufficiency' is lingering on the background of his conseptualisation of sustainability (Ehrenfeld, 2021). Similarly, Pendergrass et al.'s framework introduces a shifting in the current paradigm with a more sensible and balanced model of DP, building upon 'a good enough' quality of DP practices for CHOs fulfilling in a more critical way their purpose and containing the number of the content produced and the resource intensity, while coming to terms with an acceptable level of loss of content (p. 181). This sense of 'enoughness', as 'doing what is needed only' both in terms of producing and 'consuming' CH digital content, will be related to and understood through the notion of sufficiency in the following section.

3.2 Towards a Sufficiency Framework

The previous section with the close up on the ICT environmental impacts and their mitigation concludes with the insufficiency of the current approach and a call for sufficiency. The problematic response is not exhausted in the ICT sector only, but rather represents a broader modern 'dogma' –that of efficiency (Princen, 2008). Looking more specifically at these impacts in the DP of CH, the Pendergrass et al. (2019) framework is making the case that true sustainability in ICT use can be created by reevaluating the decisions taken during DP of CH with a mixture of efficiency-increasing and amount-reducing measures. The latter part, as mentioned, resembles to sufficiency. For this reason, in this section, the background of sufficiency is laid down in order to understand what could be a suitable interpretation for a sufficiency framework for analysing the practice of DP of CH by the CHO (section 3.3).

3.2.1 Sufficiency background; limits, growth and sustainability

Natural laws and processes are composing and imposing an exogenous reality framework on human activity. This, for instance, could be exemplified with the second law of thermodynamics dictating the linear flow of matter-energy throughput from low to high entropy (Georgescu-Roegen, 1971; Daly,1992), or to the boundaries set by the biosphere (Steffen, 2015; Rockström, 2009) or the scarcity of the finite resources provided by Earth (Kallis, 2020). The latter, the biosphere, is setting the bio-physical limits within which humans and their activities are developing. With the current pace of humanity's production activities and consumption of resources, we have been outpacing the Earth's regenerative capacity by 1.75 times (Global Footprint Network, 2019), while surpassing the boundaries of biodiversity loss, of climate change and of the global natural cycle of nitrogen (Rockström, 2009).

The above are concrete and measurable examples of the naturally observed reality and can be understood as setting limits to human activities, when studied in relation to these activities in

some system (Meadows et al., 2015). For example, as Robra and Heikkurinen (2019) lay down the matter-energy throughput system of Herman Daly (1985), in between the one-direction flow of "low entropy resources from the environment and high entropy waste back" (p. 1), stands society, metabolising this matter-energy flow "mainly in the form of economic activities" (Robra et al., 2018, p. 1). These economic activities that are happening within this system are entrenched to the larger biosphere system and consequently, are subject to its laws and to the reality set by it. And since the natural resources of matter/energy and their capacity to produce work are consumable and irreversible, unlimited economic growth based on these finite natural resources is incompatible with the natural laws (Bonaiuti, 2014; Daly, 1992)

This means that economic activities (production and consumption activities) need to be aligned with the bio-physical absolute limits of resources' use, in order to be sustained in the future (Robra et al., 2020). For this to happen, the matter-energy flow needs to be reduced and since economic growth depends on the size of the matter-energy flow, the previous conclusion also translates into a need of quantitative and qualitative change of economic growth, that has been expressed in different ways (e.g. uneconomic growth, Daly, 1991; degrowth, Kallis et al. 2014; dematerialization, Krausmann et al., 2008). Practically, the size and the quality of the reduction in resources throughput and, therefore, the implications in economic growth, depend on the theorising of sustainability and the stance from which the sustainability is attempted. The sustainability perspective adopted results in either a weaker or a stronger expression of sustainability and accordingly, such manifestations can be discussed from the context of either weak or strong sustainability.

Weak versus strong sustainability

Emerging from the field of the environmental economics, these two versions of sustainability are based on different assumptions as their starting points. The dichotomy of human/ human-made and natural capital sets the fountains of this differentiation.

A weak sustainability perspective assumes substitutability between natural capital and different types of capital (e.g. human-made capital). Based on the definition of sustainability by Pearce and Atkison (1995) as long as the total amount of natural and human capital doesn't decrease, sustainability is achieved –nothwithstanding be it the man-made capital to increase and the natural to decrease, since the monetary unit that expresses this total amount of capital, is maintained constant, if not increased. For instance, natural capital, like timber from forests, can be used up freely as long as equivalent monetary value of human/-made capital (e.g. financial capital, technology, human skills, infrastructure) is being created and the total savings rate is higher than the sum of human and natural capitals' depreciation rate (Pearce & Atkison, 1995; Gutés, 1995). Therefore, according to Gutés (1995, p. 147), "this is referred to as 'weak' sustainability since no restrictions on the degree of substitutability between natural and man-made capital are applied, and thus natural capital receives no special treatment."

On the contrary, a strong sustainability perspective stands for the non-substitutability (or really limited) of the natural by the human/ human-made capital, distinguishing clearly between their qualitative traits. This is because natural capital cannot be treated as a simple one-dimensional sum of resources (e.g. timber, water, minerals, species), but it is rather a complex ensemble of all the biotic and abiotic elements and their interactions and functions, providing unique services that cannot be substituted (Ekins et al., 2003; Brand, 2009). This can be further supported by the fact that natural resources are indispensable for manufactured capital, but not vice versa, and consequently, manufactured capital could never be perceived as a complete substitute of the natural capital (Ekins et al., 2003). In addition, once natural capital is consumed, in principle it cannot be reversed or replaced by human-made capital due to the vastness of interrelations

and complexity of its functions (e.g. Ozon layer), that don't permit their artificial reproduction by humans (Ekins et al., 2003; to Victor, 1991).

Beyond efficiency

This fundamental differentiation of the underlying assumptions that are supporting either a weak or a strong version of sustainability, reflects onto the practical aspects of achieving sustainability with pursuing –respectively– either relative or absolute levels of reduction. In this sense, the argumentation established in the beginning of this section —starting from the natural limitations, then putting in perspective the human production/consumption systems and economic growth, to the need for reduction of resources throughput— concludes with the strategies that are followed to practically pursue either version of sustainability.

Improving the quality of using natural resources and achieving a higher outcome per unit of resources by employing *efficiency* strategies, could in principle result to a lower resource throughput (Jackson, 2009). However, since substitutability of different capitals in the form of efficiency gains is assumed, and the focus lies on increasing this function through technological progress, this approach is following a weak sustainability understanding (Daly, 1991, Ekins et al. 2003, Heikkurinen & Bonnedahl, 2013). The phenomenon of the financial savings (i.e. lower cost of the good because of efficiency improvements) acting as a profit-driver and ultimately feeding back to the economic growth by bouncing up absolute resource use and leaving consumption levels unchanged, is broadly recognised –the rebound effect– as discussed earlier in section 3.1.2 (Jevons, 1990; Jackson, 2009; Alcott, 2005; Dietz & O'Neill, 2013; Kallis, 2019; Robra et al., 2020). In this feedback loop of economic growth, technological efficiency is perceived both as 'an outcome and a fundamental driver' (Jackson, 2009, p. 121). Efficiency strategies could claim contributing to sustainability only if they were to remain within ecological limits by outpacing the ever-increasing environmental impacts –historic evidence of the rebound effect, however, has been strongly suggesting otherwise (Jackson, 2009).

With efficiency widely acknowledged not being enough for delivering sustainability, the total quantity of overall resources used, needs to be addressed along with quality (Robra et al., 2020; Callmer, 2019; Alfredsson et al., 2018; Dietz & O'Neill, 2013; O'Neill et al., 2018, Jackson, 2009; Lorek and Spangenberg, 2014). The reduction in absolute terms of the resources quantity moves away from the relativism of improving the sustainability of 'inherently unsustainable practices' (Princen, 2005; Robra et al., 2020; to Heikkurinen & Bonnedahl, 2013). On the contrary, *sufficiency* talks in absolute terms and argues for a root-cause approach of being or doing what is sufficient and adequate or in other words, what is enough only for addressing a need, with no excess. Since this perspective is suggesting to decrease the overall amount of resource throughput, its alignment with the strong sustainability's assumptions has also been highlighted (Robra et al. 2020; Heikkurinen, Young & Morgan, 2019).

Consequently, sufficiency contradicts the notion of economic growth, that presupposes a positive relationship between energy and matter throughput and economic activities (i.e. increases in production and consumption), while efficiency is employed for a 'green growth', by making technologies cleaner, still embarking from a free-market economy setting and aiming at the most efficient resources allocation (Sandberg, 2021; Lorek & Fuchs, 2013; Kallis, 2014; Princen 2005). However, it is also argued that despite the different starting point, sufficiency is not incompatible with an efficiency approach and these two can be paired, as long as efficiency is happening from within a sufficiency context without undermining the absolute reduction goals and any efficiency gains are not being fed back in increasing total production/consumption (Robra et al., 2020; Heikkurinen et al., 2019, Jackson, 2009).

3.2.2 Factors for sufficiency

It is broadly argued that sufficiency is identified as a complex and multidimensional concept, normative and context-dependent. It has already been observed in literature that the concept 'lacks clarity' (Sandberg, 2021; Spangenbeerg and Lorek, 2019; Spengler, 2016) and sufficiency has also been described diversely as an "idea, a self-management principle or a social organizing principle" for sustainability within the ecological reality and biophysical limits (Princen, 2005, p. 7). Another reason for an unanimous definition being hard to reach is according to Spangenberg and Lorek (2019, p. 1071) "that the flood of research arises from different disciplinary and thematic springs, from climate science and ecology sustainable consumption research, energy economics, ecological and behavioral economics, and more" while usually this research explores sufficiency in combination or through a number of diverse theoretical concepts (e.g. good life, safe operating space, overshoot, degrowth). In most discussions however, a finitude perspective of the Earth's natural resources and the use of some type of measurement, like the planetary boundaries and the ecological footprint or environmental space approach is taken (Callmer, 2019).

Moreover, sufficiency is attributed with different foci according to the institutional setting and the spheres of actors within which it is being discussed. For example, first, it has been exercised as a country-level soft guidance in Thailand and the 'Sufficiency Economy Philosophy' for supporting prudence, moderation and risk-management in the agricultural sector (Chaipattana, 2017). It has also been discussed at an organisation's level, influencing both supply and demand by managing (1) production activities according to ecological sufficiency and (2) consumption through their corporate sustainability or business model and strategies (Dyllick & Hockerts, 2002; Heikkurinen & Bonnedahl, 2013; Bocken & Short, 2016; Bocken & Short, 2019). But also, vice versa, sufficiency can be discussed from a consumers' level, when producers are reacting to demand signals coming from the consumers side or when consumption changes are driven by the consumers (Fuchs & Lorek, 2005; Bocken & Short, 2016; Heikkurinen et al., 2019).

However, a common ground when sufficiency is discussed from the broader perspective of resources throughput and economic activities system (e.g. along with manufacturing or overconsumption issues) is its conceptualisation in antithesis to efficiency (Sandberg, 2021; Lorek and Fuchs, 2013; Spangenberg and Lorek, 2019). While efficiency is usually referred to as the production-side-strategy for doing something *better* or *more*, sufficiency is understood with doing or consuming something *less*, with limiting resources consumption, with restricting or with sacrificing profits[10] (Lorek and Fuchs, 2013; Figge et al., 2014; Spangenberg and Lorek, 2019; Princen, 2005; Robra et al., 2020)[11]. Embarking from this sufficiency and efficiency diptych, that is used by multiple disciplines researching sufficiency and connecting it to the spheres of influencing actors, key-observations can be extracted, as shown in the following. These factors are offering for a broader operationalisation of sufficiency from different types of organisations, by assessing their incentives of advancing such strategies.

Extended application basis

First, as already mentioned above, efficiency and sufficiency strategies, can and should be coupled together otherwise sustainable change cannot be achieved and will fail to deliver the "double function of reducing the amount of consumption/production and increasing the quality of the supply/demand" (Heikkurinen et al., 2019, p. 661). For this to happen, the strict condition of rebound effects not kicking in needs to be ensured (Figge et al., 2014, Robra et al.,

[10] The latter point of the the 'negative' perception, due to some kind of 'loss' attributed to sufficiency (Figge et al., 2014) will be further discussed under 3.3.1

2020). Heikkurinen et al. (2019) are explaining that (on a business level) this is possible only if the eco-sufficiency strategy "extends to the consumers as a *whole* (emphasis added)" and therefore "the overall economic activity is reduced" (p. 661). Such a requirement on the demand side would be expected to reflect on the supply side proportionally as well. Hence, it should be added that any extended sufficiency strategy to the whole of the consumers in order to curb consumption, implies directly that the whole of the supply sector (i.e all of the producers, not just individual cases) should address overproduction as well, by producing less (Heikkurinen et al., 2019). Reducing the economic activity though, is widely acknowledged that highlights a paradox in the current economic growth system (Jackson, 2009; Ehrenfeld, 2008).

Forerunner business organisations in sustainability (e.g. Patagonia) have long identified this need and dilemma for themselves. Heikkurinen et al. (2019) in their research are approaching the above issue through "the interplay of influence" among the different actors of the three operating spheres —private, public and biosphere. It is argued that for such a ground-level change of a sustainable economy to be initiated from the private sphere, the intervention and support from the public sphere (i.e. citizens and government) is necessary. This is further justified with the broader responsibility that the public sphere bears to foster sustainable change and to intervene supportively in the institutional framework in which private sector and its corporate sustainability initiatives are unfolding, according to a more integrative perspective (Heikkurinen and Mäkinen, 2018). As a broader sphere in which the private one is embedded, the public entity is also characterised by a transcending quality that is essential for ensuring continuity with a long-term perspective and targets, in respect to sustainability (DeBrabander, 2015).

Long-term perspective

A second observation on the efficiency-sufficiency 'dipole', concerns the time perspective taken by the two approaches. Following a similar distinction to the weak and strong sustainability, Princen (2003) is referring to efficiency and sufficiency policies as either 'environmental improvement' or 'sustainability', accordingly, relating them to the allocation assumptions of weak and strong sustainability. On the first case, the primary goal, that is to get more economic return per unit of environmental resources used, resonates with the logic of the most efficient allocation of resources (Young et. al, 2011). For this, the use of natural resources is a given as long as it is managed for "optimal human use" (p.34) and therefore "the time frame is immediate or short term and the scale of activity follows political boundaries." (p.35). On the contrary, in the second case, the goal is to reduce environmental resource consumption and achieve ecological integrity with a long-term perspective "over many generations of key species, including humans" (p. 35), while the allocatoin logic is need-driven and therefore normative (Young et al., 2011).

Empirical insights especially from the energy transition and sustainable housing discussions are pinpointing this observation (Toulouse et al., 2019; Dobigny and Sahakian, 2019; Fournier et al., 2020; Bohnenberger, 2019). For example, Fournier et al., (2020) using 'parametric models' to forecast energy transformation participation (for increasing social equity of disadvantageous communities) according to historic data, concluded that for the short time frame set, any marginal sufficiency manifestations are skewed by efficiency-increasing policies benefiting higher income consumers in Los Angeles who can also access more easily these policies. In regards to housing, Bohnenberger (2019) mentions the need for the housing sufficiency strategies to overcome politics' short-term decision-making.

The above examples indicate that shortsightedness does not allow for sufficiency policies to develop, since sufficiency calls for a time frame that extents beyond the business or election cycle, resonates with the bio-physical cycles and is "ecologically meaningful" (Princen, 2005,

p.32). Decision making –from myopic and risk-averse– in a strong sustainability approach "goes beyond specific time periods" adopting a time-frame that "is orienting to the indefinite future" and it is not restricted by a set period of years (Princen, 2005, p.33).

This is another inherent difference between the economic growth system established on modernisation and short-termism of discount rates, and sufficiency that is founded on intergenerational resources equity and justice; how time is conceived according to what has value (Princen, 2020; Goodman, 2009). Adopting a "normative framework that values future generations and future needs however unimaginable they may be" allows to understand and opt for these indefinite-future-oriented time-frames (Princen, 2005, p.33). On the other hand, today's sense of time derives from a measurement according to "the divisibility of tasks and the expansion of consumer goods" that is based on the notion of "mechanical time" which is structured by the work regime of modern growth economies, according to anthropologist Sydney Mintz (Princen, 2005, p.132).

This way of 'practicing' time is not attuning with the "natural time", as Princen (2005) terms this conceptualisation of time that is 'sensitive' to humanity's need for meaningfulness and compatible with the ecosystem processes. In this 'natural' conceptualisation of time the search for identity definition and for satisfaction don't find outlet in consumption, and, subsequently, consumption is decreasing, whereas the needs are defined more authentically, as will be discussed in the following.

Need driven

While efficiency as mentioned, is primarily setting the goal of the highest output per resource use, sufficiency is focusing on the total reduction of resource consumption "by emphasising 'enough production' (…) where 'enough' refers to the sufficient fulfillment of human needs" (Robra et al., 2020, p. 2). Satisfaction of the need drives the allocation logic of a sufficiency approach (Young et al., 2011). However, the conceptualization of what actually constitutes a 'need' and how their 'enough' fulfillment can be defined, is rather vague.

Various approaches and discussions have been developed around 'needs' in different disciplines. Etymologically, at least, the 'need' refers to something that should be addressed and satisfied, and usually the quality of 'what is needed?' is defined in respect to something else -tangible and intangible- or to a condition, that is in shortcoming (Ehrenfeld, 2008; Princen, 2005). Needs can be understood in various ways, for example; as different types like the minimum essential needs for sustaining life -physiological needs in the bottom of a hierarchy (Maslow, 1998); as marginal preference or demand in economics; as in a taxonomy of the fundamental needs for human development, understood collectively and based on their accomplishment by institutions (Max Neef, 1989), or on the basis of 'caring' in a taxonomy of ontological concerns around 'Being' (Ehrenfeld, 2008).

In the context of sufficiency, it is important to note the discussion of distinguishing human needs from 'wants'. Basic human needs are usually approached as thresholds between excess and sufficiency, and the latter is also ranged with upper and lower limits (Prinsen 2002). First, a sensory perception of need is possible and sets the baseline (Princen, 2005) on an individual level -we can sense the need of having food but also the excess, when the limit of having too much is surpassed, for example. In this sense, the means (objects or services that are called 'satisfiers') for satisfying the needs are –up until a certain level– indispensable for the human existence, yet relatively satiable. On the other hand, 'wants', from an economic perspective, are referring to the desire of acquiring something that depends from the ability (i.e. resources) to have it, and are insatiable. (Ehrenfeld, 2008).

Human needs are not only contained to the ones maintaining our physical existence, but are largely related to emotional, mental and spiritual needs, like for human relationships, for a sense of belonging, of identity, of meaning in life. The symbolic function of consumption has proven that further social and psychological meanings are attributed to the acquisition of consumer goods (Jackson, 2009) and so, further utility is extracted from satisfying intangible needs through material-based consumption. However, the treating of these needs with inauthentic means of satisfaction, i.e. commodified, material oriented solutions, gives rise to an ever-ending race for satisfaction through 'having' and 'acquiring', that nurtures the feedback loop of the overconsuming societal patterns (Ehrenfeld, 2008)

3.3 Framework for Sufficiency in Digital Preservation of Cultural Heritage by CHOs

In this section the measures developed out of the Pendergrass et al. (2019) framework in 3.1.3, were further elaborated according to the second criterion of the quality of their outcomes. To do so, first, the understandings on efficiency and sufficiency developed by the literature review were used to interpret sufficiency specifically for the DP of CH by CHOs (under 3.3.1). Then, applying this interpretation on a reduced version of the Pendergrass et al. framework, allowed for the analytical framework with a theoretical layer to be developed (under 3.3.2).

3.3.1 Sufficiency interpretation for DP of CH by CHOs

An inclusive interpretation of a sufficiency approach for the DP of CH is deriving from the literature review combined with the Pendergrass et al.'s detailed presentation of the technical background of all the potential measures that supported the developing of the 'Environmentally Sustainable DP Framework' by the authors. The sufficiency approach in this section is assuming the public purpose of a CHO and it is composed of three strategies that will be elaborated in the following, namely; 1) a stricto sensu sufficiency strategy, that sets the context from within which the other two are attempted, 2) the efficiency strategy, and 3) a version of efficiency, that is described as Digital Preservation efficiency (DP-Efficiency), for the needs of the coding.

Sufficiency Strategy

By adopting a strong sustainability approach, a stricto sensu *sufficiency strategy* in DP of CH is defined as reducing the energy and materials throughput in absolute terms, while keeping the DP processes *in proportion* to the CHOs' purpose. This element of proportionality is included because of the fundamental difference of public CHOs to business organisations. Therefore, absolute reductions in throughput are pursued with a sufficiency strategy (Heikkurinen et al., 2019). The differentiation is spotted in the nature of the public and non-profit-driven organisation's mission; being assigned to serve the public benefit, usually through a high-value purpose (Princen, 2005). CHOs purpose, in particular, is to fulfil a public need, (1) that of preservation of the cultural memory and heritage for the future generations and (2) of availability of this content to the public in order to meet their need of reconnecting and creating meanings of their past and the world around them through the CH content. Therefore, the "uniqueness or quality of irreversibility" of these values, are setting the temporal and resources limits of the necessary actions to be followed (Princen, 2005, p.33). Until these limits, the proportions of the absolute reductions in amount can be pursued and the meaningful engagement of the public with the content to be enhanced.

More specifically, a decrease in absolute numbers of the amount of the CH objects can be pursued during appraisal of the CH material. International and national legislation (e.g. national Antiquity Acts or Decrees) are generally directing the selection spectrum, along with the specific collecting policy of the CHO. Beyond that, a decrease in the amount of objects, according to the developed measures by the framework of Pendergrass et al. (2019), can be achieved, by **(1)**

collecting strictly CH objects that are falling within the CHO's policy, **(2)** digitising only the material for which it is explicitly necessitated (e.g. at risk), according to users' needs or asked to (e.g. tiered or on-demand digitisation), **(3)** deduplicate the same object that may be found across many collections or CHOs by increasing the interoperability and enriching the meta-data, **(4)** reappraise the preservation choice of the object regularly, with possible indicators such as the metrics of its use and its changing value in time. In this respect, essential for the sufficiency strategy is the value function of the digital CH, i.e. the *value quality* extracted by the public from its engagement with the CH content.

Efficiency strategy

In addition to sufficiency, an *efficiency strategy* in DP of CH can co-exist, if it is happening from within the above understanding of sufficient fulfillment and reduces the resource intensity of preserving and making available the CH content. In this sense, efficiency is defined as for the same amount of outcome (e.g. fixity checking of the same number of CH objects), less resources are needed. The resources savings, though, are not directed to increasing the absolute numbers of the activity, i.e in the previous example to perform fixity checks in more CH objects. Efficiency approaches are mostly found as 'stopgap' technological measures in the Pendergrass et al. (2019) framework and are also incorporated, to a lesser extent, in the 'process-shifting measures'. In both cases, the efficiency measures are understood as reducing resource-intensity (energy and materials) for preserving the *same* amount of content and with the *same* quality traits. In particular, (1) technological efficiency (including software), (2) energy efficiency through scheduling and (3) clean energy are the ones included in the framework, and are applying to all the different stages of DP.

As it is also recognised from the authors, efficiency-increases might be easier and faster to implement, however, they are only an interim response. Meaningful results out of efficiency measures are attainable, if coupled with the reevaluation of the absolute quantity of the ever-increasing CH digital content. For instance, even if extreme efficiencies of scale are achieved in the area of online storage technologies (Preservation, 3.a., in *Table 3-2*) of peta bytes capacity that may outpace the exponentially increasing volumes of digital content, in the future, the environmental impacts of the material resources put into the ICT infrastructure, are still remaining.

Digital Preservation-Efficiency strategy

The number of CH objects that will continue requiring DP is not foreseen to shrink, but the opposite. This is why the biggest part of intervention measures in the Pendergrass et al. framework, is targeting the *volume* of data of the digital content and the maintenance of the same *high quality* (Pendergrass et al., 2019).

The volume of data (e.g. in what type of format or how many copies of the *same* CH object will be maintained) and the preservation quality (e.g. how often the digital content is being migrated in order to ensure authenticity to the original copy), are decided according to the best-practices of the sector and certain standards (e.g. by ISOs like the ISO16063[12]). In this case, efficiency would be defined as for the same amount of outcome of the same quality (e.g. same frequency of migration for the same number of CH objects) less resources would be needed. However, by lowering the quality of the DP outcome, the energy and materials input could decrease even further. Therefore, by incorporating the factor of quality of the final outcome, another type of efficiency strategy for data-related activities, like DP, can be discussed for achieving higher

[12] Space Data and Information Transfer Systems—Audit and Certification of Trustworthy Digital Repositories, ISO 16363:2012 (Geneva, Switzerland: International Organization for Standardization)

decreases in the energy and material throughput, the *Digital-Preservation efficiency strategy*. In reality, however, these savings would be balanced out by the inevitable DP increase in the future. Since the selected CH is a value worth preserving, a sufficiency element could, at least, be introduced by having the DP-quality that is still sufficient to fulfil the purpose of the activity (Pendergrass et al., 2019).

In appraisal this could be implemented by **(1)** choosing formats that are 'lighter' or of 'less quality' –in terms of possible actions allowed– and therefore, diminishing the volume of data or **(2)** by customising default choices in the workflows (e.g. disk imaging), if among others "the extra environmental cost is not justified" (Dundon et al. 2020, p. 49).

The largest part of the DP efficiency measures is found especially in the stages of preservation and accessibility. There, the quality is lowered when performing certain activities that are energy demanding. The large number of measures in the Table 3-2 was grouped under a set of more general 'measures' that were identified; of sampling, infrequency, on-demand or tiering according to the value and uniqueness of the CH objects (Pendergrass et al., 2019). These broader 'principles' have been identified in almost all the areas of measures from the Preservation (except measures 2.b and 2.d of Table 3-2) and Accessibility stages.

In particular, in preservation, measures include; **(3)** applying a 'good enough' level of DP that is corresponding to the determined by the CHO percentages of acceptable loss of CH digital material and quality during the time of preservation and this is further reflecting to **(4)** establishing 'tiered approaches of the preservation resources' in respect to the value of the content, that is; more effort and resources go into material that is deemed to be more valuable.

Also, when it comes to fixity checks and their frequency, **(5)** performing 'as less frequent and less complete fixity checks' of the digital CH objects, to the extent that this is aligned to the threat model of the CHO, saves considerable amount of energy, as well as **(6)** by performing larger fixity checks upon indicative 'sampling of the copies of the CH objects', complete fixity checks may be avoided or delayed, but the greater risk of loss of quality is achnowledged.

Similarly, the file format migration policy can be **(7)** adjusted to the risk assessments of format obsolescence of the CHO, while **(8)** the file format migration can be customised (instead of keeping the software management system's settings). If possible, this could be set to be conducted; on demand when access to the material is requested (also under the accessibility stage) or; selectively, for some of the material (e.g. when ingesting to the preservation system) and not in bulk.

Rather challenging is the number of redundant copies maintained by the CHO since every extra copy does increase significantly the resource demands of the DP process. In the framework by Pendergrass et al. (2019), the copies' redundancy falls under; the similar approach **(9)** of being guided by the threat model of the organisation (e.g. contrary to standards of highest quality preservation that may suggest of 6-7 different copies to be kept in different geographical locations), and; **(10)** of 'tiering according to the value of the object'.

Finally, in accessibility, the quality factor that may be affected is in terms of timing of the delivery, by **(11)** keeping a tiered access system according to value or frequency of use of the material, from more to less easily 'at hand'. Such systems though, may allow for powering down of that storage system when not in use (e.g. Facebook's new data center). The same quality hinder of 'delay', applies to **(12)** the on-demand access migration, as mentioned above, that should be communicated to the user in advance.

3.3.2 Sufficiency Framework

For the purpose of this thesis, the measures from Tables 3-1 and 3-2 (under section 3.1.3), were grouped under broader set of measures, in terms of function similarity –for the cases that this was applying. The correspondence of the detailed measures to the quality of their outcomes, can be found in the Appendix E. Then, these categories of measures were distinguished according to the quality of their outcome (as defined for the strategies in the previous section 3.3.2), to the three strategies of Sufficiency, Efficiency and DP-Efficiency, with the use of the color codes (Table 3-3).

Table 3-3. Quality of outcomes of the intervention measures in the respective DP stages in a CHO.

Intervention Measures - Quality of outcome		
Stage	**Area of measures**	**Measures - Quality of outcome**
All	1. Technological Efficiency 2. Scheduling 3. Clean Energy	**Efficiency**
Appraisal	1. Contain storage size 2. Capture and analysis 3. Reappraisal	**Sufficiency** a. Amount of objects (collect and digitise only what needed, deduplicate) b. Volume of digitised content stored c. Customise default choices in workflows d. Continuity in time (indicators; use metrics and value)
Preservation	1. Determination of acceptable loss 2. Fixity check methods and frequency 3. Storage technologies 4. File format migration policy 5. Number of redundant copies	**DP-Efficiency** a. "Good enough" DP b. Tiered approach of preservation resources to value of the content c. Run less often complete fixity checks d. Scheduling fixity e. Sampled fixity f. Self-check-summing and self-healing software g. File format according to obsolescence risk h. Customised, on-demand or selective format migration i. Only necessary number of redundant copies of digital items j. Tiered redundancy according to value, uniqueness and stability of the item
Accessibility	1. Digitisation 2. Access storage 3. Delivery	**DP-Efficiency** a. According to users' needs v. mass digitisation b. On-demand, tiered digitisation c. Upon request access migration d. Tiered access storage system e. Communicate a delayed delivery access system to the user

Efficiency **Sufficiency** **Digital Preservation-Efficiency**

Source: Own elaboration based on Pendergrass et al., (2019)

The strategy that manifests mostly on each stage, is named on the upper top of the cell of each stage's outcomes, while through the color legend it can be identified when manifests in individual measures in other areas of measues too. The structure of the Stages has been kept to facilitate the identification of the actors and stakeholders involved in each stage, and that will be discussed later.

For the above elaborated version of the measures to be utilised for a Sufficiency approach, the component strategies need to happen from within a strong sustainability theoretical understanding, as it has been defined earlier. The Sufficiency strategy should be setting the context for the other two, while, itself should be manifesting profoundly and not marginally, as has also been argued by Robra et al., (2020) in their research, that only marginal manifestation of eco-sufficiency does not satisfy the criterion of being applied as a conscious strategy in an organisation. This theoretical layer could be visualised as a reverse pyramid seen below (Figure

3-1), where sufficiency should be largely the aim, and manifesting more than DP-Efficiency and Efficiency strategies.

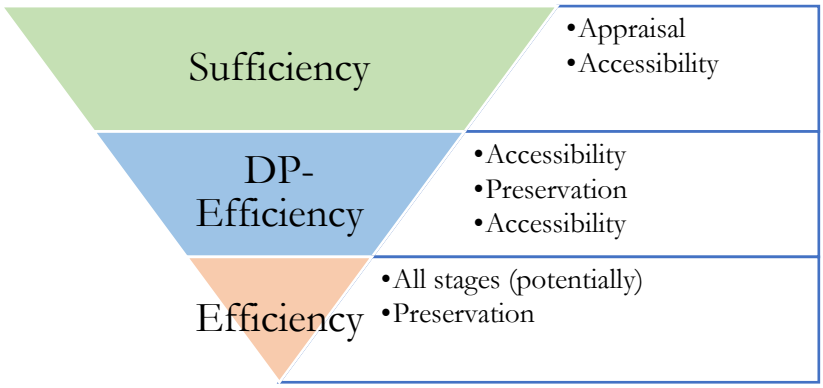

Figure 3-1. *Hierarchy of the strategies composing the Sufficiency approach for the DP of CH by a CHO*

Source : Own elaboration

Therefore, with this theoretical layer applied, the Framework of the quality of the outcomes of the intervention measures in DP of CH by CHOs (Table 3-3), can be rearranged as presented below in Table 3-4. So, the coded measures presented as the hierarchy above, suggest that the measures composing the sufficiency approach should manifest, for a a sufficiency approach to be advanced in total. Applying the strategies of the Framework (Table 3-4) from the top-down, reveals the measures that should be setting the basis in DP of CH by a CHO, in order to move towards sufficiency.

Table 3-4. *Sufficiency Framework for the DP of CH by a CHO*

	All stages	Appraisal	Preservation	Accessibility
Sufficiency		1. Collect only what needed 2. Digitise only what needed 3. Deduplicate 4. Reappraise in time		1. Digitise according to users' needs 2. On-demand and tiered digitisation
DP-Efficiency		1. Contain volume with lighter formats 2. Customise default choices in workflows	1. "Good enough" DP 2. Tiered approach of preservation 3. Run less often complete fixity checks 4. Sampled fixity 5. File format according to obsolescence risk 6. Customise, on-demand, or selective format migration 7. Only necessary number of redundant copies 8. Tiered redundancy	1. Upon request access migration 2. Tiered access storage system 3. Communicate a delayed delivery access system to the user
Efficiency	1.Technological efficiency 2. Scheduling 3. Clean Energy		1.Scheduling Fixity 2.Self-check-summing and self-healing software	

Source : Own elaboration from Table 3-3

4 Findings and Analysis

In this chapter, first, an overview of the surrounding network around the FHA and the current strategies and initiatives on DP of CH and ICT in Finland is initially detailed (Section 4.1). Then, the focus zooms in the results of the FHA documentation of the ICT use in DP, that consists of the self-questionnaires on the current practice (section 4.2.1) and the interviews input (section 4.2.2), in order to provide the material for answering the RQ1 (Section 4.2). Finally, this is put into the network perspective, zooming out again on the broader surrounding picture, to present the relevant insights from the network actors' interviews, as opportunities or challenges for the strategies (Section 4.3), addressing along with section 4.1, the RQ2. All the participants' input through interviews, for anonymity reasons, is coded with an "I" and a randomly assigned numbering, while through the 'self-questionnaires' accordingly with a "Q".

4.1 Actors' Network and strategies mapping

The network of actors involved in DP of CH was identified by collecting information around the key-department of Archives and Information Services of the case study organisation –FHA– and building the connections to the actors and the strategies around it. These connections were made based on the understanding of the DP of CH strategies that spurred the creation of the network in the first place (Section 4.1.1). The developments due to the last year's Sustainable Development strategy, are also presented (Section 4.1.2). Finally, the ICT actor and the newly ICT Environmental Sustainability strategy are also, introduced (Section 4.1.3). The integrated map of the Actor's Network and the strategies follows at the end of this section (Section 4.1.4).

4.1.1 DP of CH in Finland

Archives and Information Department and the Finnish Heritage Agency

The Archives and Information Services (AIS) department is one of the six departments, units and services –including the National Museum of Finland– that consist the Finnish Heritage Agency, as can be seen in the FHA's organogram in Figure 4-1. The Department with its four units, provides archive, picture, library and knowledge management services, meaning access to information and an image bank, while it develops and supports the museum data systems nationally (Museovirasto, 2021). The AIS, especially through the Unit of Picture Collection, is directly involved with managing the DP of CH of their collection, and in this way is contributing to the Agency's mission of preserving the CH and make it accessible to the public (I1, I2, I3, I4, I7, I8, I9; Museovirasto, 2021)

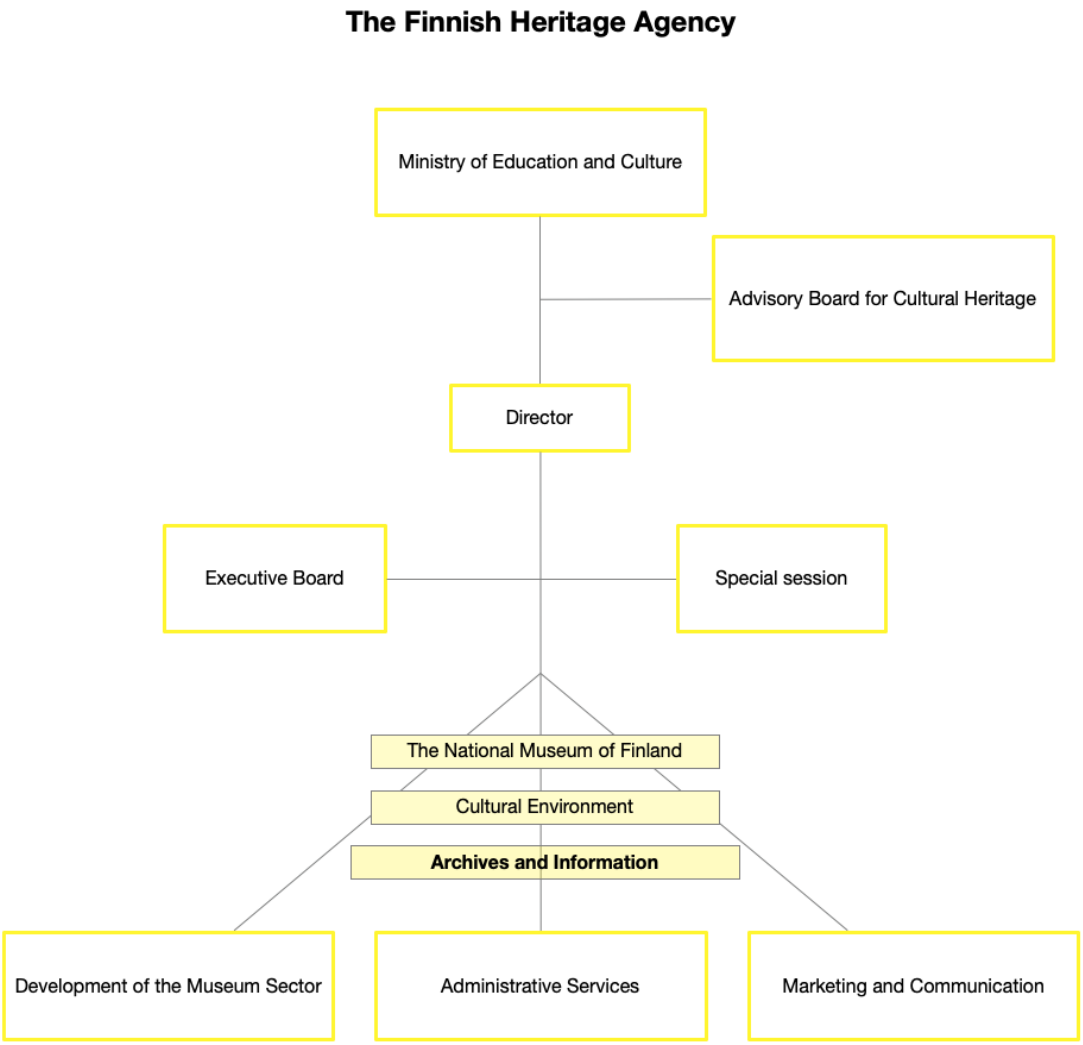

Figure 4-1. Organogram of the FHA

Source: Author's own elaboration based out of Museovirasto (Museovirasto, 2021a)

The FHA operates on the administrative level of the 'Agency' that is a very common way of organising authorites for public services in Finland (I2). Together with the other two agencies of the National Library of Finland (NLF) and the National Archive of Finland (NAF) and the private Finnish Museums Association (Suomen Museoliitto-that represents the museum organisations in Finland), is responsible -among the other activities- for collecting, protecting, promoting and studying the Finnish CH, while providing services to the public (Museovirasto, 2021). FHA is one of the 13 Agencies operating under the Ministry of Education and Culture of Finland (refer to as Ministry, hereafter) (I2, I15). This is the Ministry developing the initiative on DP of CH projects and guiding the respective actions, from a top-down approach, disseminating the programme objectives of the Finnish government through its sectoral policies (Ministry of Education and Culture, 2021; I15).

Ministry of Education and Culture and the National Digital Library

The Ministry is the main administrative actor, acting as an executive and steering board, under which the extensive and cross-sector collaboration of libraries, archives and museums (LAMs)

was established for the National Digital Library (NDL) project in 2008-2017 (Hormia-Poutanen et al., 2013). The aim of NDL was to provide a long-term preservation solution for the digital CH material preserved by these organisations for the future generations, and to ensure its accessibility and usability by the public (NDL, 2010). For this reason, a shared service system and infrastructure was developed for the first time, consisted of; (1) Finna, the public interface for searching all the datasets of the libraries, museums and archives (LAMs), based on Open Source Software (OSS) and on direct metadata exchange with third parties like Europeana and; (2) the National Digital Preservation Services (DPS) for CH, that is the Long-Term Preservation (LTP) solution offered by the Center for Scientific Computing (CSC) (Hormia-Poutanen et al., 2013; I13, I15, I16). LTP is a key component of the NDL project, with the dual purpose to support Finna and to provide data packets to LAMs management systems., as is shown in the enterprise architecture below (NDL, 2016; I16).

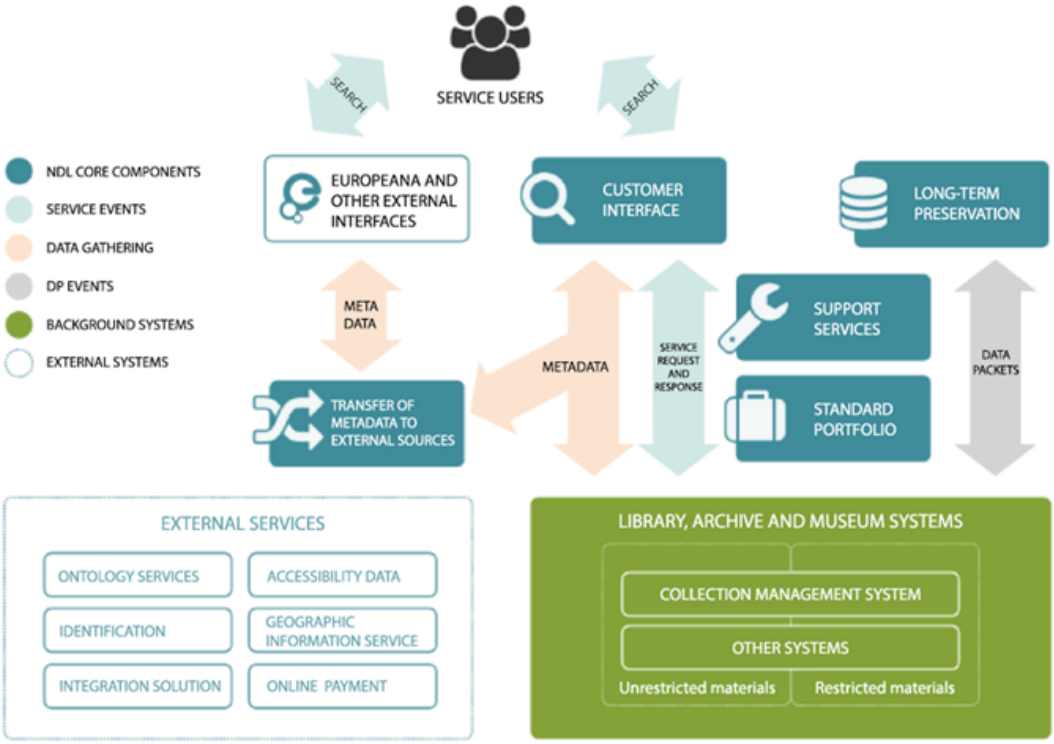

Figure 4-2. NDL enterprise architecture

Source: The National Digital Library. (2016).

The value and purpose of the NDL project still carries on under Digime (Digitaalinen kulttuutiperintömme), that means 'Our digital cultural heritage initiative'. The Ministry of Education and Culture is still responsible for the policies of the Digime initiative, while the NLF for the communicational and promotional aspects of it. The initiative is identified as the "primary information channel" containing all the digital CH-related news and events and all the information around the collaborative efforts among LAMs and, essentially, it serves as "the hub for every interconnected digital cultural heritage service, initiative and project." (Digime, n.d.). One focus point of Digime is to enhance accessibility of the digital cultural material by the public and provide information on the sources and targeted services and expertise (Digime, n.d.). On a second level, though, Digime, gathers and creates a "quite good and strong network" of various actors around it, that are responsible for coordinating and participating in the platform, as well as contributing and maintaining the content in the website (I13).

The platform was developed primarily for organising the digital CH content and the various actors engaged in it (Digime, n.d.; I15). It also creates opportunities for informal cooperation initiatives to occur among the actors interested in similar issues, especially when in view of preparation for taking up new administrative action across the CHOs. In this case, the National Information Society strategy for 2001-2011 (Hormia-Poutanen et al., 2013) that set up the NDL project, brought together the different actors and created the foundations for the digital CH network, and now that a new strategy on Sustainability is calling for action, this network still underlies both formal and informal horizontal cooperation opportunities from a grass-root level and from upwards, while embraced by the agencies' management (I13, I15, I19).

4.1.2 Sustainable Development

Sustainability Reporting and Sustainable Agencies

The way administrative actions are organised follows in general the vertical administrative structure as described in section 4.1.1 for the FHA case and as can be shown in the map under 4.1.4. The government programme is interpreted into sectoral policies for each Ministry that are put into further applicable strategies (I2, I15). Specifically, the governmental programme of Prime Minister Sanna Marin's Government sets achieving carbon neutrality by 2035, as a clear objective for Finland, aligned with the targets of the Paris Agreement for Climate Change as part of the EU (FG, 2019). For the FHA context, this objective is being cascaded downwards through the Sustainable Development Policy of the Ministry of Education and Culture and its administrative branch (I2, I3, I12, I13, I14, I15, I19, I20). Even though the objective is not explicitly mentioned in the policy (under point 3.3) (Ministry of Education and Culture, 2020), it is to be pursued in parallel with the mainstreaming of sustainability reporting in the Finnish public administration sector, that is currently being developed by the State Treasury (supported by the Ministry of Finance) on the basis of the UN Sustainable Development Goals and Agenda2030 (State Treasury, 2020).

Regarding the last point, the network was activated and four actors –the Finnish Heritage Agency, the National Archive of Finland, the Arts Promotion Center of Finland and the Governing Body of Suomenlinna– started the *Sustainable Agencies* project that got funded by the state (I2, I19, I20). The aim was to develop a common draft of the sustainability goals and the reporting indicators to use for the sustainability reporting (State Treasury, 2021). According to FHA, the sustainability development plan and the sustainability reporting, were also part of the contractual agreement the Agency signs with the Ministry every 4 years in the beginning of every working period (I2). For instance, in the contract of 2019, the contribution of the proposed project to sustainable development, is explicitly required as a funding criterion (Ministry of Education and Culture, 2019). This 'administrative' need and the already established network have created fertile ground for the collaborative initiative of Sustainable Agencies to flourish (I2, I20). Yet, it was developed from a grass-root level and upwards, concepted by people who were personally involved with other sustainability-related projects, i.e. the Wheel Chart of sustainability and Intangible Heritage –a sustainability project of FHA and the Arts Promotion Center (I2; NDPC, 2019)

Round Table for Digital CH, Carbon Footprint Modelling and Sustainable Development Working Group

In a similar vein, the National Library of Finland is taking up the Sustainable Development strategy with both informal and formal initiatives. The NLF, that is responsible for the DP of CH Digime initiative and the Finna interface with the 450 participating organisations, has started organising a *Round Table for Digital CH* with a smaller group of organisations participating in the cultural heritage network, with the intention to share best practices, brainstorm and pilot ideas on sustainable development of the digital CH sector, among other (I13).

Collaborations and interconnections with other actors are also a major incentive for NLF's 'in-house' sustainability actions. Firstly, being part of the University of Helsinki has geared them working towards the carbon neutrality until 2030 goal of the University and launching a *Carbon Footprint modelling* dedicated team (I12, I13). In addition, they have launched –after combined management initiative and grass-root interest– a *Sustainable Development Working Group* that is preparing the new strategy and indicators for their sustainability reporting (I12, I13, I14). The new strategy for sustainable change 2021-2030 that is currently being drawn, is greatly considering ecological sustainability as being aligned with cooperation, transparency, accessibility and with "durability over time" (I14). It has also been the first among the CHOs' strategies (NLF, p.c. 31 March 2021) studied, to acknowledge ICT's and DP processes' ecological footprint both in energy and material resources consumption (I14) as well as to explicitly consider 'meaningfulness of their actions', services centralisation and extending sustainability practices and attitudes to their customers (NLF, p.c. 31 March 2021).

4.1.3 ICT and sustainability strategies

National Digital Preservation Services (DPS)

A key-component in the discussion of the above strategies on digital CH and Sustainability is the environmental sustainability of the ICT equipment, that, even though it is considered, it has yet to be incorporated explicitly and in linkage to the DP processes. The Center for Scientific Computing (CSC) with the DPS is the actor assigned with managing the ICT, as far as long-term preservation is concerned, and is a non-profit special purpose company owned by the Finnish state and Finnish universities (CSC, 2020). The DPS they are offering covers a time span of decades or even centuries and is consisted of complete preservation solutions of the digital content regarding both hardware, software and management system standards (e.g. formats) that are offering to libraries, museums and archives.

For that purpose, libraries, museums and archives are maintaining their own dedicated infrastructures in the cluster of data centers, located in Kajaani that is also designed for hosting LUMI, a EuroHPC (high performance computing) super-computer (CSC, 2020). The 2020 sustainability report of CSC highlights that their procurement is following the Hansel framework, that instructs life-cycle environmental considerations to be taken into account for procurement and that energy efficiency is of key importance criterion (CSC, 2020). As an ICT provider, CSC has committed all their activities to promote climate goals and their cross-cutting strategy is aiming at the highest energy-efficiency while minimising their total environmental impacts and contributing to a green transition with their activities (CSC, 2020).

In particular, the Kajaani data center is among the 10% of most energy-efficient developments globally, and with continuous upgrades it still improves. For example, LUMI's cooling system contributes one fifth of its waste heat back to the district heating system, while it runs completely on hydro-power. The power usage effectiveness (PUE) value for the energy efficiency of the "modular data center (MDC1), which was commissioned in Kajaani in 2012, was 1.03 in 2020, which is world-class." (CSC, 2020). Also, the energy efficiency was further improved with an advanced cooling solution implemented for the Mahti supercomputer that will be counted in the results of the 2021 (CSC, 2020). However, the total energy consumption of CSC's data centers in Kajaani and Espoo has increased comparing to 2019 by almost 2.000 MWh due to the in total expansion of the network (CSC, 2020).

Climate and Environmental Strategy for the ICT sector

Having said this, another crucial component to which the discussion extents, is the volume of data production and 'flow' in the network. The Ministry of Transport and Communication in Finland has been the first one globally adopting a climate and environmental strategy for the

ICT sector, at the end of March 2021 (Ministry of Transport and Communications 2021). This first in its kind strategy, apart from recognising ICT's enabling role in mitigating environmental impacts and climate change, is drawing the attention to the very environmental impacts of the ICT's energy demand as well as of the material resources –that are usually under-represented and under-researched in comparison to the more pressuring energy consumption part (I17). For example, material resources, like scarce minerals, used for building ICT equipment are getting locked into this equipment for some period of time –ranging from 2-3 to 20-30 years– while the collection and their retrieval through recycling is challenged due to complexities like the collection logistics and the profitability of the proess (I17).

At the same time, the data volumes in the Finnish mobile networks for instance, between 2014-2018 has been increased more than sixfold, despite a more than 80% cut in the average energy consumption of data transmission in the same mobile networks (Hiekkanen et al., 2021). For this reason, even though ICT energy efficiency keeps constantly improving, ICT energy demands will still increase, as the data volume and internet traffic are projected to keep growing globally, as can be seen in the Figure 4-3.

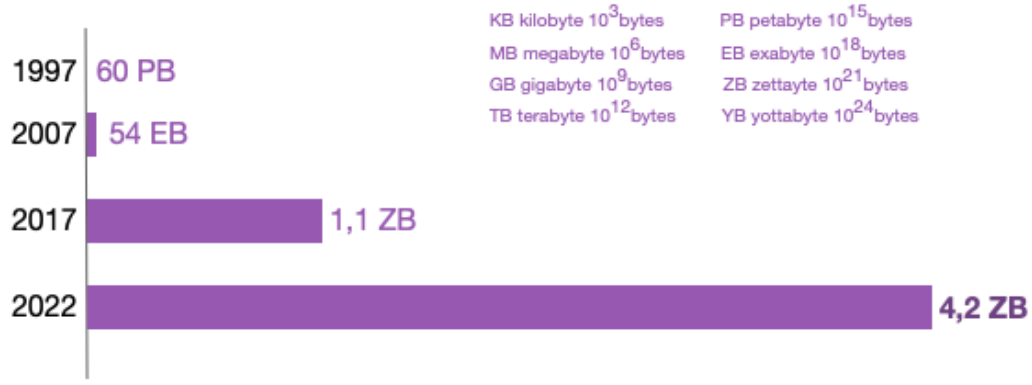

Figure 4-3. Global Internet traffic projection

Source: Ministry of Transport and Communications (2021)

This is why it is suggested that the focus should also be paid on understanding the material side of ICT impacts and the software's energy demands (i.e. green coding) (I17; Ministry of Transport and Communications, 2021). Along these lines, end-user's awareness and behavior change (e.g. streaming in lower resolution or using a smaller screen) measures are among the focal points while the role of education is highlighted (Ministry of Transport and Communications, 2021). Educational institutions have also been put among the key-actors of contributing in expanding the knowledge basis on environmental impacts and rebound effects also through other sectors like education and entertainment (Ministry of Transport and Communications 2021).

4.1.4 Summary map of Actors' and Initiatives' Network

The information gathered in the previous sections on the interrelations among the actors and the strategies surrounding the FHA, have been synthesised and imprinted in the following mapping of the Actors' and Initiatives' Network in Finland (Figure 4-4).

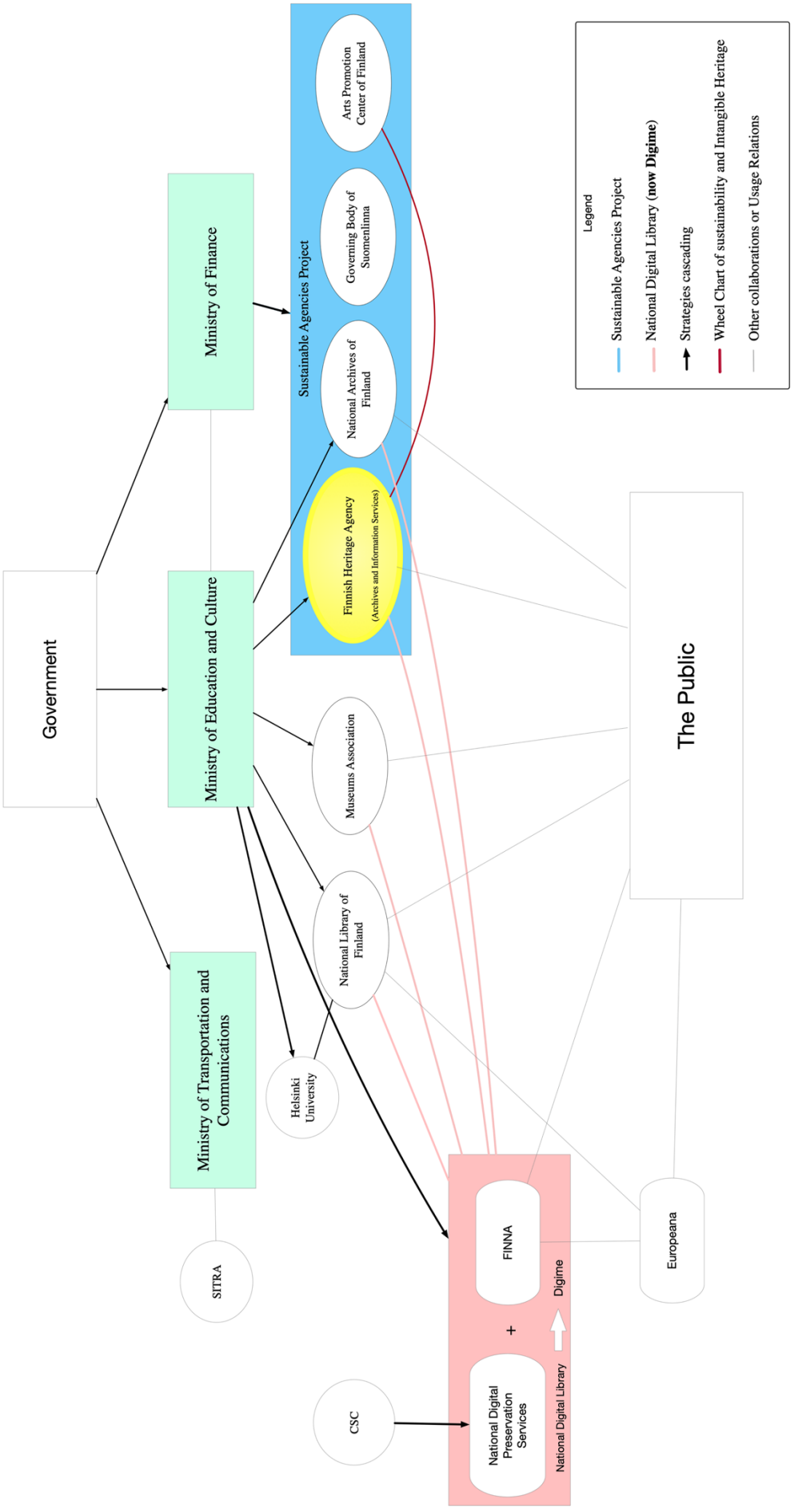
Government
Ministry of Finance
Ministry of Education and Culture
Ministry of Transportation and Communications
Sustainable Agencies Project
Arts Promotion Center of Finland
Governing Body of Suomenlinna
National Archives of Finland
Finnish Heritage Agency
(Archives and Information Services)
Museums Association
National Library of Finland
Helsinki University
SITRA
CSC
National Digital Preservation Services
+
FINNA
Digime
National Digital Library
Europeana
The Public
Legend
Sustainable Agencies Project
National Digital Library (now Digime)
Strategies cascading
Wheel Chart of sustainability and Intangible Heritage
Other collaborations or Usage Relations

Figure 4-4. Actors' and Initiatives' Network of DP of CH, around the FHA and AIS in Finland

Source: Own elaboration

4.2 Environmental sustainability in the ICT use in the DP of CH by the FHA

The current practices of ICT use in the DP of CH in the FHA offer a first picture around environmental sustainability in the DP processes by the FHA. The FHA-respective data, i.e. the eleven in-depth interviews and further seven more DP-specific input with the direct use of the Pendergrass et al. (2019) guiding self-questionnaire, are sourced from the Archives and Information Services Department, that mainly manages the DP activities in the FHA. First, the results on the questionnaires are presented, complemented where needed with the input from DPS (section 4.2.1). Then, the findings from the interviews will follow, organised as enabling and hindering factors of the strategies for sufficiency in ICT use of DP of CH (section 4.2.2).

Sustainability in the CH sector was more broadly understood with the meaning of sustainable development, while the links of environmental sustainability of ICT-use to the DP and how it is reflected to the practices of the Agency were not easily grasped. Even though discussion on these issues only now start to immerge, the willingness and the positive disposition of the Agency to work decisively towards them was stressed from the very beginning by all participants. A great deal of in-house environmental sustainability initiatives (e.g. recycling) were mentioned as being already in place, however, since the focus of this research is specifically on the ICT in DP processes' environmental impacts, only the measures related in some way to them are being considered here. Finally, this discussion is taken up more in detail under section 5.1, where the results of the questionnaires are summarised in the Table 5-1. For consistency reasons, the Table 5-1 was chosen to be presented there and not under section 4.2.1, because the further interpretation of the tables meanings under the light of the FHA's interviews analysis follows there, in section 5-1.

4.2.1 Current practice in the FHA

The findings are presented according to the DP stages of Appraisal, Preservation and Accessibility, and the areas of measures in the framework are also identified. The answers refer to measures already in application, the areas where action is considered or prepared to be taken and any restrictions for the potential measures are also indicated. In addition to the information brought in by the questionnaires, further information was added in two cases; (1) where more detailed answers were provided during the interviews of the same practitioners who took the questionnaires, and; (2) where services are outsourced to CSC, the answers from DPS are substituting that area.

Appraisal

Regarding the decisions taken for the *storage size*, the amount of the born-digital CH objects held by the FHA, is containing exclusively to the material falling within FHA's collecting policies – with no other (e.g. personal data) content maintained at the same time. The number can be influenced by the existent duplicates within the collection, that can be deduplicated by the use of pointers in the place of the removed objects (Q2). The technological resources directly identified for 'handling' the digital content, are a content management system (CMS) and the customisation of workflow systems default choices is "on progress" (Q1, Q5).

In the case of analog material, the digitisation does take place upon demonstrated need, that can be justified on the basis of legislation, natural degradation of the CH asset (rescue digitisation), users' demands and internal usability (collections, policy, catalogues for exhibition) (Q2, I1, I2,

I3). The type of image file formats mainly employed are the DNG, TIFF, JPEG –in a scale of the most 'lossless', editable and of highest quality to the least one– along also with various movie and audio file formats, and lately, 3D, as well (Q1, Q2, Q4, Q5). The file formats are being standardised following the file format standard, defined by DPS, while for quality criteria using international standards like the FADGI Guidelines, Metamorfoze and ISO standards: ISO/TR 19263-1:2017 and ISO/TS 19264-1:2017 (Q3), even though it was raised that for some purposes, smaller formats could be used (Q1).

In general, it was argued both in the questionnaires and the interviews that the material should be digitised in the *highest quality possible* (Q2, Q4), on the reasons of; (1) avoiding degitising again in the future to accommodate potential higher quality needs, (2) complying with EU or international standards, while staying within reach of the national quality standards of 2-4 star in the FADGI system, if not restrained from resources (Q3, Q4, Q5). However, the fact that the quality should be in accordance to the anticipated use, was underlying the discussion on digitisation too (Q1). The hardware used here (scanning, photography equipment and related software and infrastructure for DP servers), was more observable/visible for the respondents than for the born-digital content, since the whole digitisation process itself is more of an engaging, tangible and resource intensive process (Q1, Q2, Q4, Q5).

It was suggested that *reappraisal* should happen roughly once per year, while for some respondents can be less frequently, only if needed or during a special project, but not regularly (Q1, Q2, Q3). However, one mentioned, that since only 1% of their total collection is digitised, this [deaccessioning] should not be the case yet (Q5). On the other hand, it was mentioned by a respondent that due to fast technological progress and cultural, historic value that is constantly evolving and changing, it is rather a reinterpretation than a disposal of the material that should be taking place (Q3). Finally, there is a deaccessioning process provided in the collection policy, especially for original material preserved in the FHA collections only (Q2, Q3).

Preservation

The determination of a *"good enough" level of DP* or what could be acceptable loss over the preservation time, varies among different practitioners. In general, "good enough" is perceived as having the minimum losses as possible (Q4), and following the technical standards set for long-term preservation in DPS (Q2, Q5) while a policy from the FHA's side and activities, is under preparation (Q2). On the DPS level, once the selection is done by the organisation and the content is deemed as long-term preservation worthy for them, as the interviewee put it, "good enough" preservation means zero losses over time. In other words, selection is done in organisations and in DPS there is only data that have been defined as valuable and worth of preservation" (Q7).

In the same way, the implementation of *tiered approaches* to the DP resources according to the value and uniqueness of the CH material, differs between the various actors' purpose of preservation, even though tiered approaches are not officially provided in their policy (Q2). As long as the material is still managed completely by the FHA, before the DPS level, for some interviewees a tiered approach is identical to the prioritisation criteria applied for collections' digitisation (Q3, Q5), or, on a short-term preservation scale and "in practice, this has been done, e.g. first metadata, then digital surrogates" (Q4), and also a policy from the organisation's side is in preparation (Q2).

However, for the DPS's level of quality, in long-term preservation, there is essentially *no option* for tiered levels of approach. During ingest and e.g in storage management, they are preserving all material in the same way. This is happening so as they can handle all data effectively and as automatically as possible. When working this way, the centralised DPS is more cost effective.

On the other hand, over time some materials get more "attention and care", e.g. if file format migrations are performed, as the interviewee shared. Also, preservation planning for *some types of data* might need more efforts than others e.g. "office documents and formats" are usually more complicated than plain picture or sound files (Q7).

The above stances towards *'loss acceptance'* are shaped from the different agreements with those assigning the DP or bearing the financial cost. In the case of FHA, agreement forms incorporating this aspect exist for physical collections only and not for purely digital content (Q5). However, even though such a policy is not yet in place and no concrete language could be examined, according to another opinion "[a] degree of loss over time should be allowed" (Q2). On the other hand, the preservation service agreement of the DPS with the organisations does not allow flexibility for *any losses* and the used language is quite strict on that and "this requirement is there because of organisations' specific request" (Q7) as it was further explained. This model agreement –that was written together with the organisations– was written for the NDL project (Q7). It was for the long-term preservation needs of this project, that DPS was developed in the first place.

As indicated by all FHA respondents, the *fixity checking* that is performed during the long-term preservation, is outsourced to DPS managed by CSC, and therefore, the data presented on the current practice on that area are sourced from the responses provided by the DPS. The frequency of *fixity checks* of the AIPs (Archival Information Packages, i.e. all the necessary information components for long-term preservation of an information object, or simply the copy) is around once per year. Regarding the energy efficiency of scheduling, they try to make it when the DPS is less loaded, and in order to increase effectiveness, they are checking whole tapes at once with all the AIPs that may contain. Acccording to DPS's standards, partial/sampled fixity checks of the AIPs would not be possible since, all copies of an item should be checked to verify complete integrity and if needed in case of damaged AIPs recovery actions to be taken. (Q7)

The *storage technologies* used by the FHA and the DPS, are according to the purpose of preservation pursued. The FHA, keeps half of their material, almost 290,000 items online (published) on the Azure cloud services and around 400,000 offline on the collection management system and its servers that is outsourced to the Finnish Museums Association (Q2, Q4. I3). For this practice, *in the short term*, one DNG and TIFF are kept offline (i.e. for archive) and one JPG online. The digitised images (DNG, TIFF) are stored in their intranet reserve until catalogued and after cataloguing and publishing online, reserve files are deleted (Q5). However, for the *long-term* preservation carried by DPS, their current policy is to have 3 online copies (1 on disk, 2 on tapes) and 2 offline (on tape) since their service level requires to have at least three copies, that practically need to be online copies (I16). Therefore, in total, an object that is both preserved in the CMS and by DPS, may end up having a total of at least 8 copies.

As the DPS respondent shared, "storage has to be updated regularly. In general, disks' and tapes' life cycle is approximately 5 years. Tape environments can include components with 5-10 years life cycle." So, approximately, the migration needs might be a bit longer than 5 years. Both the environmental and energy impacts have been evaluated and this is one reason why they are using tapes (Q7). On the other hand, from the FHA's side such data on the environmental impacts of the storage solutions are not available, however, they would be interested in looking into this information (Q1, Q2, Q3, Q4, Q5).

Local format policies have been developed in close collaboration with the CHOs that are preserving their material with DPS, and the file format migrations policies have also been customised accordingly (Q2, Q7). This is also because of the *interoperability* levels set by the NDL, that

recognises DPS file formal specifications and therefore the organisations participating in NDL, like the FHA, are obliged to follow them if they are uploading their material there (Q7). Also, even though the selected 'acceptable formats' are followed, some *migration* still needs to be done before the long-term preservation, to the preservation format (Q3) that is also more effective for access (Q7). File format policies, at this level, again, are applied for the *whole* of the material and cannot be applied selectively.

Finally, similarly to the storage technologies, the necessary redundancy of copies (AIPs) is based on the DPS responses (as it tis outsoursed to CSC) (Q2), and on the conduct of a threat model, among others (including AIP copy policy, selection of storage media, need for geographically distributed system, etc) (Q7). However, as acknowledged, is "really hard to define how many copies is really enough or how many is "too much", but according to the interview, there are well known principles that someone should at least follow on bit-level preservation; (1) Create several copies (mitigate risks regarding software and hardware failure and single-point-of-failure); (2) Use various media types (mitigate risks regarding media and hardware failure and single-point-of-failure etc); (3) Store data in different locations (mitigate risks regarding one site, operator errors, natural disasters, etc); (4) Maintain offline copies (mitigate risks regarding internal and external attacks, system or operator errors etc.) (Q7). Nevertheless, a *tiered approach* cannot be adopted, because retaining the same number of copies for all preserved digital content equals, reduces the manual work and helps building "fully automated DPS" (Q7).

Accessibility

The way the CH material becomes accessible to the users is mainly managed by the FHA. In terms of defining the *scale of digitisation needs*, this does not happen by users' demonstrated needs of an entire collection for instance, but is rather prioritised by the practitioners themselves (Q1, Q2, Q5). The selection of the scale of digitisation needs is influenced by factors like that in minor collections, whole entities are more useful e.g. for research purposes. At the moment, selection (scale) is done by FHA themselves] trying to meet also the user needs. However, an interviewee shared that, changes are expected on this aspect in the future, seeing an increase in user needs and its weight for the selection (Q4). On-demand digitisation and access are accommodated by the Customer Service on a moderate fee for a digital copy, while the clear articulation to the user of the on-demand digitisation as saving unnecessary trips for viewing analog material will be an important part of the digitisation policy that is "on progress" (Q2, Q4, Q5).

In order to *access storage*, according to the CMS, there is no need to migrate content to an access copy, as the users have access "basically to the same content (not all metadata) as we (collection management system)" (Q4), that is high resolution copies available online. If the user needs more resolution for Hi-Res publishing (posters, books), the copy is then digitized on demand (Q5). Also, no *tiered storage system* of the access copies has been adopted yet, that facilitates powering down when not in use (Q4, Q5). For the national DPS and their OIAS model, the access copy (DIP–Dissemination Information Packages) is "available upon organisation's request and stored on specific disk area for a while" (Q7).

As for the delivery of the content to the user, it goes through the FHA. The DPS delivers the requested material to the FHA, who is responsible of the material and enjoys the flexibility of organising the public access to the material in different ways, but still keeping the control of the usage of the materials (Q7). So, on the FHA'a side there is no at the present, delayed delivery system in use or a communication of such system to the user and apart from general instructions, no other supplemental material is accompanying the copy (Q5).

4.2.2 Barriers and enablers of the sufficiency set of strategies

The above information from the answers to the Pendergrass questionnaire offer an indicative and systematic first understanding of the ICT-use practices in regards to the DP processes of CH, of what practice is implemented already, what is considered and what is limited in application. However, through the in-depth interviews, issues that may enable or hinder the sufficiency set of strategies, were identified and presented here, as they deemed crucial for a more holistic and accurate understanding of the current ICT practice in the FHA.

In general, the focus on the ICT angle of sustainability in only now emerging among CHOs in DP processes. All of the interviewees shared that it must be discussed more, take concrete action and implementation to follow the commitments and policies. Apart from the CHO-internal measures, the external and educational role of CHO to the public was stressed by most of the interviewees as well.

Barriers and enablers for sufficiency strategies

In order to decrease the absolute amount of energy and materials throughput to be achieved, stricto sensu sufficiency strategies are aiming at decreasing the amount of digital CH objects produced by increasing simultaneously the quality of use. However, first, a legal minimum on the CH content that should be preserved is set by the international conventions, EU and national legislation, and more specifically, by the legal statutes, which are detailed national law on what the legislator and the Ministry are expecting the FHA to preserve and by their purpose (I2). In addition, the margin of reducing the number of digital CH objects is restricted by the objectives set with negotiations (I3) with the 4 years contractual agreement with the Ministry setting an increase of 20,000 objects per year to becoming available online and "which is monitored through metrics twice a year" (I2). At the same time the statistics of people's interaction (in number of downloads) is also followed by getting these figures every month (I3) as it is also included in one of the objectives in the contractual agreement with the Ministry for 2020-2023 (Ministry of Education and Culture, 2019).

In practice, the digitisation strategy for the whole FHA that is under writing, considers a number of *criteria* that have been in the discussion and are in practice implemented in digitisation activities. These could be summarised in digitising; (1) the materials that they know their customers are most interested in and are asking more frequently; (2) materials that they themselves or their stakeholders think that might have really great impact, e.g. underrepresented groups, minorities, difficult or topical issues; (3) analog materials that deteriorate very quickly and it's kind of a rescue digitisation, and finally; (4) materials necessary for the internal functioning of the institution, because it's not only for the public, but for their experts (e.g. curators) as well that they are digitising (I2).

On the other hand, could be said that the core of sufficiency in DP is acknowledged, that "not everything can be turn into a digital format, because of the sustainability concerns" (I2). As an interviewee put it, "We have in our collections 18 million images, it's a lot, is really a lot, and if we are to digitise all of them this would require so much energy and resources (…) it is so much data which must be preserved in the long term and as we are digitising in best quality this means that these files are really really heavy" (I3). Best quality is aimed at, for being valid in the future as well not doing it twice (I10). So, in relation to the storage capacity, one interviewee made the point that "so the strategy is not to digitise everything as fast as we can with the best possible quality, but also kind of curate what is being digitised and for this we are creating a digitisation strategy for the Finnish Heritage Agency" (I2). As de facto sufficiency enabler was also mentioned the limited budget and resources that naturally lead to collection and digitisation prioritising (I8).

An important aspect on the intersection of the FHA context and the rest of the CHOs network, also included in the objectives, are the interoperability and metadata guidelines that enhance shareability of the content. Starting from a national level, FHA have created guidelines for cataloguing –based on the Spectrum standard for cataloguing– that are openly published and system independent. This way the standardisation and interoperability of metadata across different CHOs that may have same objects in their collection is enhanced, and this way CHOs could identify the duplicates and save double DP processing (I2). Finna is also using Europeana's standards and data models, in order to ensure interoperability on an international level too (I3). In general, establishing high quality meta-data standards, as it is required for publishing content on the Finna platform, allows for higher accessibility and usability of the material (I5) and it is a default value (I10).

Finally, one of the most important angles of the appraisal and the numbe of materials to be digitised –if not the most important– is related to equity and democratic participation in cultural and historic representation of different communities. "If we have only published let's say 300,000 images, they should reflect the history as it was and not only the high end of the hierarchical pyramid that was more involved with that [archives and collections] rather than minorities [did]. (…) This is why we should actively put the highlight on the voice of these minorities and margins since this hegemonic culture it is overrepresented in the media and are cementing themselves in the history anyway." (I4). Having a transparent discussion with communities and citizens at large on what is important to be included and engaging them more in the decision-making could democratise appraisal (I4), while at the same time, would need to be followed by an increase in digitisation of material to increase representability.

Barriers and enablers for "Digital Preservation-Efficiency" strategies

Absolute throughput reductions may be achieved by *lowering the quality of the final outcome*, whilst this outcome is on the level of serving the purpose of the process. The link of technical quality standards and the quality of use of the final outcome is pinpointed by one interviewee; "Still when you are digitising is mostly about how it looks, but behind this, there are technical data and quality that we are measuring, and we are trying to do it in the best possible quality. So, for example we are preserving the original [picture] file in a negative form and we are making a Tiff format for us and everybody to use, and this means that for one image we may have at least 2 or 3 different files (…) But for the CMS is us [FHA] deciding the standards of how, in which format and quality we will use" (I3).

This quality race is also driven by the constantly *evolving technological equipment* used that "has raised the quality requirements a lot, as, for example the cameras, and scanners etc of 20, 15, 10 years ago, are of quite lower quality comparing to today's (..) and of course software thirsty, so does [getting better] the software. That means we have the tools to produce better and better quality. So, this is what we are trying to do" (I3). Is added though, that the level of standard high quality they are producing right now is perceived as enough for them and the researchers for example, who may need high quality for performing some activities (I3, I1) but, maybe that in the next 5 years they will still need to increase it step by step" (I3).

A tangible example is the *size of image files*, where many standards are strongly suggesting to use the 16bit file that, in theory, offers more possibilities of processing the file –in practice though, with an 8bit file nobody sees the difference to (…) the 16bit, [that] needs double the storage space and is more useful for special purposes, like researchers who will inspect the object or if you want to print out of it" (I1). Workflow and camera technology plays a role in the image size, as well as the technology developments, that have somehow been saturated nowadays, and it is "good enough for the job" (I1). But, the question still remains by another interviewee, whether the same printing quality digitisation should apply to *all* of the objects in a mass digitisation

project, *irrespectively* of their value (I5). Contrary to that, when only JPEG is available online and Hi-Res images can be requested on-demand, the use of extra resources, natural and not only, is seen as a disadvantage (I7).

However, there is awareness and understanding that "the data storage capacity is developing all the time, but there are so many questions related to sustainability of the data storage, we should be careful of *how much* we expand the capacity of the storage" (I2). The end-user is considered and plays also a role in the quality standards –for example, "200,000 His-Res images became available this year for downloading in Finna, but we have been discussing that people can choose to download a smaller resolution image instead for preserving a Hi-Res one in their computers" (I3). It is mostly for users to know that this object of CH does exist and in the same line that has been paid attention on the material being usable and searchable and meta-data rich. This trend is also "increasing I would say, as we are now also discussing of publishing our digitised catalogues, or at least some of them which can be published (…) and make people aware and give them access in these collections like that." (I3)

Barriers and enablers for efficiency strategies

Increasing environmental efficiency of ICT use in DP calls for a highest output per unit of resources used (energy and materials). Introducing environmental criteria when *tendering* equipment or outsourcing a service, was brought up by most of the interviewees, with a focus on generalising their use in all kind of needed products and services and making such criteria mandatory, especially in regards to the quality of energy used and the overall carbon footprint (e.g. of the data servers) (I1, I2, I4, I5). Right now, these guidelines are only on a *voluntary* basis or up until a certain percentage that the 4 years contractual agreement is requiring from the Agency to include them in their funding applications (I2). Nevertheless, with 3D digitisation diffusing to an ever-larger extent, and the energy demands increasing – to a 500-700fold (in average) file size comparing to a 2D Hi-Res file (I3, I4)– efficiency measures (e.g. clean energy and scheduling) are more widely considered to be adopted, while this incentivises the development of more efficient managing and storing technologies, due to the limited funding and resources in the CH sector.

The above point ties to the importance of good reliable *digital infrastructure* to be set from the beginning, especially with the increasing amounts of data produced (I5). As one interviewee put it pragmatically, "putting data in our system, moving them, going through them and storing them is energy thirsty, but if we have well-coded systems, they are not just efficient, they are energy efficient too" (I5). This, highlights, that energy efficiency of the software itself and of energy demand related to users' behavior as well, are built in the software's code in the first place. In this respect green-coding, apart from high performance concerns of the software itself, can address the energy saving potentials from the root of the DP process (I5).

A great efficiency catalyst, that was identified among most of the interviewees that is gearing energy consumption towards cleaner energy sources, has been the carbon neutrality commitment of Finland by 2035, and therefore the need for measuring and monitoring of the organisations' carbon emissions (I2, I3, I4, I7, I8, I9, I11). In this respect, it was stressed that the organisations are initially responsible for shifting to clean energy, as a service provider in a monopoly situation, and this burden should not be rolled down to the end-users (I4), but platforms (e.g. Finna) to use metrics and incentives for the improving of the individual carbon footprint as well. In the case that personal emissions are counted in, it has been greatly put forward by the majority of the interviewees that increased digitisation and digital access to the CH content saves travel to the facility in order to view the material and therefore, saves personal emissions (I5, I7, I8, I9, I10).

Finally, the understanding of the on-the-ground practitioners that digitisation is being more efficient, is also shaped in light of the energy demands of the conservation conditions required for the hardcopy material, from the building environment to the ventilation and temperature systems, that are energy-demanding (I1, I3, I4, I5, I10). However, the cases for FHA where materials can be destroyed after being digitised and therefore allow for buildings decommissioning or preservation energy costs saving, are rare (I5, I10).

4.3 Opportunities and challenges identified in relation to the Network

In this section, zooming out of the information gathered around the environmental sustainability in the ICT use in the DP of CH by the FHA (section 4.2), the findings on the organisations comprising the network around FHA (section 4.1) are presented. This will be done by identifying the input from the interviewees' of the National Library of Finland (NLF), National Archives of Finland (NAF), DPS, Ministry of Education and Culture and the Sitra Foundation, as opportunities and challenges arising within the network and, in relation to the broader sufficiency strategies and functions of the measures of the framework. As important to set the context from the beginning, a general observation and the role of NLF in the intersection of the above actors is following below.

Awareness is being raised increasingly among the museums, libraries and archives sectors around the environmental sustainability of their activities, even though it might not be in the center of their organisational purpose. This is also reinforced by the role of individuals who were already environmentally conscious, or became aware of the global discussion on climate change by attending Fridays for Future, calls to action or museum events on sustainability and climate change (I14). In some organisations it happened from the very grassroot level, where the individual workers have been discussing it among their colleagues and then it spreads up to the strategic level, where also environmental sustainability was a topic of future action (I14). So, the case so far has been to be going both bottom-up and top-down, where grassroot initiatives are meeting the support of the management that is further coinciding with a strategic opportunity and official recommendations from the Ministry (I1, I4, I12, I13, I14, I15, I18, I19).

Especially in the case of NLF that is a service provider at a national level not only for the Finnish Libraries but also for the archives and museums, with Finna they are well-positioned to hear and discuss things cross sector and facilitate discussions that involve all of the CH sectors (I14). For example, they organised the first webinar on digital CH and the sustainability agenda with an interdisciplinary approach and a special focus on the digital carbon footprint and the impacts of ICT discussed with a Sitra expert (I14, I17). Finna's role is being broadly recognized as endorsing the tradition of working together within digital CH by bringing the various organisations together (I2). Also, with around 450 organisations participating in Finna and the digital CH round table initiative, new streams of collaboration and knowledge exchange as well as, of ways for adding value, can be found (I13).

4.3.1 Opportunities and challenges for sufficiency strategies

Challenges and opportunities on strategies related to sufficiency and concerning the network, are centered around the amount of the digital objects, the practices of selecting them and the value quality of the user's from accessing them.

Deduplicating and saving the same material only once instead of multiple times among different collections or organisations (e.g. identical administrative documents in many different archives handled by NAF (I19)) is also something that is being pursued, with the in-house appraisal activities or before publishing on platforms like Finna (I20). It may take place even earlier, when creating the physical collections by guiding organisations with common criteria to identify same

photographs and physical objects across many museum collections (e.g. the TACO project) (I6). This is also supported by destroying the physical object format after the information harvesting and consequently decommissioning the physical storage spaces, that, for instance, in the case of the National Archives are corresponding to an almost 50% of the Agency's funding (I20).

Emphasis in what is being digitised is given with the 4 years contracts with the Ministry, where creating quality content is one of the requirements (I2). By quality it is meant not only selecting to digitise and publish material that is well-preserved or unique, but also material that is meta-data rich (I14). By having rich meta-data, curated or thematic collections and content can be created, as it happens in Europeana (I2, I15, I18). The same has happened already in a way in Finna too, with Finna Classroom, that gathered all the relevant educational material in one place and saves time from students and teachers "not wandering around in the platform trying to find what they are looking for" (I14). Curated and personalised content this way adds quality to the navigation experience of the user, especially when there are millions of objects in a platform like Finna, and in general, most platforms have a critical mass of content already (I2, I14, I16, I18).

One of the main challenges, regarding the meta-data, comes from the cataloguing system and its original purpose of usage. (I2). Standardisation of meta-data across many different organisations is achieved up until a point, i.e. for content that is published on the Finna interface or Europeana and minimum cataloguing standards need to be met (I18). Also, another point raised by some interviewees, is that the public should have the possibility to enrich the metadata on Finna (I4, I20). Largely, the CHOs engagement with the public and the social impact of and interaction with the CH have been recognised by some of the interviewees and for instance an open discussion with the public on what content they would find valuable and useful to have digitised could be initiated and it could be held by search platforms, like for instance Finna. There can be a combined opportunity with the users' surveys and participatory tools already in place (I8, I9, I15).

In general, though, the argument of having to increase the amount of digitisation was brought up by most of the interviewees (I12, I13, I14, I15, I16, I19, I20) as being less environmentally impactful than maintain the physical infrastructure for conservating the physical CH items under strict and stable environment conditions (i.e. humidity, temperature) (I16, I19, I20). The direct impacts of these premises have not been calculated with the total of DP ICT-use environmental impacts, for which LCAs are needed, as it was mentioned by some of the interviewees (I12, I14, I20).

4.3.2 Opportunities and challenges for "Digital Preservation-efficiency" strategies

Decreasing the volume of the digital content by lowering the standards of the quality of the outcome is mainly coming from the CHOs themselves. Any reduction on the DPS's side –apart from their commitment to their already established high standards because of the type of preservation they are offering– would be so hard to be pursued because of the amount of the material they are managing and the effectiveness of automation, that a cost-benefit analysis would be needed, for instance, of performing tiered fixity checksums according to uniqueness and value of the content (I16).

In some cases, already from the organisations' level, the digitised material is produced in lower quality (and therefore smaller file size), e.g. in black and white or grey scale only, for the newspapers before 80' preserved by NLF, since color-printing wasn't diffused (I12). However, certain quality for the functions offered must be maintained (e.g. zooming in and out, search through the text), and no lower quality than the one allowing for that would be acceptable (I12, I20). They could easily switch to a higher quality than the one they currently use (e.g from 300-

400dpi to 600dpi upon request by a publisher), but a minimum standard should be there for the functionality of desired purposes, like in-text search (I12).

As one interviewee shared "ICT-use should be spared from somewhere else, not from the accessing quality" (I12). However, the CHOs are the ones defining the quality characteristics of the access copy according to their needs, and of the master copy for long-term preservation by DPS, since in some use cases is identical (e.g. file format) (I16). And in the latter case, hierarchical storage systems are not really an option because of the nature of preservation done by DPS that is all the data have to be checked for possible bit errors, in order to be verified as uncorrupted (I16). It therefore, seems like for these decisions on quality, there is room on a CHO's level and their CMS quality of preservation, only. But still, even on a DPS quality level of long-term preservation, there are automated solutions that could be employed, and are currently being explored (e.g. AI) (I16, I20).

4.3.3 Opportunities and challenges for efficiency strategies

The main issues identified among the network regarding efficiency, have been around clean energy and technological efficiency, in view of the carbon neutrality objective.

Opportunities through the network, on the efficiency side of the measures, are mainly appearing via formal and legal requirements. First, developing common criteria for the sustainability reporting –that all the public agencies will need to take up, starting by the end of 2021– has been received as the main moving force into initiating the discussion and putting together the working groups for carbon footprint measuring in the individual Agencies (I12, I13, I14, I15, I20). On a larger scale though, it has also been steering for informal action to be taken on the network's level and the Sustainable Agencies to be formed. Similarly, the environmental criteria promoted by the Ministry of Education and Culture for when Agencies are procuring equipment or outsourcing services, have been disseminating technological and energy efficiency concerns down to the Agencies and their departments –on a voluntary though basis (I15, I19).

In general, organising digital access and long-term preservation under joint systems, with Finna and CSC, respectively, for all CHOs in Finland, is more efficient than for each CHO running their own system (I14, I15, I16, I20). Because of the diverse CH objects and needs of the CHOs more concrete and targeted actions and solutions should be coming from the institutions themselves and the Ministry maintain the role of facilitator (I15). On the collective, national level though, as it was mentioned under 4.1, CSC's solutions are constantly increasing in energy efficiency (e.g. LUMMI) and in using the material resources up until the end of the natural life span, after which more sustainable solutions can be introduced (e.g. when the tape archives are reaching their end of life and are to be replaced) (I16). Or on an EU-network level, much further into the future, higher efficiency opportunities may occur, since the DNA data storage is envisioned as a large-scale possibility and its mainstreaming is researched experimentally, by the EU Time Machine project (I20).

However, the close dependencies with other organisations, especially on technical issues, e.g. the electricity quality or the technical infrastructure of the University of Helsinki whose part the National Library is, shapes the decision making of the CHOs in some cases (I12), in the sense that the choice of the energy quality emissions of the 'mother organisation' reflects on the carbon footprint of the dependent organisation (I12, I14). For example, CSC's decisions about their own energy consumption and emissions, are partially reflecting down to the organisations whose CH content is there for long-term preservation (I12), if the CHOs are deciding to extend their system's boundaries and include that part in their own system carbon calculations too. In addition, any such proportional calculations of the use of the servers, for example, would be extremely complex to be done in detail, even if they were to be calculated per bit (I16).

The last point implies also, the absence of common criteria as a challenging factor for implementing efficiency strategies. The need for concrete guidelines was stressed by all the organisations of the network as indispensable for putting the sustainability objectives into practice in a more systematic way, than coming down to the lots of self-motivated individuals picking criteria that suit each specific organisation (I14). An example of potential incoherence that such a situation creates are the various carbon footprint models and calculators that are taking different assumptions and system boundaries, making therefore any results hard to monitor and compare among the different organisations (I12, I14). So, the targets that are common on a national level and might also be interdependent in some organisations' cases are hard to follow up.

5 Discussion

In this chapter the results of the current practice in FHA are further interpreted and discussed (section 5.1), in the light of the literature reviewed, enabling to reach some new understandings on the potentials of a sufficiency approach for the ICT use in the DP of CH by CHOs (section 5.2). These understandings are then complemented with reflections on the theoretical framework developed, on the implications following the methodological choices made for conducting this research and on the generalisability of the results (section 5.3).

5.1 Understanding the current DP practice in the FHA

The findings from the questionnaires, that are presented under section 4.2.1, are suggesting, that a clear result about the current state of a sufficiency approach in the ICT use in the DP practice could be drawn. According to the results of the 'self-questionnaires', in the way they are summarised in the Table 5-1, it could be said, at least in the first sight of the color coding, that the measures resulting in stricto sensu sufficiency outcomes seem to be mostly present in the current practices of the involved practitioners of the Department. This can be read with the indication boxes next to each measure, where; the green represents measures that are already in some short of application; the yellow ones are referring to measures where action is considered, planned or prepared to be taken soon, and; the red boxes are for measures where specific technical standards for quality are applying in that area and are restricting the application of the identified measure. For the measures where the answers were provided by the DPS, the box is indicated with a black frame.

Table 5-1. Results of Sufficiency Framework for the DP of CH by AIS in the FHA.

	All stages	Appraisal	Preservation	Accessibility
Sufficiency		1. Collect only what needed 2. Digitise only what needed 3. Deduplicate 4. Reappraise in time		1. Digitise according to users' needs 2. On-demand and tiered digitisation
DP-Efficiency		1. Contain volume with lighter formats 2. Customise default choices in workflows	1. "Good enough" DP 2. Tiered approach of preservation 3. Run less often complete fixity checks 4. Sampled fixity 5. File format according to obsolescence risk 6. Customise, on-demand, or selective format migration 7. Only necessary number of redundant copies 8. Tiered redundancy	1. Upon request access migration 2. Tiered access storage system 3. Communicate a delayed delivery access system to the user
Efficiency	1.Technological efficiency 2. Scheduling 3. Clean Energy		1.Scheduling Fixity 2.Self-check-summing and self-healing software	

Applied somehow | Action is considered, planned or prepared | Application is restricted | DPS provided

Source : Own elaboration

However, these results must be put into context in order to be interpreted for the sufficiency interpretation that was formulated for the needs of this thesis. And the dual reasoning for that was clearly outlined when read in combination with the interviews' input.

First, the documentation of the DP process was conducted from within the current context of practice. That is, a wide and dynamic discussion around sustainability in the Department has been taken up, especially during the last year, when the Sustainable Development goals have been cascaded down to the FHA through the contractual agreement with the Ministry of Education and Culture. The environmental sustainability aspect has been focused on the in-house practices (e.g. recycling, LED lighting), while in regards to the DP process itself and its extensions on the use of ICT equipment, these aspects are not discussed yet, but are implicitly approached (I1, I2, I3, I4, I5, I9, I11). That is when addressing other practical issues in the DP process, out of e.g. funding or human and time resources' constraints, that positive implications can be identified in the environmental impacts of the ICT-use in DP. Nevertheless, it was acknowledged that these were not happening because of adopting any targeted or explicit policies on environmental impacts of ICT. Therefore, making these connections for the first time between environmental sustainability, ICT and DP processes more explicit, was met with much interest and excitement by most of the interviewees (I1, I2, I3, I4, I5, I9, I11). However, this lack of previous understanding of the links between environmental sustainability of ICT and the DP processes must be factored in when interpreting the findings from the 'self-questionnaires'.

Second, both the DP process and the CH, are depending on multiple decisions for their practicing and management respectively, which are taken by a number of different practitioners collaborating within and outside the Archives and Information Services. Therefore, multiple factors, some of them more exposed to subjective decision-making than others (e.g. the technical standards of migration media life-cycle, versus the selection of CH items and cultural representation decisions) are playing in. Specifically, awareness on the environmental aspects of different decisions depends on individuals' understanding on the influencing factors. For example, the photographer's awareness of the resources needed and the volume of data produced when photographing a CH object, would justify the use of a lower image size or even the digitisation of one CH object out of a big number of similar objects (I1), while for a curator or conservator, for cohesion reasons of documentation of a group of objects, it would not be questioned using the same high quality for all of them (I6, I4). Subsequently, is hard a concrete assessment to be conducted, since, practitioners' biases on the DP process, lead to diverse levels of awareness around the environmental aspects and sustainability of ICT-use in DP.

These two factors of (1) the timing of when the research documentation was conducted in relation to the broader sustainability discussion in the Agency and subsequently, the lack of pre-understanding and, (2) the DP practice biases, are both underlying the assessment of the results. This is noted for the interpretation and discussion that follows on the case-study organisation's practice of DP and sufficiency potentials provided from the surrounding network.

5.1.1 Inherent sufficiency

The FHA and the department of AIS specifically, have already sustainability in the focus of their stated mission in general, even though this has not been made explicit or linked to the DP practices followed and further, with their ICT-use. The documentation of their practice according to the categories of the questionnaire, shows that most of the recommended measures, identified as promoting a sufficiency strategy, which, according to the Sufficiency Framework must be the one to manifest the most (among the three component strategies) in order to advance a complete sufficiency approach, are in application or considered to be applied (Table 5-1).

The above seem irreconcilable with the reality and the number of digital collections planned to grow further, with 20.000 objects/year according to the Performance Agreement Between the Ministry of Education and Culture, and the Agency (OKM/23/210/2019). Nevertheless, an increase in numbers of CH objects it is 'accepted' in the sufficiency strategy –the way a sufficiency strategy was defined for the DP by a CHO– as it is justified due to the purpose and the nature of the organisation (Princen, 2005). Moreover, this increase, is acknowledged not to be uncontrolled, but is practically restricted by the digitisation-criteria of the FHA digitisation strategy and by the limited human and funding resources. The validity of the initial selection criteria, is to be checked in times, following also the metrics in numbers of use (I2, I3).

However, there is still an absolute increase of the number of CH objects being digitised, and therefore an absolute increase of the total matter/energy throughput. This is why, according to the literature review (section 3.3.1), the weight is put on the quality too; on how the dual purpose of CHOs and DP –not only of preservation but also of use of the CH material– is being fulfilled.

Achieving a higher *value quality* from the use of the CH material that is already digitised (e.g. to make better sense of it, or to connect more with its meanings), is identified as the second function of a sufficiency strategy (under 3.3.1). But such a value is hard to follow with metrics, even with follow-up users' surveys, while is more effective if addressing the CH needs on-demand –prior to the use– or on a more open and public-contribution basis (I2, I4). And this is why this angle has not been captured by the existent practice in the AIS, even though a part of it (i.e. digitise according to users' needs) was reported by the respondents as it does happen. However, this is mostly the case for individual requests and it cannot be described as the leading practice in the sector. For addressing a broader basis, it is something that only now started happening with cultural communities in Finland (e.g. Sámi), as a response to public demands for equity and inclusivity in the CH sector decision-making (Harlin, 2019).

Nevertheless, these are only indicative examples of how a complete sufficiency strategy could be implemented. Additionally, this should not be emerging sporadically, but across the organisation's level and to manifest predominantly in the organisation's purpose (Robra et al., 2020).

5.1.2 Efficiency-driven orientation

Efficiency was the only strategy found to be consciously associated to the sustainability of DP process, in two ways; both as the DP process being the medium for efficiency and; as the efficiency within the DP process itself. In the first case it was perceived as an argument for doing more DP, because it delivers efficiency to the CHOs' purposes of preserving and making accessible the CH, compared to the building and transportation costs for maintaining and accessing the physical CH assets. In the second case, the technological and energy efficiency increases, in regards to the ICT use, were the major measures discussed and applied according to the framework by the CHO and the outsourcing partners.

However, there is no clear manifestation whether these efficiency measures happen from within the sufficiency strategy context as defined for DP of CH. On the contrary, it confirms the insights of the literature, that the case study CHO and the outsourcing partners adopt an efficiency response due to the increasing demands of DP. Such an approach though, as the literature suggests, is insufficient on its own (see Hilty et al. 2011 to; Koomeny et al. 2011). Especially since demands in data storage and ICT infrastructure are projected to grow unprecedentedly in the coming years, with the new applications coming up in DP (i.e. 3D, AI), the limits of the efficiency potentials became more tangible to the practitioners of the AIS, too. But most importantly, such a realisation highlights; (1) the materiality side that accompanies

efficiency as a standalone approach; (2) the necessity of a sufficiency context and; (3) the needed societal shaping of digitisation in general (under 3.1.2).

The *quality* of the final DP outcome, identified as a common factor underlying the above issues, could play a major role in bridging the transitioning gap between the purely efficiency and the sufficiency strategies. By introducing this quality factor into the efficiency equation of DP, its inversely proportional function could catalyse both the decrease of the resources input, as well as the definition of 'how much' quality (e.g. resolution, timely accessibility) is needed for the public's engagement with the CH assets to be meaningful.

5.1.3 "On-progress" DP-efficiency

The above-mentioned quality factor was coded under the term DP-efficiency, that is the strategy promoting this specific version of efficiency. This quality factor is targeting the volume of data being produced, preserved and accessed, by reassessing the minimum acceptable quality for fulfilling the purpose (under 3.3.1).

The Preservation stage could be deemed as critical for implementation of DP-efficiency measures (Table 5-1). The majority of these measures is found on this stage, because this is where most decisions around the quality of data (e.g. safety) are taken. However, according to the current quality standards followed in the DP, almost half of the measures included in the framework, are incompatible to implement. This proved particularly to be the case for the DP processes outsourced and managed by the DPS, where high standards are followed strictly, due to the quality and scale of preservation DPS offered (I16) and for uniformity reasons across the CHOs with whom they are collaborating.

On the other hand, for most of the measures related to processes or decisions managed by the AIS themselves, relevant action was found to be under way with the new digitisation policy planned by the Department, or to be considered upon (Table 5-1). In any case, a certain degree of flexibility was identified, in comparison to the activities managed by DPS. And this can be explained by the differentiation in the preservation purposes (i.e. DPS is responsible for the long-term preservation) and the scale of their activities that restricts a more tiered management of the CH assets to be implemented according to the quality of their value or their use by the end-users.

However, the issue that hasn't been answered is the definition of the acceptable minimum level of *quality*, that is still needed to fall within the limits of satisfying the needs of the CHO's dedicated purposes. The definition of the 'need', as mentioned in the literature review, is subjected to the debates and perspectives on the factors influencing the determination of the authenticity of the need –and even more when discussed for the sufficiency context and what is perceived as 'enough' satisfaction of the need (Ehrenfeld, 2008; Princen, 2005). Such a definition would be unfeasible to be pursued unilaterally, from the CHO only, but would rather require co-creation with the public and horizontal, cross-sector cooperation on the administrative level.

5.2 Contextualise the analysis in the CH Actors' Network

Based on the observations under section 3.2.2, the more; (1) an extensive application basis, (2) a long-term perspective and (3) a need-driven allocation of resources are characterising an organisation, the more there are incentives and therefore potentials, to enhance the uptake of sufficiency. The level of manifestation of these three elements on the results of the case-study organisation, it is discussed to the corresponding opportunities and challenges presented and identified in the existing network of actors and initiatives, surrounding the FHA (sections 4.1

and 4.3). This way the potentials for advancing a sufficiency approach in the DP processes of the Department will be identified.

5.2.1 Quality of fulfillment of needs

Starting vice versa with the need-driven allocation of resources, that is a core-element of sufficiency, there is an inherent alignment with the nature of the non-profit CHOs, who are fundamentally driven by the public purpose of preserving the CH material and making it accessible for the public to engage with (Khan et al., 2018). For the sufficiency approach in DP by CHOs, the focus is on the level of quality that is necessary to be achieved, for CHOs to fulfill these needs. That is, the acceptable minimum quality in terms of preservation and the highest value quality of use of the CH content by the public.

The results of the specific practice in the FHA in section 5.1 highlight the lack of explicitly considering this tiering according to quality of preservation and the value quality of use. This is the factor hindering the most the realisation of sufficiency–in the way the sufficiency approach was defined for DP with its component strategies (Figure 3-1). Namely, this shortcoming is commonly detected, across all three of the component strategies, in that; a *sufficiency strategy* is missing the second function of increasing the value quality for the users; the *efficiency strategy* is not happening from within a sufficiency-oriented context; therefore, the value quality factor is disregarded, and; a *DP-efficiency strategy* is also not problematising (at the present) the tiering of the quality of the preservation outcome.

On the network's level, the value quality of use can be advanced by emphasising the creation of digital content with rich meta-data, meaning rich context and background information (I14, I18). Network-wise, on the Finna interface, this would facilitate the curation of the content into more personalised and thematic collections as it has already been happening in the Europeana interface (I15, I18). This approach can be further enhanced with the creation of more targeted content areas, where CH content will be showcased for special audiences, like it has happened for the educational materials (e.g. Finna Classroom), responding to remote schooling demands with great success (I14).

A persistent challenge for that, is the level of meta-data standards set and the original purpose of use of the cataloguing systems, that were for professional and organisational use mainly (I2, I14). This is why tools, like the users' surveys that are already in place on the Finna interface for instance, could be used as an open participation chance for users to shape not only the content they would be most interested in accessing, but also the background information necessary for them to make more sense and value out of the content, with the possibility to enrich the meta-data themselves (I4, I20).

Finally, on the end-users' level, there could also be more room for customising the technical standards of quality. It was mentioned to be 'under consideration', to provide the option of choosing a lower resolution of the picture for downloading, that still serves the quality demands for fulfilling end-users' needs, while decreasing their personal ICT-use environmental impact.

5.2.2 'Holistically' long-term perspective

The temporal perspective taken by a CHO for serving their dual mission and the above needs is a truly long-term one that extends, as a respondent from the networks' actors shared, for "hundreds of hundreds of years into the future, and for generations to come" (I13). This is directly aligned with a sufficiency approach and its resonance with a strong sustainability notion that strives, as Princen (2015) put it, for ecological integrity "over many generations of key species, including humans" (p. 35).

Since, the allocation logic of a sufficiency approach, as explained above under section 5.2.3, is need-driven, it is therefore normative (Young et al., 2011) and as a process, evolves dynamically in the future (Princen, 2005). For this reason, firstly, it was hard to capture a specific and unanimous (by all the FHA respondents) time span into the future –even though, almost all of them indicated that the time perspective taken for the CHO's mission is a very long one, of many decades or hundreds of years (I1, I2, I3, I4, I5, I6, I7, I8, I9, I10).

Secondly, it is not addressed explicitly on the results of the questionnaire because there was no direct such question, but manifests implicitly to the sufficiency and DP-efficiency strategies. Specifically, the long-term time perspective is considered for the *sufficiency strategy* and the reappraisal measures of the digital CH content according to the dynamic change of the value of the CH content in time and based on metrics of use (Table 3-3), that for FHA happens roughly every year. Additionally, the long-term perspective is explicitly addressed for the *DP-efficiency*, in the current practice by DPS, with the development of local file format policies according to the risk assessment calculations for format obsolescence. Nevertheless, it has to be clarified that, all the currently implemented measures by the FHA, including the efficiency strategy measures, contribute in some way to the attainment of the Agency's purposes in the long-run.

On the other hand, the measures mentioned as indicating a consideration of the long-term perspective, only manifest marginally from within a sufficiency approach. There is no indication of happening from a strong sustainability background, sharing the same motivations on decreasing resources consumption and remaining within the bio-physical cycles (Princen, 2005). Even though, for fulfilling the CHO purposes a long-term time span as for a sufficiency approach is assumed, paradoxically, the environmental sustainability is not reflected upon as a necessary condition for any other long-term goals to be attempted.

On the network's level and in regards to the aforementioned measures identified in the FHA's context, the opportunities are presenting in two sides. Similarly, to the public's participation that was presented under 5.2.1, for reappraisal, the already open streams of participation could be used here as well, as a source for following-up the change in use throughout time. For the adjustment of file format according to the format obsolescence risk, the DPS that implements it, presents the advantage of a standardised practice for all the CHOs that have their long-term preservation there. This is also offering for a broader application basis as it is discussed in the continue.

5.2.3 Broad Network's application basis

Ensuring a broad application basis is a critical element for the practical implementation of a sufficiency approach. The rich, interconnected network of different actors that was mapped around the FHA and the AIS, gave an overview of that and of how the actors and initiatives evolved in parallel to the respective strategies on the DP of CH and Sustainable Development (Figure 4-4). The Digime project with the Finna and DPS infrastructures, brought up the National Library, that manages the Finna platform, and the Ministry of Education and Culture, that issues the respective policies, as being the hub for the digital CH.

This common interface, provides immediately a broad implementation basis of the Ministry's policies on CHOs (around 450 organisations), who need to follow the minimum of standardisation criteria applied by Finna and DPS (I2, I8, I15). In addition, Finna is positioned in such a way that links directly its meta-data requirements to CHOs' management systems and to the DPS' quality standards of long-term preservation (Figure 4-4). So, this positioning created a direct communication stream between the public administration policies and the technical standards that are determining the quality of preservation among the rest of the actors. However, the value quality by the end-users, is only captured in numbers (e.g. of downloads of

a picture file), while, more qualitative aspects on the further use of the CH content with which they are engaged, could be introduced in the feedback tools and surveys already in place., along with the broader opening up of participation and inclusion of the public as mentioned under 5.2.1 and 5.2.2.

This existing application basis for the DP of CH strategies and initiatives is further expanded by the strategies around Sustainable Development and the smaller clusters of actors emerged among individual Agencies, like the Sustainable Agencies (section 4.1.2), creating links of the broader network to the Ministry of Finance and the State Treasury. Even though, their workings are still on progress, sustainability reporting is expected to enhance monitoring and decreasing of carbon emissions along with green public procurement. However, it is broadly argued that for any sufficiency strategy to be implemented it must necessarily entail some intentionality (Linz 2017; Vivanco et al 2016; Stengel 2013). In the opportunities identified in the network for the enablers recognised from FHA focused on efficiency increasing measures (Table 5-1), there is no sufficiency approach framing them, and even more connecting them to the DP processes or the ICT environmental impact.

An observation extracted from the findings though –that could be researched as an additional potential incentivising sub-indicator (under the extensive application basis) for a sufficiency approach in the public CHOs– was the personal motivation and taking up of sustainability initiatives by the individuals interviewed within the organisations (I2, I4, I5, I14, I18, I20). This reveals a flexibility in the organisational structure, that allows grass-root initiatives and projects (e.g. Sustainable Agencies) across the DP of CH Network to develop upwards. Then, they were met with support from the Agencies' management, that they were further coinciding with a strategic opportunity and official recommendations from the Ministry of Education and Culture or lately the Ministry of Finance (e.g. Sustainable Development Working Group) (I1, I4, I12, I13, I14, I15, I18, I19).

In view of the new Climate and Environmental Strategy for the ICT sector, the observation made above could offer a potential entry point for a sufficiency approach. The strategy, that pinpoints the continuous ICT growth with the environmental impact of its energy and resources demand, highlights, among others, the end users' engagement for the promotion of climate and environmentally friendly digitilisation (Ojala & Oksanen, 2021). This strategy, by cascading down and linking the ICT use to the DP of CH processes, offers potentially, a chance for broader participation of the public and end-users of the digital CH content. This can happen, not only from the CHOs' side increasing users' awareness and competences (Ojala & Oksanen, 2021), but also vice versa, with the users communicating and signaling the preservation quality needed and the value quality they are getting.

5.3 Reflections

Discussing a sufficiency approach in the intersection of ICT use and DP of CH proves to be rather complicated, since, there is a combination of different technical factors and quality functions that need to be considered. Additional complexity is added, since, for the CH sector, the analysis of this combination cannot be performed in CHOs silos, but is embedded in the surrounding actors' network, with which a CHO is co-evolving. Thus, this internal dynamic process is inevitably in a dialogue with society and the public, who are also participating in the CH management by engaging and interacting with the CH content, fulfilling in this way the existential purpose of the CHOs (Pendergrass et al., 2019). Therefore, in order to identify the potentials for advancing a sufficiency approach in a CHO, is crucial, for the public (e.g. as individual end-users, as cultural communities or as society) to be involved in a substantial way, as well.

With this general reflection on the results of this research, further reflections on the sufficiency framework, the methodological choices and the generalisability of the findings are provided.

5.3.1 Sufficiency Framework

Since, according to the best of the author's knowledge, there was no previous research taking a sufficiency approach on the ICT use for the DP of CH processes, it was deemed beneficial that the most relevant framework, by Pendergrass et al. (2019) to offer a basis for developing an applicable one to sufficiency. Even if it was the only one identified by the author, it does offer a detailed elaboration of the potential measures for making more environmentally sustainable decisions during the DP practice associated to the ICT environmental impact, while thoroughly referring to all the technical aspects.

However, due to the targeted subjects of action assumed by the authors of the framework, i.e the cultural heritage professionals, the perspective taken was from their point of action, and not of other actors (e.g. end-users). For this, a layer of the end-users as active participants in advancing the environmental sustainability of DP of CH with a sufficiency approach, was added to the sufficiency framework developed for this thesis, through the second function of the stricto sensu sufficiency strategy, but still, without reflecting on the per se measures extracted from the original self-questionnaire of Pendergrass et al. (2019).

5.3.2 Methodological choices

The data collection sources accordingly to the previous section, relied on interviews conducted exclusively with various professionals from within the case study organisation and the surrounding network. Even though, various data sources were used, and triangulation of data was aimed in order to ensure internal validity, direct observation would have deepened the understanding of the practice. Weren't for the Covid-19 travel restrictions, in person observation of the practitioners and of the premises of the data rooms could have been conducted. For instance, observing in practice the photographing process of a collection and the handling of the equipment would enhance the understanding of the workflow standards or minimum quality restrictions when digitising.

On the other hand, normalising the availability for interviewing remotely via Zoom or other videocalling applications, enabled the access to interviewees that might be harder to have contacted, if they had not accustomed themselves in the use of these tools.

In addition, as explained under 5.3.1, having included a sample of the end-users of the case study's organisations could have enriched the analysis and the application of that element of the framework directly on the data sourced from them. However, due to personal data protection reasons of the online users of the Finna platform and of the survey participants, including them in the interviwees' scope was not feasible.

5.3.3 Findings

As it has been already addressed under section 2.2 and especially 2.2.3 on the limitations of conducting a case study and ensuring its quality, the generalisability of the results of a case-study is aimed to be achieved on the analytical level (Yin, 2009). The results of the case study are context specific to the AIS Department and the FHA, and the unique Finnish network of actors and strategies in place. The exact same way of organising public services, or the internal structure of the CHOs cannot be expected to be found outside Finland. In addition, as was shown under the mapping of the actors and initiatives, the FHA and the AIS specifically, are situated within a unique CH network, presenting a high degree of interconnectedness among its actors and clustered in various overlapping initiative groups, that is also unlikely to express in the same way

elsewhere. Nevertheless, generalising can be achieved on the basis of the characteristics extracted from the case and from the targeted subjects (Blaikie & Priest, 2009).

Therefore, in this study, generalisability of the discrepancy between the perception and the actual practice of the practitioners in regards to the environmental sustainability of their DP practice along all DP stages can be drawn. The occurrence of a sufficiency approach cannot be verified, unless there is a conscious and intentional plan. Even if some sufficiency measures might be applied out of necessity or subconsciously, especially during the appraisal and accessibility stages (e.g. the on-demand digitisation of CH content on higher, printing quality), the efficiency measures are the first ones manifesting predominantly, on the early stages of taking up environmental sustainability considerations in the DP of CH.

Finally, the probability of positive potential for CHOs to enhance sufficiency strategies, is greater among a large and interconnected network of actors in CH. This is from the angle of centralisation of certain applications e.g.; interfaces, like Finna, that can offer a large reach out basis to the public in order to steer the qualitative direction of sustainability related measures, or; preservation services, like DPS, that can apply to a larger scale and homogenously, any DP-efficiency measures, like a lower format quality, agreed among the CHOs.

6 Conclusion

Digital preservation of Cultural Heritage (CH) enabled by ICT, has been growing unprecedently, bringing up the need of a strong sustainability response –which is also coinciding with the long-term perspective of CH. In order this perspective to apply in the CH sector, the understanding of the environmental impact of ICT as stand-alone equipment, needs to be linked clearly to the environmental sustainability of the DP process. Only consciously, by conceiving this linkage, the mitigating approach of sufficiency for ICT can be understood along efficiency and, thus, can be implemented in the context of DP. Therefore, an inclusive interpretation of sufficiency and its interaction with the CH context, that is further embedded in a dynamic network, needs to be investigated.

Thus, the objective of this research has been to explore, how environmental sustainability in a strong sense, can be integrated holistically in the Cultural Heritage Organisation's (CHO) DP practices by advancing a sufficiency approach within the CHOs' context. Employing an exploratory case study, For, which the Finnish Heritage Agency and the Archives and Information Services department was selected, this thesis addressed specifically two questions:

> RQ1: What is the current practice of sufficiency regarding the ICT use in DP of CH by the involved actors, in the case of the Finnish Heritage Agency?
>
> RQ2: How can the existing network of actors and initiatives surrounding the FHA, help the advancing of a sufficiency approach, in the CHOs context?

For this reason, the author created a sufficiency framework for the DP of CH by a CHO, by elaborating on the environmentally sustainable DP framework of Pendergrass et al. (2019) and deriving from the model 'self-questionnaires' the respective broader measures. Structuring the measures in the framework's axes according to; the identified hierarchy of the component strategies for a sufficiency approach in the DP of CH and; the relevant DP stages of appraisal, preservation and accessibility, allowed for two main findings to be extracted, respectively to the research questions, in order to answer the two research questions.

First, that the assessment of the documented practice according to the questionnaires, revealed that all three of the component strategies for sufficiency are somehow, partially manifested. However, discrepancies were revealed between the current understanding of the measures as found in the questionnaires results and the on-the-ground practices as uncovered through the analysis on the interview findings. Is important to highlight that the sustainability agenda has been adopted only recently in the organisation's context, and in general, in the whole CH sector, on an administrative level.

Specifically, it was demonstrated that; (1) the qualitative function for the *sufficiency strategy* is not manifesting because the engagement of the users with the content is followed up in numbers only and the value quality is not understood in that; (2) the *DP-efficiency strategy* was reported as currently being considered mostly on the Archives and Information Services' level of preservation, but its extension is restricted due to interdependencies with the long-term preservation outsourcing service (DPS). Its inherent differentiation in DP preservation technical standards hinders qualitative nuances to be factored in and to decrease the resources throughput of their preservation. Also, (3) the *efficiency strategy* is perceived as the 'mainstream' sustainability approach to tbe taken in respect to the ICT use for DP, however it is not understood as happening from within the sufficiency strategy context (because the value quality function, needed according to the hierarchy for a sufficiency approach, is missing). Finally, an overarching observation on the above findings is the decision-making structure (e.g. for the quality standards

of the digitised material) that is restricted within the CHO and the network, hindering sufficiency uptake from the ground level of the users.

Secondly, the above analysis was put in the context of the network of actors and initiatives surrounding the FHA and the AIS department. Positively, all three of incentivising factors for the uptake of sufficiency –the long-term perspective, the need-driven nature of the organisation and an extensive application basis– are *fundamentally aligned* with the very nature of the CHO. For sufficiency to happen, though, the qualitative function (i.e. the level of preservation quality and value quality by the end-users, as defined in all three sufficiency-component strategies) needs to be induced further. Discussion of the opportunities and challenges presented in the network's context, with the the above three factors, concluded in one overarching potential for advancing sufficiency; the *highly interconnected network* of actors and initiatives with their *inclusive organisational structures*. This could instigate the qualitative function by allowing for a broader participation of the public in the DP processes decision-making and then by offering their insights of what content and preservation quality is enough to access for satisfying their respective needs in the highest value quality. Anyhow, *intentionality*, should underline any measures taken, otherwise, sufficiency is hard to manifest predominantly in the CH sector, even if there is an inherent propensity

6.1 Recommendations

As an exploratory case study, this research, first and foremost, constitutes an initial step into outlining the current state of ICT-use in DP of CH processes in the Finnish context and rethinking their environmental sustainability from a sufficiency point of view. Therefore, it offers recommendations to the practitioners of the case-study organisation, to the actors of the Finnish network, as well as for policymakers, as they follow:

For the Archives and Information Services department and the Finnish Heritage Agency – The results suggest that the Agency being in the process of developing their digitisation policy, can move dynamically to the measures they have already been considering, and which are falling under the DP-Efficiency strategy of the framework. This could further influence their partners, as FHA is founding themselves in the middle of more than one initiatives (i.e. Digime and Sustainable Agencies). They could play a key role in adopting a value quality perspective in their in-house practices, especially in the appraisal and accessibility stages, by encouraging the direct involvement of the public and their end-users. Finally, the museums' impact assessment tool that they are currently elaborating together with other CHOs and stakeholders, could also be used as a tool for capturing the value quality extracted from the public and society at large.

For the CH Actors in Finland – For integrating interdisciplinarity and creating a common understanding and language around the environmental issues of ICT and DP and the sufficiency approach, across-network working groups or smaller scale projects and collaborations can be launched with academia and research foundations. For advancing the qualitative function for a sufficiency approach through their already established Finna interface, surveys or new participatory tools can be taken up as a way to involve the public actively as a key actor. This would advance the CHOs external communication to the public. Internally, within the organisations, the organisational structure can become even more inclusive, by encouraging further the openness and bottom-up initiatives establishing transparent streams of communication. In addition, acting commonly, as a network, upon the new Climate and Environmental Strategy for the ICT Sector can be pursued on the basis of the above points.

For Finnish and EU policymakers – For ensuring sustainable public procurement, the use of environmental criteria must become mandatory in all public services, supported by standardisation processes, while must be extended beyond hardware, to software as well. For

the Finnish specific context, the Sustainability Reporting must be followed-up for DP projects funding. Lastly, since there is a great overlapping of the ICT issues across sectors, Ministries should elaborate on implementation plans in collaboration.

6.2 Academic contribution and recommendations for future research

Researching on the phenomenon of ICT environmental impact in the CH sector processes and the sufficiency advancement in the context of the surrounding network, has contributed, to the better understanding of the intersection of the ICT, CH and sufficiency areas, to each one of them separately, as well. This research substantiated the recent phenomenon of data overgeneration in the CH sector from their sufficiency perspective. The intricacy of the CH as a versatile object, with fluid and variant value assumptions made when handled by the CHOs and a versatile use by the public, compose a dynamic and complex research context. To balance this, the development of a framework for a sufficiency approach is offered not only for the specific case, but as a practical tool that shows potential to be utilised in a flexible way in other case studies and academic areas as well. The sufficiency hierarchy for the DP of CH applies to similar data-centric research subjects where a sufficiency take is pursued according to a strong sustainability viewpoint.

However, the specific framework is not exhaustive and developed in detailed of the measures, which could be further elaborated in collaboration with archiving and cultural management practitioners. Further research could be also conducted by addressing how to integrate the public's and end-user's perspective in the stages of appraisal and accessing of the digital CH content. To this end, future research may consider various pathways; from a more applicable perspective of tools to communicate and involve directly the end-user with the technical quality decisions (e.g. software to calculate and communicate to the user how much more energy downloading a CH item in this format will need than a lower one); to a more theoretical level discussion on how and to what extent, humans and human experience have been merged with a technological way of being.

Bibliography

Ackroyd, S., & Karlsson, J. (2014). Critical Realism, Research Techniques, and Research Designs. In [Edwards, P., O'Mahoney, J., Vincent, S.] (Eds), *Studying Organizations Using Critical Realism: A Practical Guide*. Oxford University Press. Retrieved from [https://oxford.universitypressscholarship.com/view/10.1093/acprof:oso/9780199665525.001.0001/acprof-9780199665525-chapter-2]

Añón Higón, D., Gholami, R., & Shirazi, F. (2017). ICT and environmental sustainability: A global perspective. *Telematics and Informatics*, *34*(4), 85–95. https://doi.org/10.1016/j.tele.2017.01.001

Arushanyan, Y. (2016). Environmental Impacts of ICT: Present and Future (PhD dissertation). Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-188133

Avgerinou, M., Bertoldi, P., Castellazzi, L., (2017). *Trends in Data Centre Energy Consumption under the European Code of Conduct for Data Centre Energy Efficiency*. Energies 10, 1470. https://doi.org/10.3390/en10101470.

Baig, A., Hall, B., Jenkins, P., Lamarre, E., & McCarthy, B. (2020). *The COVID-19 recovery will be digital: A plan for the first 90 days*. 8.

Barry, J. (2012). *The politics of actually existing unsustainability: Human flourishing in a climate-changed, carbon constrained world*. Oxford University Press.

Berkhout, F., Hertin, J. (2004). De-materialising and re-materialising: Digital technologies and the environment. Futures. 36. 903-920. 10.1016/j.futures.2004.01.003.

Bertoldi, P, Avgerinou, M. & Castellazzi, L. (2017). *Trends in data centre energy consumption under the European Code of Conduct for Data Centre Energy Efficiency*. European Commission's Joint Research Centre.

Blaikie, N., & Priest, J. (2019). *Designing social research: The logic of anticipation*. Cambridge, UK : Polity Press.

Bocken, N.M.P., & Short, S. W. (2016). Towards a sufficiency-driven business model: Experiences and opportunities. Environmental Innovation and Societal Transitions, 18, 41–61. https://doi.org/10.1016/j.eist.2015.07.010

Bocken, N..P., & Short, S. W. (2020). "Transforming business models: towards a sufficiency-based circular economy". In *Handbook of the Circular Economy*. Cheltenham, UK: Edward Elgar Publishing.

Bonaiuti, Mauro. (2014). The Great Transition. 10.4324/9781315819570.

Bonnedahl, K.J., Heikkurinen, P. (2018). *Strongly Sustainable Societies: Organising Human Activities on a Hot and Full Earth*. Routledge, New York.

Börjesson Rivera, M., Håkansson, C., Svenfelt, Å., & Finnveden, G. (2014). Including second order effects in environmental assessments of ICT. *Environmental Modelling & Software*, *56*, 105–115. https://doi.org/10.1016/j.envsoft.2014.02.005

Bryman, A. (2012). *Social Research methods* (4th ed.). Oxford University Press.

Cafaro, P. (2018). Economic Growth or the Flourishing of Life. *Proceedings of the XXIII World Congress of Philosophy*, *11*, 21–24.

Callmer, Å. (2019). *Making sense of sufficiency: Entries, practices and politics* (PhD dissertation, KTH Royal Institute of Technology). Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-265582

Chowdhury, G. G. (2016). How to improve the sustainability of digital libraries and information Services? *Journal of the Association for Information Science and Technology*, *67*(10), 2379–2391. https://doi.org/10.1002/asi.23599

Creswell, J. W. (2014). *Research Design; Qualitative, Quantitative and Mixed Methods Approaches* (SAFE).

CSC – IT CENTER FOR SCIENCE LTD. (2020). *Yhteiskuntavastuu.* Retrieved from [https://www.csc.fi/en/corporate-social-responsibility]

Daly, H.E. (1985). *The Circular Flow of Exchange Value and the Linear Throughput of Matter-Energy: A Case of Misplaced Concreteness,* Rev. Soc. Econ. 43 (1985) 279–297 https://doi.org/10.1080/00346768500000032 .

Daly, H.E. (1992). *Allocation, distribution, and scale: towards an economics that is efficient, just, and sustainable.* Ecol. Econ. 6 (3), 185e193.

Digime (n.d.). *Our Digital Cultural Heritage.* Retrieved from [https://www.digime.fi/en/our-digital-cultural-heritage/]

Digital Preservation Coalition (DPC) (2020). *Digital preservation Handbook.* Retrieved from [https://www.dpconline.org/handbook/organisational-activities/acquisition-and-appraisal]

Dundon, K. et al. (2020, May 1). G*uidelines for Efficient Archival Processing in the University of California Libraries* (Version 4). EScholarship. Retrieved from [https://escholarship.org/uc/item/4b81g01z]

Durham, C. J. (2019). *The Necessity of Environmentally Sustainable Digital Preservation and its Effects on Preservation Workflow.* Retrieved from [https://jscholarship.library.jhu.edu/bitstream/handle/1774.2/62122/Durham,%20Curtis%20J.pdf?sequence=1]

Dyllick, T., Hockerts, K., (2002). *Beyond the business case for corporate sustainability.* Bus. Strategy. Environ. 11 (2), 130e141.

Ehrenfeld, J. (2008). *Sustainability by design: A subversive strategy for transforming our consumer culture.* Yale Univercity Press.

Ekins, P., Simon, S., Deutsch, L., Folke, C., De Groot, R., (2003). *A framework for the practical application of the concepts of critical natural capital and strong sustainability.* Ecological Economics, 44, 165–185.

European Commission (EC). (2009). *DIRECTIVE 2009/125/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products, OJ L 285.*

European Commission (EC). (2019). *The European Green Deal, (COM/2019/640 final).* Brussels.

European Commission (EC). (2019a). *Regulation (EU) 2017/1369 setting a framework for energy labelling and repealing Directive 2010/30/EU.*

European Commission (EC). (2019b). *Regualtion (EU) 2019/424 of 15 March 2019 laying down ecodesign requirements for servers and data storage products pursuant to Directive 2009/125/EC of the European Parliament and of the Council and amending Commission Regulation (EU) No 617/2013.*

European Commission (EC). (2020). *EU green public procurement criteria for data centres, server rooms and cloud services.* Brussels.

European Commission (EC). (2021). *2030 Digital Compass: the European way for the Digital Decade, (COM/2021/118 final).* Brussels.

Figge, F., Young, W., Barkemeyer, R., (2014). *Sufficiency or efficiency to achieve lower resource consumption and emissions? The role of the rebound effect.* J. Clean. Prod. 69, 216e224.

Finnish Government (FG). (2019). *3.1 Carbon neutral Finland that protects biodiversity.* Retrieved from [https://valtioneuvosto.fi/en/marin/government-programme/carbon-neutral-finland-that-protects-biodiversity]

Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). *The Global E-waste Monitor 2020.* 120.

Fournier, E., Cudd, R., Federico, F., Pincetl, S.. (2020). O*n energy sufficiency and the need for new policies to combat growing inequities in the residential energy sector.* Elem Sci Anth. 8. 24. 10.1525/elementa.419.

Georgescu-Roegen, N., 1975. *Energy and economic myths.* South. Econ. J. 41, 347e381.

Goldman, B. (2019). It's Not Easy Being Green(e): Digital Preservation in the Age of Climate Change. In *Archival Values: Essays in Honor of Mark Greene.* Society of American Archivists.

Gröger, J./Köhler, A./Naumann, S./Filler, A./Guldner, A./Kern, E./Hilty, L. M./Maksimov, Y. (2018): Entwicklung und Anwendung von Bewertungsgrundlagen für ressourceneffiziente Software unter Berücksichtigung bestehender Methodik. Dessau-Roßlau, UBA.

Gutés, M., (1995). "*Commentary: The Concept of Weak Sustainability."* Ecological Economics 17(1996): 147-156.

M.C. Gutés M. C. (1996). *The concept of weak sustainability.* Ecological Economics, 17 (3) (1996), pp. 147-156

Harlin, E. K. (2019) Sámi Archaeology and the Fear of Political Involvement: Finnish Archaeologists' Perspectives on Ethnicity and the Repatriation of Sámi Cultural Heritage. *Arch* 15, 254–284 (2019).

Heikkurinen, P., & Bonnedahl, K. J. (2013). Corporate responsibility for sustainable development: A review and conceptual comparison of market- and stakeholder-oriented strategies. *Journal of Cleaner Production*, *43*, 191-198.

Heikkurinen, P., Mäkinen, J. (2018). *Synthesising Corporate Responsibility on Organisational and Societal Levels of Analysis: An Integrative Perspective.* J Bus Ethics **149,** 589–607 (2018). https://doi.org/10.1007/s10551-016-3094-x

Heikkurinen, P., Young, C. W., & Morgan, E. (2019). Business for sustainable change: Extending eco-efficiency and eco-sufficiency strategies to consumers. *Journal of Cleaner Production*, *218*, 656–664. https://doi.org/10.1016/j.jclepro.2019.02.053

Hiekkanen, K., Seppälä, T. & Ylhäinen, I. (2020). I*nformaatiosektorin energian- ja sähkönkäyttö Suomessa. ETLA Raportti No. 104*. Retrieved from [https://pub.etla.fi/ETLA-Raportit- Reports-104.pdf]

Hintemann, R. (2015). Consolidation, Colocation, Virtualization, and Cloud Computing: The Impact of the Changing Structure of Data Centers on Total Electricity Demand. In L. M. Hilty & B. Aebischer (Eds.), *ICT Innovations for Sustainability* (Vol. 310, pp. 125–136). Springer International Publishing. https://doi.org/10.1007/978-3-319-09228-7_7

Hintemann, R. & Hinterholzer, S. (2019). *Energy Consumption of Data Centers Worldwide – How will the Internet become Green.* Proceedings of the 6th International Conference of ICT for Sustainability, Lappeenranta, Finland, June 10–14, 2019.

Hilty L. M., Aebischer, B. (2019). *ICT Innovations for Sustainability* (Vol. 310, pp. 125–136). Springer International Publishing. https://doi.org/10.1007/978-3-319-09228-7_7

Hilty, L., Lohmann, W., & Huang, E. M. (2011). *Sustainability and ICT - An overview of the field.* https://doi.org/10.5167/UZH-55640

Hoang, A., Do, P. & Iung, B. (2014). *Integrating Energy Efficiency-based Prognostic Approaches into Energy Management Systems of Base Stations.* 2014 IEEE International Conference on Advanced Technologies for Communications (ATC).

Hormia-Poutanen, P. K., Kautonen, H. J., & Aki, L. (2013). The Finnish National Digital Library: a national service is developed in collaboration with a network of libraries, archives and museums. *Insights*, *26*(1), 60-65. https://doi.org/10.1629/2048-7754.26.1.60

International Council of Museums (ICOM) (2020). *Museums, museum professionals and COVID-19* [Full Report]. Retrieved from [https://icom.museum/wp-content/uploads/2020/05/Report-Museums-and-COVID-19.pdf

International Telecommunication Union (ITU). (2020, June). *Creating a circular economy for ICT equipment*. https://www.itu.int/en/mediacentre/backgrounders/Pages/e-waste.aspx

IPCC. (2015). *Climate change 2014: Synthesis report* [Full Report]. Intergovernmental Panel on Climate Change (IPCC). https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

IPCC. (2018). *Global warming of 1.5°C* [Full Report]. Intergovernmental Panel on Climate Change (IPCC). http://www .ipcc.ch/report/sr15/

Jackson, T. (2009). Prosperity Without Growth. Sustainable Development Commission (Vol. 14). https://doi.org/10.1111/j.1530-9290.2009.00213.x

Jevons, W.S., (1906). *The coal question: an inquiry concerning the progress of the nation, and the probable exhaustion of our coal-mines*. Macmillan, London (original work published 1865).

Joint Research Center (JRC) (2021). 2*021 Best Practice Guidelines for the EU Code of Conduct on Data Centre Energy Efficiency*

Kallis, Giorgos. (2020). *Limits,* Redwood City: Stanford University Press.

Khan, N. A., Shafi, S. M., & Ahangar, H. (2018). Digitization of Cultural Heritage: Global Initiatives, Opportunities and Challenges. *Journal of Cases on Information Technology*, *20*(4), 1–16. https://doi.org/10.4018/JCIT.2018100101

Khazzoom, J.D., (1980). *Economic implications of mandated efficiency in standards for household appliances*. The Energy Journal 1, 21–40.

Koomey, J., Berard, S., Sanchez, M. and Wong, H., (2011). *"Implications of Historical Trends in the Electrical Efficiency of Computing"*, IEEE Annals of the History of Computing, 33(3), 46-54.

Lange, S., Pohl, J., & Santarius, T. (2020). Digitalization and energy consumption. Does ICT reduce energy demand? *Ecological Economics*, *176*, 106760. https://doi.org/10.1016/j.ecolecon.2020.106760

Lorek, S., & Fuchs, D. (2013). Strong sustainable consumption governance–precondition for a degrowth path?. *Journal of cleaner production*, *38*, 36-43.

Malmodin, J., Lundén, D., Moberg, Å., Andersson, G., & Nilsson, M. (2014). Life Cycle Assessment of ICT: Carbon Footprint and Operational Electricity Use from the Operator, National, and Subscriber Perspective in Sweden. *Journal of Industrial Ecology*, *18*(6), 829–845. https://doi.org/10.1111/jiec.12145

Malmodin, J. & Lundén, D. (2018). *The energy and carbon footprint of the global ICT and E&M sectors 2010– 2015*. Sustainability, Vol. 10, Iss. 9, p. 3027.

Manhart, A./Blepp, M./Fischer, C./Graulich, K./Prakash, S./Priess, R./Schleicher, T./Tür, M. (2016): Resource Efficiency in the ICT Sector. Final Report. Hamburg, Greenpeace.

Manžuch, Z., (2017) Ethical Issues In Digitization Of Cultural Heritage. *Journal of Contemporary Archival Studies, 4(12), 1-17*.

Mattila, M. (2018). *Museum of Opportunities - The Museum Policy Programme 2030 of the Ministry of Education and Culture*. Finland; Ministry of Education and Culture

Mas, M., Robledo, J. C. & Pérez, J. (2012). *ICT Sector Definition Transition from NACE Rev. 1.1 to NACE Rev. 2: A Methodological Note*. JRC Technical Reports. Joint Research Centre, European Commission.

Masanet, E., Shehabi, A., Lei, N., Smith, S. & Koomey, J. (2020). *Recalibrating global data center energy-use estimates*. Science, Vol. 367, pp. 984–986.

Mickoleit, A. (2010). *Greener and Smarter*. Retrieved from [https://www.oecd-

ilibrary.org/content/paper/5k9h3635kdbt-en]

Ministry of Education and Culture. (2019). Tulostavoiteasiakirja OKM/23/210/2019.

Ministry of Education and Culture. (2020). *Sustainable Development Policy*. Retrieved from [https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162185/OKM_2020_11.pdf]

Ministry of Education and Culture. (2021). *Digital Cultural Heritage*. Retrieved from [https://minedu.fi/en/digital-cultural-heritage]

Ministry of Transport and Communiations. (2021). *Climate and Environmental Strategy for the ICT sector*. Retrieved from [https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/162912/LVM_2021_06.pdf?sequence=1&isAllowed=y]

Museovirasto. (2021). *Strategy*. Retrieved from [https://www.museovirasto.fi/en/about-us/strategy]

Museovirasto. (2021a). *Organsiaation*. Retrieved from [https://www.museovirasto.fi/en/about-us/organisation]

Museovirasto. (2020). High-resolution pictures made freely accessible – why?. Retrieved from [https://www.museovirasto.fi/en/blog/high-resolution-pictures-made-freely-accessible-why]

Museovirasto. (2019). *MOI - Museums of Impact*. Retrieved from [https://www.museovirasto.fi/en/museum-sector-development/moi-museums-of-impact]

NDPC. (2019). *The wheel chart of sustainability and intangible cultural heritage*. Retrieved form [https://www.ndpculture.org/news/the-wheel-chart-of-sustainability-and-intangible-cultural-heritage]

OECD. (1998). *21st Century Technologies: Promises and Perils of a Dynamic Future*. OECD. https://doi.org/10.1787/9789264163539-en

OECD. (2015). *The potential of ICTs to combat climate change and improve environmental performance*. OECD. Retrieved from [https://www.oecd.org/newsroom/thepotentialofictstocombatclimatechangeandimproveenvironmentalperformance.htm]

Osburg, T., & Lohrmann, C. (2017). *Sustainability in a Digital World: New Opportunities Through New Technologies*. https://doi.org/10.1007/978-3-319-54603-2

Pearce, D. W. and G. Atkinson, 1995. Measuring sustainable development. In: D. W. Bromley (ed.). The Handbook of Environmental Economics. Blackwell, Oxford.
(1) (PDF) Viewpoint: Weak versus Strong Sustainability. Retrieved from [https://www.researchgate.net/publication/4871307_Viewpoint_Weak_versus_Strong_Sustainability]

Pendergrass, K. L., Sampson, W., Walsh, T., & Alagna, L. (2019). Toward Environmentally Sustainable Digital Preservation. *The American Archivist*, *82*(1), 165–206. https://doi.org/10.17723/0360-9081-82.1.165

Princen, T. (2003) *Principles for Sustainability: From Cooperation and Efficiency to Sufficiency*. Global Environmental Politics 3: 33-50. Environmental Politics, 3 (February), 33–51.

Princen T. (2005) T*he logic of sufficiency*. The MIT Press, Cambridge, Massachusetts.

Pohl, J., & Finkbeiner, M. (2017). *Digitalisation for sustainability? Challenges in environmental assessment of digital services*. https://doi.org/10.18420/IN2017_199

Pohl, J., Hilty, L. M., & Finkbeiner, M. (2019). How LCA contributes to the environmental assessment of higher order effects of ICT application: A review of different approaches. *Journal of Cleaner Production*, *219*, 698–712. https://doi.org/10.1016/j.jclepro.2019.02.018

Pohl, J., Höfner, A., Albers, E., Rohde, F. (2021). D*esign Options for Long-lasting, Efficient and Open Hardware and Software*. Ökologisches Wirtschaften - Fachzeitschrift. 36. 20-24. 10.14512/OEWO360120.

Pouri, M. J., & Hilty, L. M. (2018). ICT-Enabled Sharing Economy and Environmental Sustainability—A Resource-Oriented Approach. In H.-J. Bungartz, D. Kranzlmüller, V. Weinberg, J. Weismüller, & V. Wohlgemuth (Eds.), *Advances and New Trends in Environmental Informatics* (pp. 53–65). Springer International Publishing.

Ringenson, T. (2021). *Mobilising digitalisation to serve environmental goals* (Issue 2044) [PhD Thesis]. KTH, Strategic Sustainability Studies.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Stuart Chapin, F., Lambin, E., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., De Wit, C.A., Hughes, T., Van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.H., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., Foley, J., (2009). *Planetary boundaries: exploring the safe operating space for humanity*. Ecol. Soc. 14 (2), 32.

Robra, B., Heikkurinen, P., & Nesterova, I. (2020). Commons-based peer production for degrowth? - The case for eco-sufficiency in economic organisations. *Sustainable Futures*, *2*, 100035. https://doi.org/10.1016/j.sftr.2020.100035

Sandberg, M. (2021). Sufficiency transitions: A review of consumption changes for environmental sustainability. *Journal of Cleaner Production*, *293*, [126097]. https://doi.org/10.1016/j.jclepro.2021.126097

Santarius, T., Pohl, J., & Lange, S. (2020). Digitalization and the Decoupling Debate: Can ICT Help to Reduce Environmental Impacts While the Economy Keeps Growing? *Sustainability*, *12*(18), 7496. https://doi.org/10.3390/su12187496

Scholz, R. (2011). Environmental Literacy in Science and Society: From Knowledge to Decisions.

Sorrell, S., 2007. *The Rebound Effect: an assessment of the evidence for economy-wide energy savings from improved energy efficiency*. UK Energy Research Centre London, London.

Spangenberg, J. H., & Lorek, S. (2019). Sufficiency and consumer behaviour: From theory to policy. *Energy Policy*, *129*, 1070-1079.

State Treasury. (2020). *Sustainability reporting within the central government. Retrieved from [https://www.valtiokonttori.fi/en/service/responsibility-reporting-within-the-central-government/#general_government-sustainability-reporting-to-be-harmonised]*

State Treasury. (2021), *KAIKU-TYÖELÄMÄN KEHITTÄMISRAHAN HAKEMUSLOMAKE.*

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B., & Sörlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, *347*(6223), 1259855. https://doi.org/10.1126/science.1259855

Streb, C. K. (2010). Exploratory Case Study. In *Encyclopedia of Case Study Research* (Sage Publications). Thousand Oaks.

The National Digital Library (NDL). (2016). *ENTERPRISE ARCHITECTURE FOR THE NATIONAL DIGITAL LIBRARY V3.0*. Retrieved from [https://www.digime.fi/wp-content/uploads/2019/03/NDL_Enterprise_Architecture_3_0.pdf]

Throop, W. (2016). Flourishing in the Age of Climate Change: Finding the Heart of Sustainability. *Midwest Studies In Philosophy*, *40*(1), 296–314. https://doi.org/10.1111/misp.12062

Tully, G. (2020). Are we living the future? Museums in the time of Covid-19. In [F. Burini] (Ed), *Tourism facing a pandemic: from crisis to recovery*. Bergamo: Università degli Studi di Bergamo. ISBN: 978-88-97253-04-4

UN Educational, Scientific and Cultural Organisation (UNESCO) (1954). *Convention for the Protection of Cultural Property in the Event of Armed Conflict*, 14 May 1954

UN Educational, Scientific and Cultural Organisation (UNESCO). (1972). *Convention Concerning the Protection of the World Cultural and Natural Heritage*.

UN Educational, Scientific and Cultural Organisation (UNESCO) (2003). *Convention for the Safeguarding of the Intangible Cultural Heritage*.

UN Educational, Scientific and Cultural Organisation (UNESCO) (2020). *What is meant by "cultural heritage"?* [online] Available at: < http://www.unesco.org/new/en/culture/themes/illicit-trafficking-of-cultural-property/unesco-database-of-national-cultural-heritage-laws/frequently-asked-questions/definition-of-the-cultural-heritage/].

UN Educational, Scientific and Cultural Organisation (UNESCO) (2020a). *Protecting and preserving cultural diversity in the digital era* [online] Available at: < https://en.unesco.org/news/cutting-edge-protecting-and-preserving-cultural-diversity-digital-era].

UN Educational, Scientific and Cultural Organisation (UNESCO) (2020b). *Museums* Retrieved from [https://en.unesco.org/themes/museums]

UN Educational, Scientific and Cultural Organisation (UNESCO) (2020d). *Museums around the world in the face of COVID-19* [Full Report]. Retrieved from [https://unesdoc.unesco.org/ark:/48223/pf0000373530]

UN Educational, Scientific and Cultural Organisation (UNESCO) (2020e). *UNESCO builds an international policy agenda for digital preservation of documentary heritage.* Retrieved from [https://en.unesco.org/news/unesco-builds-international-policy-agenda-digital-preservation-documentary-heritage]

Van Heddeghem, W., Lambert, S., Lannoo, B., Colle, D., Pickavet, M. & Demeester, P. (2014). *Trends in worldwide ICT electricity consumption from 2007 to 2012*, Computer Communication.

Victor, P.A. (1991). *Indicators of sustainable development: some lessons from capital theory.* Ecological Economics, 4, pp. 191-213

Wäger, P. A., Hischier, R., & Widmer, R. (2015). The Material Basis of ICT. In L. M. Hilty & B. Aebischer (Eds.), *ICT Innovations for Sustainability* (pp. 209–221). Springer International Publishing.

We Are Social. (2020). *Digital 2020: Global Digital Overview*. https://wearesocial.com/digital-2020

Winn, S. (2020). Dying Well in the Anthropocene: On the End of Archivists, In E. Tansev & R. Montova (Eds) *Libraries and Archives in the Anthropocene. Special Issue.* Journal of Critical Library and Information Studies 3, no. 1 DOI: 10.24242/jclis.v3i1.107.

Wohlin, C. (2014). *Guidelines for Snowballing in Systematic Literature Studies and a Replication in Software Engineering.* Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.709.9164&rep=rep1&type=pdf

Yin, R. K. (2009). *Case Study Research: Design and Methods* (4th ed.). Thousand Oaks: Sage Publications.

Yin, R. K. (2014). *Case Study Research: Design and Methods* (2nd ed., Vol. 5). Sage Publications.

Young, W., Ellis, L., Figge, F. (2011). *Moving to eco-sufficiency to create a transformative sustainable business model.* Retrieved from [https://www.crrconference.org/Previous_conferences/downloads/crrc2011youngellisfigge.pdf]

Appendix A: Pendergrass et al. (2019) Self-questionnaire

1. Questions to Guide Environmentally Sustainable Appraisal

Areas for sustainable decisions	Questions	
	Born-digital content	**Digitized content**
Storage size	• Is the entirety of the digital content within your organization's collecting policies? Is there some content (e.g., personal or system data) that you should not acquire? • Is it necessary to capture and maintain a disk image? What are the use cases? • Do duplicates exist within the collection? If so, can you deduplicate, using metadata or descriptive pointers in the place of duplicate copies?	• Do you have a demonstrated need for digital availability of the analog materials? • What file format(s) are you generating? Would different formats result in smaller storage demands while satisfying preservation and user needs? • Should you digitize material to the highest quality possible, or is lesser quality acceptable?
Capture and analysis	• What technology resources are required to capture, analyze, or arrange the digital content?	• What technology resources are required to digitize the analog materials and conduct quality control of the digital surrogates?
Reappraisal	• How regularly should you conduct reappraisal? • What procedures are in place for deaccessioning in the event that you deem some or all of the digital content not valuable during reappraisal?	

2. Questions to Guide Environmentally Sustainable Permanence

Areas for sustainable decisions	Questions
Determination of acceptable loss	• Have you established organizational policies around what constitutes "good enough" digital preservation, and what might constitute acceptable amounts of loss over time? • Have you implemented tiered approaches to digital preservation, where resources are allocated according to the value and uniqueness of materials being preserved? • Do your digital preservation policies and donor agreements allow enough flexibility for you to engage in sustainable digital preservation? What language is used around the effort and resources spent on preservation over time? Does this language allow for any degree of loss over time?
Fixity check methods and frequency	• How often do you run scheduled fixity checks? • Do you run fixity checks during peak or off-peak energy and network hours? • Is it necessary to run fixity checks on all AIPs, or is verifying a sample of AIPs adequate to meet organizational needs? • Are file-based checksums supplemented by other integrity checks, such as natively checksumming file systems or block/ media-level hardware checks? If so, can you responsibly reduce the frequency of file-by-file fixity checks?
Storage technologies utilized	• How many copies are in online vs. nearline or offline storage? • On what media do you store digital content? Do these media need frequent replacement? What are the environmental costs of manufacturing, transporting, and disposing of these media? • Have you evaluated the environmental impact and energy sources of vendor and cloud services used?

3. Questions to Guide Environmentally Sustainable Availability

Areas for sustainable decisions	Questions
Digitization	• Is there a specific or demonstrated need for digitization of an entire collection? If not, how can you alter the scale of the digitization project to meet user needs? • If there is a demonstrated need for digital access to particular items in a collection, what digitization and access methods will most immediately serve the user while keeping organizational commitment to a minimum? • Are you clearly articulating on-demand digitization policies to users to avoid unnecessary trips to view analog materials?
Access storage	• Is it necessary to migrate content to an access copy? If so, is it necessary to do so prior to a request for the content? • Are you retaining access copies in a storage system that facilitates media powering down when not in use?
Delivery	• If you are storing access copies in a system for delayed delivery, do you have language to indicate this to users? • If a user requests born-digital content or content with component files, can the retrieval system bundle this content appropriately? • Is there any supplemental documentation you should provide to the user with the content (e.g., how to access a particular file format)?

Appendix B: List of search terms for Literature Review

Literature Review block	Research terms used
(I) Environmental impact of ICT and mitigation	- Environmental impacts - Life-cycle/ LCA - Direct impact - Higher order effects - Sustainable ICT/ Green IT - ICT for Sustainability/ IT for Green - Sustainable/ Green software - Jevons Paradox/ Rebound effects - Resources Decoupling - ICT/ technological efficiency Combined (non-systematically) with; - ICT - Digitilisation - Data centers - EU Policy - Cultural Heritage - Digital Preservation
(II) Sufficiency interpretation	- Eco-Sufficiency/Sufficiency - Eco-Efficiency/ Efficiency - Strong/ Weak Sustainability - Absolute throughput reductions - Ecological limits - Sustainable transitions - Growth

Source: Own elaboration

Appendix C: Interview Information Sheet, Questions and Consent Form

Environmental Sustainability in Digital Preservation (DP) of Cultural Heritage (CH); advancing a Sufficiency strategy for CH Organisations

INFORMATION SHEET

Description of the Research Project

The digital transformation undergoing on the CH sector is being accelerated (1) by the harshening of climate change phenomena putting CH directly at risk and (2) by the outbreak of Covid-19 pandemic highlighting resilience as a key-feature for the future. For instance, with the 94.7% of museums forced to close their doors in the breaking of the pandemic, a 15% of them established their digital presence for the first time after the lockdown, while an approximately 40% still has no online collections and exhibitions and is expected to proceed to their digitisation (ICOM, 2020; UNESCO, 2020).
However, DP is relying heavily on ICT use and the increased production of digital content will result proportionally in increased demands of such equipment to accommodate the processing, storage and accessing needs, which in turn are being translated into increased resources and energy consumption (Goldman, 2019; Hilty et al., 2011; Pendergrass et al., 2019). Environmental sustainability considerations are currently found to be absent from the decision-making standards for DP of CH, that CH Organisations (CHO) are following, but efficiency and sufficiency approaches to ICT use are deemed necessary to mitigate its impacts if we are to respond to the climate emergency in the coming decade.

In this respect, this thesis, undertaken in the context of completing the MSc. Environmental Management and Policy, at the International Institute of Industrial Environmental Economics, Lund University, could be an opportunity for exploring:

- How a Sufficiency strategy can be understood and implemented in a CHO context for integrating environmental sustainability in Digital Preservation of CH?

As part of this research project, I invite you to an interview to further discuss around the themes below:

(according to interviewee's position in the organisation)

1. ICT environmental impacts; what are the current awareness, understanding and practices in Digital Preservation of Cultural Heritage? How is sustainability discussed? Why do you think is that?
2. More specifically, how the decisions are taken during appraisal, permanence and availability? (Pendergrass questionnaire to be used here, by checking how environmental sustainability factors (efficiency/sufficiency) playing in)
3. Organisation's mission and long-term fulfilment; to your knowledge, what are the reflections of environmental sustainability on the strategy plan? What is the Strategy's interplay with environmental considerations/ interaction with natural environment?
4. Different actors' communication and collaboration network; where are you positioned on the organisation's ecosystem, who is linked to whom? What interdisciplinarity levels are needed and achieved among practitioners for decision-making?
5. How the dynamics and needs with the users of the content are playing in?

The collected material will be used in the final thesis paper and presentation.

7 **Data Management**

All the data for this project is collected and stored in accordance with the General Data Protection Regulation (GDPR) 2016/679 of the European Union. More information about GDPR implementation at Lund University can be found: lunduniversity.lu.se/gdpr. All the research materials, including the participants' data will be securely stored during the continuation of the thesis project at a protected shared Cloud of Lund University, which is of the researcher's personal use. At any stage of the research project, the research participants have a right to gain

access to their own personal data, request its correction or deletion or limitation to processing of data as well as they can file a complaint about how their personal data is used.

CONSENT FORM

This form is to ensure that you have been given information about DP of CH research project (see Information Sheet) and to give you opportunity to confirm that you are willing to take part in this research. For all statements below please indicate in case some are not applying to you:

I have been **familiarised** with the DP of CH thesis project, I have had the possibility to ask questions and I have received satisfactory answers to my questions
As a research participant, I am aware of my **right to withdraw participation** at any time
I give my consent that the interview can be **audio-recorded**, transcribed, and analysed
I give my consent to **be identified by my organization**
I understand that the results of the research will be presented in a way so that **no information can be traced to me personally**
I give my consent that a record of my interview can be **safely stored** for future reference

Note: Your participation is voluntary. As an interviewee, you do not have to answer all the questions that are asked; you reserve the right to refuse or cease participation in the interview process without stating your reason and may request to keep certain materials confidential.

*For taking the interview in written, the same as above are applying and where recording refer to the written answers of the participants.

Please, **confirm** your consent verbally upon beginning of the interview.

Thank you in advance and for any inquiries please do contact:

Paschalidou Evangelia
LLB, LLM Financial and Business Law, MSc Environmental Management and Policy candidate
International Institute for Industrial Environmental Economics, Lund University
email: ev7452pa-s@student.lu.se

Appendix D: List of Interviewees

Interview	Organisation	Department/ Position*	Format	Date**
I1	FHA	AIS	Video Call	March 2021
I2	FHA	AIS	Video Call	March 2021
I3	FHA	AIS	Video Call	March 2021
I4	FHA	AIS	Video Call	March 2021
I5	FHA	AIS	Video Call	March 2021
I6	FHA	AIS	Video Call	March 2021
I7	FHA	AIS	Written interview guide	March 2021
I8	FHA	AIS	Written interview guide	April 2021
I9	FHA	AIS	Written interview guide	March 2021
I10	FHA	AIS	Written interview guide	April 2021
I11	FHA	AIS	Written interview guide	March 2021
I12	National Library of Finland	Service	Video Call	March 2021
I13	National Library of Finland	Service	Video Call	April 2021
I14	National Library of Finland	Service	Video Call	April 2021
I15	Ministry of Culture and Education of Finland	Art and Cultural Policy	Video Call	April 2021

I16	CSC-DPS	Development Manager	Video Call	April 2021
I17	Sitra Innovation Fund	Circular Economy Specialist	Video Call	April 2021
I18	Europeana Foundation	Senior Software Developer	Video Call	April 2021
I19	National Archives of Finland	General Administarteion Manager	Video Call	April 2021
I20	National Archives of Finland	Development Manager	Video Call	March 2021

Source: Own elaboration

*In order anonymity to be ensured, position of the participants in the case study organisation is not provided. This is because the content of the interview would be easily linked to individual interviewees in the case that only one person is considered in the specific position.
**Similarly, for non-traceability reasons, exact date of conducting the interview was not provided, since the scheduling of some interview dates was known among to more than one interviewees in the organisation.

Appendix E: Correspondence of detailed measures to the quality of their outcome

Medium of change - Process		
Stage	**Area**	**Measures**
Appraisal	1. Contain storage size	a. Acquiring only the material falling within the CHO's collecting policy b. Digitizing material that is explicitly needed c. Generating 'lighter' file formats or in lesser quality d. Deduplicating using metadata or descriptions for the removed content e. Reevaluating the use of default choices in workflows e.g. disk images
	2. Capture and analysis	a. Make explicit the technology resources needed for capture, analyse and arrange the digital content
	3. Reappraisal	a. Regular reappraisal (including coincidental accessing of the data) and by using metrics of value
Preservation	1. Determination of acceptable loss	a. Establishing organisational policies on what constitutes "good enough" DP and an acceptable amount of loss over time b. Implementing tiered approaches to DP resources according to the value and uniqueness of material c. Allow loss-flexibility with the language used in the preservation policies and donor agreements
	2. Fixity check methods and frequency	a. Run complete fixity checks as infrequently as would be responsible by the threat management model of the collection b. Schedule fixity checks during off-peak energy and network hours c. Large and random sampling of AIPs for fixity checks, as indicative for further investigation d. Supplement file-based checksums with self-check-summing and self-healing file systems or media-level hardware checks instead of frequent file by file fixity checks
	3. Storage technologies	a. Evaluate environmental impact and energy sources of online storage vendor and cloud services provider —benefited from efficiencies of scale b. Evaluate environmental impact of manufacturing, transporting and disposing media for nearline or offline storage, as well the frequency of replacement need —benefited from no need for permanent networking infrastructure
	4. File format migration policy	a. Develop local file format policies according to specific for the CHO calculated risk assessments on format obsolescence b. Customize accordingly the file format migration policy of the digital preservation software system c. Conduct format migrations on-demand at the time of access and not during ingest to a preservation repository for some material, when appropriate d. Apply file format policies (e.g. migration at ingest) selectively on the preserved content and not in bulk
	5. Number of redundant copies	a. Preserve a necessary number of copies of AIPs according to the threat model for the AIPs conducted by the organisation b. Aim for a tiered redundancy level of AIPs copies, according to the uniqueness and value of the assets preserved c. Limit redundant surrogates for stable analog materials
Accessibility	1. Digitisation	a. Digitize according to users' demonstrated needs b. Provide access on-demand by utilizing a tiered -"track"- approach c. Articulate the on-demand digitisation policy to the user, as intending to save unnecessary trips to access analog material
	2. Access storage	a. Migrate content to an access copy upon request b. Apply a tiered storage system and retain access copies to a storage system that facilitates media power down when not in use

	3. Delivery	a. Indicate if access copies are kept on a delayed delivery system b. Bundle component files with the born digital content upon retrieval c. Provide supplemental user's documentation if necessary	

Source: Own elaboration