NAVIGATING ETHICAL LONG-TERM PERSONAL DATA STORAGE: PRIVACY, SECURITY, REGULATORY CHALLENGES, AND SOCIETAL IMPACT REVIEW

Simeon Ayoade Adedokun[1*]; Theophilus Adedayo Adedokun[2]

Department of Computer Science[1]
Ladoke Akintola University of Technology, Ogbomosho, Nigeria[1]
https://www.lautech.edu.ng/
simadedokun@gmail.com[1*]

Research and Postgraduate Support[2]
Durban University of Technology, South Africa[2]
https://www.dut.ac.za/
theoday88@gmail.com[2]

(*) Corresponding Author

Abstract— *Digital data storage is now fundamental to modern society, facilitating the collection and utilization of vast information resources. Yet, the exponential growth of stored data has intensified ethical concerns, particularly regarding long-term retention. This multidisciplinary review synthesizes literature on the ethical implications of long-term data storage, focusing on privacy, security, data ownership, accessibility, sustainability, and societal impact. The study analyzes ethical frameworks encompassing deontology, privacy by design, fair information practices, data minimization, and accountability while examining the responsibilities of organizations, individuals, regulators, technology providers, and ethics committees in upholding ethical standards. Key findings reveal that the ethical landscape of long-term data storage is highly complex and demands a collaborative, multi-stakeholder approach. The review concludes by recommending the integration of robust security measures, enhanced user control and consent mechanisms, sustainable storage technologies, and governance frameworks prioritizing fairness, non-discrimination, and the public good. These recommendations aim to guide stakeholders toward responsible and ethical data stewardship, ensuring that digital data storage practices remain trustworthy and sustainable amid ongoing technological and societal change.*

Keywords: *data storag,; digital data, ethical consideration, long-term data, privacy.*

Abstrak—Penyimpanan data digital kini menjadi hal mendasar bagi masyarakat modern, memfasilitasi pengumpulan dan pemanfaatan sumber daya informasi yang sangat besar. Namun, pertumbuhan eksponensial data yang tersimpan telah meningkatkan kekhawatiran etika, terutama terkait retensi jangka panjang. Tinjauan multidisiplin ini mensintesis literatur tentang implikasi etika penyimpanan data jangka panjang, dengan fokus pada privasi, keamanan, kepemilikan data, aksesibilitas, keberlanjutan, dan dampak sosial. Studi ini menganalisis kerangka kerja etika yang mencakup deontologi, privasi berdasarkan desain, praktik informasi yang adil, minimisasi data, dan akuntabilitas sambil mengkaji tanggung jawab organisasi, individu, regulator, penyedia teknologi, dan komite etika dalam menegakkan standar etika. Temuan utama mengungkapkan bahwa lanskap etika penyimpanan data jangka panjang sangat kompleks dan menuntut pendekatan kolaboratif dan multi-pemangku kepentingan. Tinjauan ini diakhiri dengan merekomendasikan integrasi langkah-langkah keamanan yang kuat, peningkatan kontrol dan mekanisme persetujuan pengguna, teknologi penyimpanan berkelanjutan, dan kerangka kerja tata kelola yang memprioritaskan keadilan, non-diskriminasi, dan kepentingan publik. Rekomendasi ini bertujuan untuk memandu para pemangku kepentingan menuju pengelolaan data yang bertanggung jawab dan etis, memastikan bahwa praktik penyimpanan data digital tetap dapat dipercaya dan berkelanjutan di tengah perubahan teknologi dan masyarakat yang sedang berlangsung.

***Kata Kunci**: penyimpanan data, data digital, pertimbangan etis, data jangka panjang, privasi.*

INTRODUCTION

In today's digital age, data has become an invaluable asset, shaping the way we live, work, and interact with the world around us (Marr, 2021). The ability to store, analyze, and leverage data has transformed industries, enabled groundbreaking technological advancements, and revolutionized decision-making processes across various sectors. As a result, digital data storage has become an integral part of modern society, fundamentally altering how information is created, stored, and accessed. With the exponential growth of digital data, driven by the ubiquity of digital devices, the Internet of Things (IoT), and the rise of cloud computing (Rani et al., 2023), the need for long-term data storage solutions has become increasingly critical.

Organizations and individuals alike are grappling with the challenge of managing and preserving vast amounts of data for extended periods, ranging from personal memories and records to business-critical information and historical archives. However, the proliferation of digital data and the necessity for long-term storage raise significant ethical concerns that must be addressed (Chang, 2021). The ethical dimensions of long-term data storage encompass a wide range of issues, including data privacy, security, ownership, accessibility, and preservation. These concerns pose significant challenges that have far-reaching implications for individuals, organizations, and society as a whole.

One of the primary ethical considerations is data privacy and the protection of sensitive information. As data accumulates over time, the risk of unauthorized access, data breaches, and misuse increases, potentially leading to violations of personal privacy, identity theft, and other harmful consequences. Ensuring the confidentiality and integrity of stored data is paramount, particularly in sectors such as healthcare, finance, and government, where sensitive information is handled.

Another critical ethical concern is data ownership and control (Hummel et al., 2021a). As data is stored for extended periods, questions arise regarding who has the right to access, modify, or delete it. This issue becomes particularly complex when data involves multiple parties or spans generations, raising questions about inheriting digital legacies and the potential consequences of data mishandling.

Furthermore, the longevity of digital data storage raises questions about accessibility and preservation (Doricchi et al., 2022). As technology rapidly evolves, the risk of data becoming inaccessible due to format obsolescence or hardware/software incompatibility increases. Ensuring that data remains readable and interpretable over time is a significant challenge, as is maintaining the integrity and authenticity of historical records.

Furthermore, the ethical implications of long-term data storage extend beyond individual privacy and ownership concerns. The responsible management and use of data have societal impacts, influencing decision-making processes, shaping policies, and potentially perpetuating biases or inequalities if data is mishandled or misinterpreted (Oladosu et al., 2024).

While existing literature has extensively examined individual aspects of data ethics such as privacy protection (Marr, 2021), data ownership frameworks (Hummel et al., 2021a), and technological preservation challenges (Doricchi et al., 2022), there remains a significant gap in comprehensive research that integrates these disparate ethical dimensions within the specific context of long-term data storage. Previous studies have predominantly focused on short-term data management ethics or addressed single ethical concerns in isolation, failing to capture the complex interdependencies and evolving nature of ethical challenges that emerge over extended storage periods. Furthermore, limited research has systematically examined the multi-stakeholder responsibilities and societal implications when data spans generations, particularly regarding digital inheritance and the perpetuation of historical biases through preserved datasets (Oladosu et al., 2024).

This research addresses these critical gaps by providing a holistic framework that synthesizes privacy, ownership, accessibility, and societal impact concerns within a unified long-term storage paradigm. By examining the interconnected nature of these ethical dimensions and their evolution over time, this study offers a comprehensive understanding of how prolonged data retention amplifies existing ethical challenges while creating novel dilemmas unique to extended temporal contexts.

Additionally, this research contributes to the field by proposing integrated stakeholder responsibility models and practical recommendations that account for the dynamic nature of technology, legal frameworks, and societal values across the extended lifecycles of stored data. This paper delves into the ethical dimensions of long-term data storage, exploring the multifaceted challenges and implications for individuals, organizations, and society as a whole. By examining these issues, this study aims to shed light on the

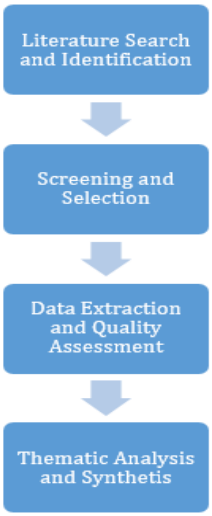
ethical considerations that must be addressed to ensure the responsible and sustainable management of digital data for generations to come. The specific objectives of this study are:

1. Investigate the ethical implications of storing personal and sensitive data for extended periods.
2. Analyze the potential risks and benefits of long-term data storage from an ethical standpoint.
3. Explore the responsibilities of stakeholders in ensuring ethical data storage practices.
4. Propose recommendations for addressing ethical challenges and promoting responsible data storage practices.

MATERIALS AND METHODS

Research Design

This study employs a comprehensive literature review methodology (Khando et al., 2021) to examine the ethical considerations surrounding long-term digital data storage. The research was conducted in four distinct stages: (1) literature search and identification, (2) screening and selection, (3) data extraction and quality assessment, and (4) thematic analysis and synthesis. This systematic approach ensures a rigorous examination of the ethical landscape while maintaining methodological transparency and reproducibility. These stages are represented in **Figure 1** below:



Source**:** (Research Results, 2025)

Figure 1: Research stages

Data Sources

The literature search was conducted using various academic databases, including Web of Science, Scopus, and Google Scholar. Data sources were limited to peer-reviewed journal articles, conference proceedings, and academic books published within the last fifteen years (2000-2025) to ensure the inclusion of the most recent and relevant literature. However, seminal works and foundational ethical theories were also considered, regardless of their publication date.

The quality of data sources was assessed based on multiple criteria including journal impact factor, publisher reputation, citation metrics, and peer-review status. Priority was given to publications from established academic publishers and journals with high impact factors in relevant fields such as information ethics, computer science, and data management. Conference proceedings were included only from recognized international conferences with rigorous peer-review processes.

Data Collection Technique

The search terms included "digital data storage," "long-term data storage," "data ethics," "data privacy," "data security," "data ownership," "data accessibility," "data sustainability," and "ethical frameworks." Boolean operators (AND, OR) were used to combine search terms effectively, and truncation symbols were employed to capture variations of key terms. The initial search yielded over 700 potentially relevant sources. Screening was conducted in two phases: first, titles and abstracts were reviewed for relevance using predetermined inclusion and exclusion criteria; second, full-text articles were assessed for their direct contribution to understanding ethical considerations in long-term data storage. Duplicates were systematically removed using Mendeley reference management software. After this comprehensive screening process, the number of sources was narrowed down to approximately 150, which were then further refined to identify the most relevant sources for in-depth analysis.

Data Analysis

The selected literature underwent thorough review and analysis using a systematic thematic approach. Data extraction was performed using a standardized template that captured key information including study objectives, ethical frameworks employed, stakeholder perspectives, identified challenges, and proposed solutions. The analysis employed an inductive coding method where themes emerged from the data rather than being predetermined. Initial codes were developed through open coding of the literature, followed by axial coding to identify relationships between concepts. Finally, selective coding was used to organize findings into coherent thematic categories. This process was facilitated by NVivo qualitative data analysis software to ensure systematic and transparent coding procedures. The findings were organized into six primary thematic categories: privacy concerns, data security, data ownership and

control, accessibility and interoperability, sustainability and environmental impact, and the broader societal impact of long-term data storage. Each theme was further subdivided into relevant sub-themes to capture the nuanced aspects of ethical considerations.

The literature review encompassed various ethical theories and frameworks, such as deontology, fair information practices, data minimization, and accountability principles. Also, the roles and responsibilities of key stakeholders, including organizations, individuals, regulatory bodies, technology providers, and ethics committees were systematically examined and synthesized. This systematic approach allowed for a comprehensive understanding of the ethical landscape surrounding long-term data storage and facilitated the identification of gaps and areas requiring further research.

RESULTS AND DISCUSSION

This study explores the multifaceted ethical considerations surrounding long-term data storage, revealing a complex intersection of technological capabilities, regulatory frameworks, and societal obligations. The research identifies five critical ethical domains that demand immediate attention from stakeholders across all sectors: privacy and security, data ownership and control, accessibility and interoperability, environmental sustainability, and societal responsibility. As shown in **Figure 2**, privacy and security, along with environmental sustainability, appear as the most urgent concerns, while ownership, accessibility, and societal responsibility remain highly significant but comparatively less urgent.

Privacy and Security as Foundational Pillars

Privacy emerges as the cornerstone of ethical long-term data storage practices, fundamentally transforming how organizations must approach data protection. As data accumulates over extended periods, the risk profile changes dramatically, creating amplified vulnerabilities to unauthorized access, security breaches, and potential misuse of sensitive information. The temporal dimension of long-term storage introduces unique privacy challenges that traditional short-term data management approaches fail to address adequately. Recent research reinforces this concern, highlighting that privacy protection in long-term storage requires robust security measures throughout the entire data lifecycle, from collection to storage to processing and disposal, safeguarding data integrity and confidentiality (Bandari, 2023).

Contemporary data ethics frameworks emphasize that privacy encompasses not only preventing unauthorized access but also ensuring transparency, fairness, and accountability in data handling practices. Data ethics sets the boundaries for what is considered acceptable behavior when working with data, both in the private and public sectors, making privacy considerations central to ethical data stewardship. Organizations bear the primary responsibility for implementing comprehensive security architectures that can withstand evolving threats over decades, including advanced encryption protocols, granular access controls, regular security audits, and robust incident response capabilities (Ang'udi, 2023).

The challenge of maintaining privacy in long-term storage is further complicated by the potential for re-identification of supposedly anonymized data. Recent research shows that re-identification risk scores, representing the estimated probability of any given individual being re-identified, vary greatly depending on dataset characteristics and attack scenarios in clinical trial datasets (Rodriguez et al., 2025). These scores range from very low probabilities to certainty of re-identification within finer-grained data strata, underscoring the inadequacy of traditional anonymization techniques for long-term data protection. This variability highlights the urgent need for sophisticated privacy-preserving technologies and adaptive governance frameworks that can dynamically respond to evolving re-identification risks over extended timeframes.

The ethical imperative extends beyond mere compliance to encompass a proactive commitment to protecting individual privacy rights across extended timeframes. Regulatory frameworks play an essential role in establishing minimum standards for privacy protection, with the General Data Protection Regulation (GDPR) in the European Union exemplifying how comprehensive legislation can create accountability mechanisms and enforce penalties for privacy violations (Bharti & Aryal, 2023)). However, the global nature of data storage requires harmonized international standards to address cross-border data flows and jurisdictional challenges. As reflected in **Figure 2**, privacy and security stand as the most urgent domain requiring immediate attention.

Data Ownership and Control Complexities

Closely intertwined with privacy concerns is the contentious question of data ownership, which represents one of the most complex ethical issues in long-term storage scenarios. Individuals possess fundamental rights regarding their personal information, including the ability to provide informed consent, access their data, and exercise control over its use throughout extended storage periods. These rights become increasingly complex

when data is stored for decades, potentially outlasting the original consent agreements or changing personal circumstances (Hummel et al., 2021b).

Modern data ethics principles emphasize that an individual has ownership over their personal information, establishing this as a foundational principle for ethical data practices. However, implementing this principle in long-term storage contexts presents significant challenges, particularly when considering the evolution of technology, changing organizational structures, and shifting legal frameworks over extended periods (Bibikian, 2023). Organizations and researchers must navigate these complexities by adopting clear policies on data stewardship, including defining ownership rights, consent management, and data sharing agreements that remain valid over time. The use of trusted data repositories and licensing agreements can help clarify ownership and reuse rights, ensuring data is preserved and shared responsibly while respecting individual control (Sørensen & Kocksch, 2021).

Transparency serves as the foundation for ethical data ownership practices, requiring organizations to provide clear, comprehensible information about their data collection, storage, and usage practices, enabling individuals to make informed decisions about their participation (Cheng et al., 2024). This transparency obligation extends to explaining how data will be used, shared, and protected over time, including provisions for changing technologies and organizational structures. Effective data governance frameworks within organizations are crucial for ensuring accountability and ethical decision-making throughout the data lifecycle, addressing consent management, data subject rights, and procedures for handling requests for data access, correction, or deletion across extended timeframes.

The implementation of meaningful consent mechanisms for long-term storage requires innovative approaches that can accommodate changing circumstances while preserving individual autonomy. Organizations must develop adaptive consent systems that allow individuals to modify their preferences over time and provide clear pathways for exercising their rights throughout extended storage periods. As seen in **Figure 2**, ownership and control rank just below privacy and sustainability in urgency but remain indispensable for ethical stewardship.

Accessibility and Interoperability Imperatives

Long-term data storage presents unique challenges related to technological evolution and format obsolescence that carry significant ethical implications. Data stored today using current technologies may become inaccessible due to changes in software, hardware, or industry standards over extended periods, creating ethical obligations to ensure that stored data remains accessible and usable for its intended purposes. The adoption of open standards and interoperable formats represents a critical strategy for addressing technological obsolescence (Medina et al., 2022), requiring organizations to prioritize standardized formats and develop comprehensive data migration strategies to ensure long-term accessibility.

Data ethics frameworks serve to protect the privacy rights of individuals by establishing suitable practices for data collection, storage, and sharing, and these frameworks must extend to ensuring data accessibility across technological generations. This approach demands significant upfront investment but serves the ethical imperative of preserving data value for future use. Collaboration between organizations, standards bodies, and technology providers is essential for promoting seamless data exchange and preventing digital obsolescence (Gujar, 2025), with industry-wide initiatives to develop and maintain open standards helping ensure that today's data investments continue to provide value across extended timeframes.

The ethical dimensions of data accessibility extend beyond technical considerations to encompass questions of digital equity and social justice. Organizations must consider how their storage decisions might affect different communities' access to information and ensure that preservation efforts do not inadvertently create or perpetuate digital divides. This requires proactive engagement with diverse stakeholders and consideration of how data accessibility challenges might disproportionately affect marginalized communities. As illustrated in **Figure 2**, accessibility and interoperability are recognized as critical but moderately urgent domains that intersect strongly with equity considerations.

Environmental Sustainability Urgency

The environmental impact of long-term data storage represents an increasingly critical ethical consideration that can no longer be overlooked. Data centers consume substantial amounts of energy for processing, storage, and cooling, contributing significantly to carbon emissions and environmental degradation. As the volume of data requiring long-term storage continues to grow exponentially, the environmental implications become increasingly urgent.

Recent studies highlight the magnitude of this challenge, revealing that the data storage industry is growing at 40% annually, making environmental considerations increasingly urgent

(EaseUS, 2025). The environmental impact extends beyond energy consumption to include e-waste generation as a result of the need for frequent upgrades and replacements of hardware in data centers, which can emit toxic substances when improperly disposed of (Uohara, 2025).

Research indicates that storing 100 GB in the cloud creates a carbon footprint of 0.2 tons of CO2, emphasizing the cumulative environmental impact of large-scale data storage operations. This finding underscores the importance of data minimization strategies and efficient storage practices in reducing environmental impact. Organizations and technology providers bear responsibility for prioritizing energy-efficient solutions and renewable energy sources in their storage infrastructure (Oloruntoba, 2024), including investments in advanced cooling technologies, server utilization optimization, and sophisticated power management systems.

The environmental challenges are further compounded by the rapid growth of e-waste. A 2024 UN report indicates that e-waste is growing five times faster than documented recycling efforts, highlighting the urgent need for sustainable approaches to hardware lifecycle management in data storage operations (Geneva Environment Network, 2024). The ethical imperative extends to considering the full lifecycle environmental impact of storage technologies, encompassing manufacturing, operation, and disposal phases. As highlighted in **Figure 2**, environmental sustainability ranks alongside privacy and security as the highest priority domain, underscoring its urgency.

Societal Impact and Intergenerational Ethics

Long-term data storage practices generate far-reaching implications for individuals, communities, and society as a whole, creating profound ethical responsibilities that extend beyond immediate stakeholders. The decisions made today about what data to preserve, how to protect it, and who can access it will influence future generations' understanding of history, scientific progress, and social development (Pardhi & Suri, 2025).

Contemporary ethical frameworks recognize that consent, openness, justice, accountability, and limiting damage are all facets of data ethics, and these principles must be applied with particular attention to their long-term implications. The societal impact of data storage decisions extends beyond immediate stakeholders to encompass future generations who will inherit the consequences of today's choices (Bartram, 2025).

Ethics committees and advisory boards play a vital role in evaluating data storage practices and providing guidance on complex ethical dilemmas, helping organizations navigate competing interests, assess societal implications, and ensure that storage decisions align with broader ethical principles and social values (Ferretti et al., 2022). The societal impact of long-term data storage also encompasses questions of digital equity and access, requiring proactive efforts to address digital divides and promote inclusive access to preserved information for diverse communities and future generations (Khan, 2024).

The intergenerational dimensions of long-term data storage create unique ethical obligations that traditional frameworks may not adequately address. Organizations must consider how their storage decisions will affect future generations' access to information, their privacy rights, and their ability to understand and interpret historical data. This requires developing new ethical frameworks that can balance present needs with future obligations and ensure that data preservation efforts serve the broader interests of society across extended timeframes. As shown in **Figure 2**, societal responsibility ranks slightly lower in urgency but remains essential for long-term ethical stewardship.

Implications for Current Practice and Future Directions

This study reveals that ethical considerations in long-term data storage cannot be addressed through piecemeal approaches or isolated interventions. Instead, the interconnected nature of privacy, security, ownership, accessibility, sustainability, and societal impact demands comprehensive ethical frameworks that address these dimensions holistically. The temporal dimension of long-term storage fundamentally transforms traditional ethical considerations, making privacy rights that may seem straightforward in short-term contexts become complex when extended across decades. Data that appears benign today may become sensitive in future contexts, requiring adaptive protection mechanisms that can evolve with changing social norms and technological capabilities.

Current data ethics challenges require careful attention and proactive solutions. The challenges associated with data ethics can hinder the adoption of responsible data practices and require careful attention and proactive solutions. This underscores the need for organizations to move beyond reactive compliance toward proactive ethical stewardship that anticipates future challenges and develops adaptive responses (Monah et al., 2022).

The complexity of long-term data storage ethics necessitates collaborative governance

models that engage multiple stakeholders in ongoing dialogue and decision-making processes. Organizations cannot address these challenges in isolation but require support from regulatory bodies, technology providers, ethics experts, and civil society organizations. Organizations and businesses must assume primary responsibility for implementing ethical data storage practices, including developing robust security measures, establishing transparent data governance frameworks, and creating accountability mechanisms for ethical decision-making. They must also invest in long-term planning and risk assessment to anticipate future ethical challenges and technological changes (Adekunle et al., 2023).

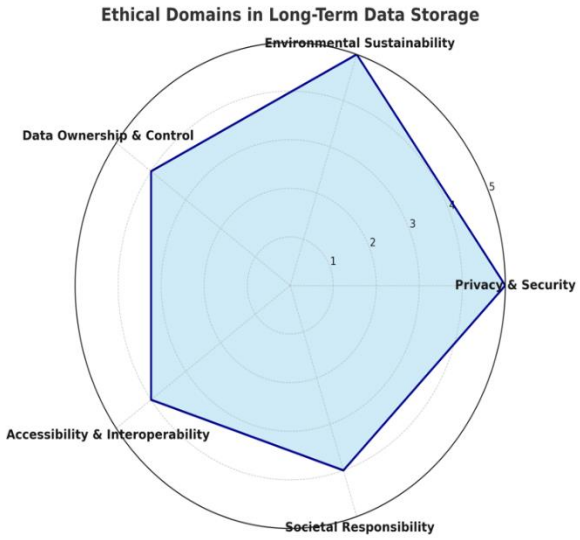
Regulatory bodies and governments play crucial roles in establishing legal frameworks and enforcement mechanisms that support ethical data storage practices, developing comprehensive data protection laws, providing guidance on best practices, and ensuring compliance through regular audits and investigations (Bharti & Aryal, 2023). Technology providers bear responsibility for designing and developing solutions that facilitate ethical data storage practices, creating privacy-enhancing technologies, implementing security-by-design principles, and providing tools that enable organizations to meet their ethical obligations effectively (Odumuwagun, 2025).

Individuals and data subjects must be empowered to participate meaningfully in decisions about their data through enhanced digital literacy, clear consent mechanisms, and accessible tools for exercising their rights throughout extended storage periods. This collaborative approach recognizes that no single entity possesses the expertise, authority, or resources necessary to address the full spectrum of ethical challenges inherent in long-term data storage.

The rapid pace of technological development continues to generate new ethical challenges in long-term data storage, with artificial intelligence and machine learning technologies creating new possibilities for analyzing stored data and potentially revealing insights that were not anticipated when the data was originally collected. These developments require ongoing ethical assessment and adaptive governance approaches that can respond to emerging risks and opportunities. The global nature of data storage creates additional complexity through varying legal frameworks, cultural norms, and ethical standards across jurisdictions, making the harmonization of different approaches while respecting local values and sovereignty an ongoing challenge for international data governance.

Climate change and environmental degradation add urgency to the sustainability dimensions of long-term data storage, requiring organizations to increasingly consider the environmental trade-offs of data preservation and develop strategies for minimizing the carbon footprint of digital permanence. The study's findings point to several critical recommendations for promoting ethical long-term data storage practices. Organizations should implement adaptive governance structures that can evolve with changing technologies, social norms, and regulatory requirements while maintaining core ethical principles (Lescrauwaet et al., 2022).

Ethical data storage requires substantial upfront investment in technologies, processes, and human resources that may not provide immediate returns but are essential for meeting long-term obligations. Industry associations, standards bodies, and regulatory organizations should facilitate ongoing dialogue and coordination among stakeholders to address complex ethical challenges collectively. Organizations should implement comprehensive reporting mechanisms that enable external oversight and public accountability for their long-term data storage practices, while the data storage industry must accelerate the transition to renewable energy sources and energy-efficient technologies to address the environmental impact of digital permanence. As summarized in **Figure 2**, these domains are deeply interconnected, requiring holistic governance frameworks rather than isolated interventions.



Source: (Research Results, 2025)

Figure 2: Ethical domains in long-term data storage, showing relative urgency/priority across privacy & security, environmental sustainability, data ownership & control, accessibility & interoperability, and societal responsibility

This study examined the ethical frameworks governing long-term digital data

storage, revealing that current approaches are fundamentally inadequate for addressing the complex challenges posed by extended data persistence. The study identified five interconnected ethical domains that require immediate attention: privacy and security, data ownership and control, accessibility and interoperability, environmental sustainability, and societal responsibility. The temporal dimension of long-term storage fundamentally transforms traditional ethical considerations, creating unprecedented categories of risk that extend far beyond conventional data management timeframes.

The research demonstrates that privacy protection in long-term storage contexts requires adaptive mechanisms capable of evolving with changing technological capabilities and social norms over decades. Traditional privacy frameworks, designed for short-term data handling, prove insufficient when applied to scenarios where data may be stored and accessed across multiple generations. The study reveals that data ownership rights become increasingly complex in long-term contexts, as original consent agreements may become obsolete and individual circumstances change over extended periods, necessitating new approaches to consent management and individual autonomy preservation.

Environmental sustainability emerges as a critical ethical imperative that has been largely overlooked in traditional data ethics frameworks. The research establishes that the exponential growth of data storage, combined with the energy-intensive nature of data centers, creates significant environmental obligations that organizations must integrate into their ethical decision-making processes. The study demonstrates that current environmental considerations are inadequate for addressing the full lifecycle impact of long-term data storage, from manufacturing through disposal of storage technologies.

The research reveals that accessibility and interoperability challenges in long-term storage carry profound ethical implications, as technological obsolescence can effectively deny future generations access to preserved data. This finding highlights the ethical obligation to ensure that today's storage decisions do not inadvertently create digital divides or limit future access to information. The study establishes that current approaches to data format preservation and migration are insufficient for meeting long-term accessibility requirements.

Societal impact considerations extend beyond immediate stakeholders to encompass intergenerational responsibilities that traditional ethical frameworks do not adequately address. The research demonstrates that decisions made today about data preservation and access will fundamentally shape future generations' understanding of history, scientific progress, and social development. This finding reveals the need for new ethical frameworks that can balance present needs with future obligations across extended timeframes.

The study concludes that addressing these challenges requires collaborative governance models that engage multiple stakeholders in ongoing dialogue and adaptive decision-making processes. No single organization or regulatory body possesses the expertise and resources necessary to address the full spectrum of ethical challenges inherent in long-term data storage. The research establishes that organizations must transition from reactive compliance approaches to proactive ethical stewardship that anticipates future challenges and develops adaptive responses to emerging ethical dilemmas.

These findings have immediate implications for current practice, requiring organizations to begin investing in interoperable storage formats, renewable energy infrastructure, and transparent data governance systems. Policymakers must prioritize the development of international standards for cross-border data storage ethics and environmental sustainability requirements. Technology providers must focus on creating privacy-preserving storage technologies and tools that facilitate ethical compliance across extended timeframes. The urgency of these actions cannot be overstated, as today's decisions will determine the ethical landscape of digital heritage for generations to come.

Research Limitations and Future Directions

Limitations

This study acknowledges several important limitations that constrain the generalizability and scope of its findings. The research primarily focused on Western ethical frameworks and may not adequately represent diverse cultural perspectives on data stewardship and intergenerational responsibility that could significantly influence global approaches to long-term storage ethics. The rapidly evolving nature of storage technologies means that some technological assumptions underlying the ethical analysis may become obsolete more quickly than anticipated, potentially limiting the long-term relevance of specific recommendations. Additionally, the study's emphasis on organizational and policy-level interventions may underestimate the complexity of implementing ethical frameworks across diverse institutional contexts with varying resources, capabilities, and competing priorities. The research also faces inherent limitations in predicting future

technological developments, social norms, and environmental conditions that will shape the ethical landscape over the extended timeframes central to long-term storage considerations.

Directions for Further Research

Future research should prioritize several critical areas to advance understanding and implementation of ethical long-term data storage frameworks. Cross-cultural studies examining how different societies conceptualize data stewardship, intergenerational responsibility, and digital heritage preservation would provide essential insights for developing truly global ethical standards. Longitudinal studies tracking the actual implementation and effectiveness of proposed ethical frameworks across different organizational contexts would offer valuable evidence for refining theoretical recommendations. Research into emerging technologies such as DNA storage, quantum storage systems, and distributed ledger technologies should examine their unique ethical implications and integration challenges within existing frameworks. Additionally, interdisciplinary collaboration between ethicists, technologists, environmental scientists, and policymakers should focus on developing practical tools and metrics for evaluating ethical compliance in long-term storage decisions. Finally, research into community-based and participatory approaches to data governance could reveal alternative models that better balance individual autonomy with collective stewardship responsibilities across extended timeframes.

CONCLUSION

This study emphasizes that long-term digital data storage presents ethical challenges that are not yet accommodated by conventional frameworks. Five main issues require attention: privacy and security, data ownership and control, accessibility and interoperability, environmental sustainability, and intergenerational social responsibility. A collaborative and adaptive governance model involving multiple stakeholders is needed to ensure that data storage practices are not only focused on short-term compliance but also on long-term sustainability and ethical responsibility. These findings encourage organizations, technology providers, and policymakers to immediately invest in interoperable storage formats, environmentally friendly infrastructure, and transparent data governance systems to ensure that digital heritage is preserved for future generations.

REFERENCES

Adekunle, B. I., Chukwuma-Eke, E. C., Balogun, E. D., & Ogunsola, K. O. (2023). Integrating AI-driven risk assessment frameworks in financial operations: A model for enhanced corporate governance. *International Journal of Scientific Research in Computer Science, Engineering and Information Technology*, *9*(6), 445-464.

Ang'udi, J. J. (2023). Security challenges in cloud computing: A comprehensive analysis. *World Journal of Advanced Engineering Technology and Sciences*, *10*(2), 155-181.

Bandari, V. (2023). Enterprise data security measures: A comparative review of effectiveness and risks across different industries and organization types. *International Journal of Business Intelligence and Big Data Analytics*, *6*(1), 1-11. doi:10.17613/9fer-nw82

Bartram, I. (2025). Unintended social effects of newborn genomic data use and storage in the age of sociogenomics and genetic surveillance. *Ethik in der Medizin*, 1-19.

Bharti, S. S., & Aryal, S. K. (2023). The right to privacy and an implication of the EU General Data Protection Regulation (GDPR) in Europe: Challenges to the companies. *Journal of Contemporary European Studies*, *31*(4), 1391-1402. doi:10.1080/14782804.2022.2130193

Chang, V. (2021). An ethical framework for big data and smart cities. *Technological Forecasting and Social Change*, *165*, 120559. doi:10.1016/j.techfore.2020.120559

Cheng, L., Han, J., & Nasirov, J. (2024). Ethical considerations related to personal data collection and reuse: Trust and transparency in language and speech technologies. *International Journal of Legal Discourse*, *9*(2), 217-235.

Doricchi, A., Platnich, C. M., Gimpel, A., Horn, F., Earle, M., Lanzavecchia, G., . . . Garoli, D. (2022). Emerging approaches to DNA data storage: Challenges and prospects. *ACS Nano*, *16*(11), 17552-17571.

EaseUS. (2025). *White paper EaseUS: 2025 data storage statistics, facts, and trends*. Retrieved from https://www.easeus.com/whitepapers/2025-data-storage-statistics-facts-and-trends.html

Ferretti, A., Ienca, M., Velarde, M. R., Hurst, S., & Vayena, E. (2022). The challenges of big data for research ethics committees: A qualitative Swiss study. *Journal of Empirical Research on Human Research*

Ethics, *17*(1-2), 129-143. doi:10.1177/15562646211053538

Geneva Environment Network. (2024, October 9). The growing environmental risks of e-waste. *Geneva Environment Network*. Retrieved from https://www.genevaenvironmentnetwork.org/resources/updates/the-growing-environmental-risks-of-e-waste/

Gujar, P. (2025). Data standardization and interoperability. In *Data usability in the enterprise: How usability leads to optimal digital experiences* (pp. 89-110). Berkeley, CA: Apress.

Hummel, P., Braun, M., & Dabrock, P. (2021). Own data? Ethical reflections on data ownership. *Philosophy & Technology*, *34*(3), 545-572. doi:10.1007/s13347-020-00404-9

Hummel, P., Braun, M., Tretter, M., & Dabrock, P. (2021). Data sovereignty: A review. *Big Data & Society*, *8*(1), 1-17. doi:10.1177/2053951720982012

Khan, S. (2024). Mapping the digital divide: Bridging inequalities in access to information and technology. *Policy Journal of Social Science Review*, *2*(02), 48-55.

Khando, K., Gao, S., Islam, S. M., & Salman, A. (2021). Enhancing employees information security awareness in private and public organisations: A systematic literature review. *Computers & Security*, *106*, 1-22. doi:10.1016/j.cose.2021.102267

Lescrauwaet, L., Wagner, H., Yoon, C., & Shukla, S. (2022). Adaptive legal frameworks and economic dynamics in emerging technologies: Navigating the intersection for responsible innovation. *Law and Economics*, *16*(3), 202-220.

Marr, B. (2021). *Data strategy: How to profit from a world of big data, analytics and artificial intelligence*. New York, NY: Kogan Page Publishers.

Medina, J., Ziaullah, A. W., Park, H., Castelli, I. E., Shaon, A., Bensmail, H., & El-Mellouhi, F. (2022). Accelerating the adoption of research data management strategies. *Matter*, *5*(11), 3614-3642. doi:10.1016/j.matt.2022.10.007

Monah, S. R., Wagner, M. W., Biswas, A., Khalvati, F., Erdman, L. E., Amirabadi, A., . . . Ertl-Wagner, B. B. (2022). Data governance functions to support responsible data stewardship in pediatric radiology research studies using artificial intelligence. *Pediatric Radiology*, *52*(11), 2111-2119. doi:10.1007/s00247-022-05427-2

Odumuwagun, O. (2025). Future of security in FinTech: Balancing user privacy, compliance, and technological advancements. *International Journal of Research Publication and Reviews*, *6*(1), 1296-1310.

Oladosu, S. A., Ike, C. C., Adepoju, P. A., Afolabi, A. I., Ige, A. B., & Amoo, O. O. (2024). Frameworks for ethical data governance in machine learning: Privacy, fairness, and business optimization. *Magna Scientia Advanced Research and Reviews*, *7*(2), 96–106.

Oloruntoba, O. (2024). Green cloud computing: AI for sustainable database management. *World Journal of Advanced Research and Reviews*, *23*(03), 3242-3257. doi:10.30574/wjarr.2024.23.3.2611

Pardhi, P. R., & Suri, C. S. (2025). Ethical and security measures for environmental data collection. In *Machine learning for environmental monitoring in wireless sensor networks* (pp. 53-92). Hershey, PA: IGI Global.

Rani, S., Bhambri, P., & Kataria, A. (2023). Integration of IoT, big data, and cloud computing technologies: Trend of the era. In *Big data, cloud computing and IoT* (pp. 1-21). Boca Raton, FL: Chapman and Hall/CRC.

Rodriguez, A., Williams, L. J., Lewis, S. C., Sinclair, P., Eldridge, S., Jackson, T., & Weir, C. J. (2025). Evaluating re-identification risks scores in publicly available clinical trial datasets: Insights and implications. *Clinical Trials*, 1-18. doi:10.1177/17407745251356423

Sørensen, E., & Kocksch, L. (2021). Data durabilities: Towards conceptualizations of scientific long-term data storage. *Engaging Science, Technology, and Society*, *7*(1), 12-21. doi:10.17351/ests2021.777

Uohara, E. (2025, March 6). The environmental impact of data centers and artificial intelligence. *Office of Sustainability – Student Blog*. Retrieved from https://usfblogs.usfca.edu/sustainability/2025/03/06/the-environmental-impact-of-data-centers-and-artificial-intelligence/