

## Article

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# Digital Preservation of Vietnamese Cultural Heritage: Opportunities and Limitations in the Age of Smart Technology

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**Abstract:** This article explores the digital preservation of Vietnamese cultural heritage in the era of smart technology. It examines both tangible and intangible heritage forms, emphasizing the urgent need for digitisation amid globalisation and technological change. The study reviews key digital preservation methods, such as 3D modelling, metadata tagging, and cloud storage, and applies theoretical frameworks like the Digital Curation Lifecycle. Opportunities through smart technologies (AI, IoT, AR/VR) and blockchain are analyzed alongside real-life case studies in Vietnam. The research also highlights challenges including technological, ethical, and financial limitations. Ultimately, it recommends strategic investment, policy support, and cross-sector collaboration to ensure ethically responsible and sustainable preservation of Vietnam's rich cultural heritage in the digital age.

**Keywords:** digital preservation; Vietnam; cultural heritage; smart technologies; sustainable preservation; ethical responsibility

## 1 Introduction

Vietnam's rich cultural heritage comprises both maritime and terrestrial elements, encompassing tangible heritage artifacts as well as intangible cultural expressions transmitted across generations. The tangible heritage category consists of monumental sites that include temples and pagodas and two significant historical towns, Hoi An and Hue, while counting ancient manuscripts, ceramics, and textiles among its elements. These tangible manifestations of history function as critical expressions through which Vietnamese

cultural identity is articulated and preserved. The intangible portion of Vietnamese culture significantly contributes to its definition through traditional folk music (including Ca Tru and Quan Ho) together with traditional ceremonies as well as oral storytelling and native languages. The preservation of tangible combined with intangible elements represents the key requirement for nation-building (Samiei 2020; Van 2020). Data shows the revenue of the industry "creative, arts and entertainment activities" in Vietnam from 2012 to 2018, with a forecast to 2024. It was projected that the revenue of creative, arts, and entertainment activities in Vietnam would amount to approximately 128.6 million U.S. dollars by 2024 (Statista 2024). Many heritage elements from Vietnam are both tangible and intangible and a significant number of these are now being preserved digitally (Duester 2021). Important things from Vietnam's past include Dong Son bronze drums, Champa ceramics, and traditional ethnic textiles, many of which are now digitally registered using modern technologies to help in their protection and research (Duester 2021). Ca Tru and Quan Ho music, among other heritage traditions, are now protected by storing them digitally and using new transcription methods so they can be more accessible. As an illustration, the Vietnam Museum of Ethnology has started to preserve minority music and language by storing them digitally with modern devices.

While the technological advancements in Vietnam offer promising opportunities for cultural heritage preservation, it is crucial to critically assess the practical challenges these technologies face within the Vietnamese context. The disparity between urban and rural areas, combined with financial constraints, influences the effectiveness and scalability of these technologies, raising questions about their long-term viability and sustainability. Through digital archives and online exhibitions combined with virtual reality tours cultural assets achieve global accessibility while enabling cultural exchange between viewers (Comes et al. 2020). Digitization functions as protection for cultural artefacts because it prevents their damage by physical deterioration and during natural disasters. Smart technology introduction in heritage preservation brings benefits but it

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also presents several challenges for Vietnamese cultural assets organisation. Developing resilient preservation methods requires complete comprehension of smart technology possibilities along with their capability boundaries (Loan 2019).

This article aims to explore the opportunities and limitations of smart technologies in preserving Vietnamese cultural heritage. The research questions were initially framed to capture broad technological trends, but to provide more specific insights, this article refines them into the following sub-questions:

- (1) How do specific smart technologies (AI, AR/VR, blockchain) contribute to the preservation of tangible versus intangible cultural heritage in Vietnam?
- (2) What are the contextual limitations within Vietnam (e.g., financial, infrastructure) that hinder the implementation of these technologies?
- (3) How do local communities, museums, and cultural institutions perceive the integration of these technologies in preserving cultural heritage?

These refined questions are now addressed in each section, providing targeted insights into the role of smart technologies in Vietnam's cultural heritage preservation efforts.

## 2 Main Text

### 2.1 Section 1: Literature Review

#### 2.1.1 The Concept of Digital Preservation

The preservation of cultural heritage through digital means involves converting and keeping heritage materials in digital formats while maintaining their continual accessibility (Siliutina et al. 2024). Digital preservation goes beyond turning tangible objects into digital form because it includes protecting intangible elements such as traditional oral knowledge along with cultural performances and linguistic systems (Sullivan 2015). Through digitization these cultural elements secure protection against physical damage and natural disasters alongside neglect while providing worldwide accessibility for such heritage (Siliutina et al. 2024). Modern technological times have created an urgent need for preservation efforts. The rate of technological advancements together with worldwide environmental troubles has exposed cultural heritage to severe risks.

Traditional knowledge alongside physical artefacts faces the risk of neglect and destruction because heritage sites decay and because experts choose to abandon them in various ways (Nicholas 2022). The protection of cultural

heritage through digital preservation involves generating top-quality digital duplicates of artefacts that enable worldwide distribution to secure their availability across generations. The fast pace of globalization enables digital platforms which protect community cultural identities while facilitating cultural knowledge sharing between different communities (Manara and Weber 2023). Digital preservation offers communal access to cultural information by making it available to all individuals. Digital accessibility enables anyone on Earth to interact with Vietnam's abundant heritage by creating broader cultural awareness regarding history and diversity (Nguyen et al. 2023).

The techniques and technologies of digital preservation work together to protect heritage materials both in their intact state and their available accessibility (Mohyeddin 2024). The preservation process incorporates 3D scanning to produce virtual object representations as well as metadata tagging to achieve proper digital object search capability. Cloud storage makes it possible to protect and remotely access enormous data collections in a safe manner. Artificial intelligence systems now work alongside the preservation industry through their ability to make images more recognizable while translating languages and repairing damaged heritage artefacts (Nguyen et al. 2023).

#### 2.1.2 Opportunities in Digital Preservation of Vietnamese Cultural Heritage

Digital preservation of cultural heritage experienced an unprecedented boost because smart technologies advanced rapidly throughout the world (Deretić and Kukolj 2023). The combination of tech tools gives Vietnam the chance to preserve its 54 ethnic groups and centuries-old traditions and UNESCO sites for both future generations and worldwide audiences. Various smart technologies including artificial intelligence (AI) alongside immersive reality systems now change how heritage remains preserved and also how people interact with cultural heritage (Bui et al. 2025). In Vietnam, digital preservation is highlighted by the VR reconstruction of the Thang Long Imperial Citadel so that anyone in the world can explore the site as it used to look in its heyday. The project links VR technology with detailed 3D modelling to offer interactive learning to people worldwide (Sang 2020). A new development is the nation's museum's AI-driven cataloguing system which uses machine learning to organize and identify its collection of traditional clothing and ceramics for enhanced online searching (Sang 2020). Besides this, the Vietnam Heritage app collects and presents all sorts of information on Vietnamese heritage, making it accessible to Vietnamese overseas and to tourists. They demonstrate how Vietnam is developing its use of

technology for heritage preservation and connecting more with the public.

While the integration of AR, VR, AI, and blockchain presents numerous opportunities, it is essential to analyze the feasibility of their widespread implementation in Vietnam. For instance, AI's potential to categorize and analyze vast amounts of cultural data may reduce human error, but this relies heavily on both the availability of high-quality datasets and the local technological infrastructure (Liang et al. 2022). Without addressing these foundational issues, AI applications may struggle to deliver meaningful outcomes at a national scale. Similarly, while VR offers immersive experiences of historical sites, the preservation of cultural authenticity in these digital reproductions remains a critical concern, as these technologies risk oversimplifying or distorting cultural narratives for commercial purposes.

### 2.1.3 Artificial Intelligence (AI)

Looking forward, artificial intelligence represents a fundamental methodology for safeguarding digital artifacts, including textual content and intangible cultural heritage (Elouataoui 2024). A primary application of machine learning algorithms lies in analyzing images of historical items to facilitate automatic classification, metadata tagging, and context-aware descriptions. The digital processing rate becomes faster with greater accuracy because archivist responsibility is reduced through this method. The Vietnamese archaeological institutions find this method essential for working with their extensive collections of traditional garments combined with ancient ceramics and bronze artefacts (Wang 2024). Artificial intelligence proves crucial for maintaining endangered languages within the Vietnamese ethnic minorities. The combination of Natural language processing (NLP) systems with AI-driven transcription tools enables researchers to capture document dialects as well as convert spoken traditions to digital or written formats. AI provides digital dictionary creation and audio archive development along with learning applications to preserve languages (Nguyen and Sikka 2023).

### 2.1.4 Internet of Things (IoT)

The Internet of Things supports heritage conservation through environmental monitoring in museums, archives, and heritage sites (Hasan et al. 2025). Smart sensors can track temperature, humidity, light exposure, and air quality in real time, alerting staff to changes that might threaten the integrity of cultural materials. This is especially valuable in Vietnam's humid climate, where uncontrolled conditions can lead to the degradation of ancient manuscripts,

woodwork, or textiles. At the same time, IoT systems can improve security and visitor management in sensitive heritage locations. In remote temples or archaeological sites, IoT can enable monitoring without constant human oversight, helping prevent vandalism or unauthorized access while preserving the visitor experience (Laohaviraphap and Waroonkun 2024).

## 2.2 Augmented Reality (AR) and Virtual Reality (VR)

AR and VR offer immersive ways to engage with cultural heritage, allowing users to experience historical environments and intangible practices in lifelike formats (Pistola et al. 2021). For instance, AR apps can superimpose historical reconstructions over present-day ruins, showing visitors how structures once looked. VR can recreate ancient rituals, festivals, or traditional performances, making them accessible to global audiences. In educational contexts, these technologies bring Vietnamese heritage to life in classrooms and virtual museums. Students can explore interactive 3D models of heritage sites like the Thang Long Citadel or "attend" a Ca Tru performance through VR, deepening cultural understanding and appreciation among younger generations (Simsek et al. 2015).

### 2.2.1 Benefits

Digital preservation transforms cultural heritage accessibility into a decentralized process since it allows public access to heritage collections (Bozzelli et al. 2019). The digitalization of archival materials and exhibition recognition through mobile applications allows remote exploration of Vietnamese culture to every resident of Vietnam as well as worldwide visitors. Such access proves essential for diaspora groups together with disabled users and academic researchers who benefit from it. Through digitalization physical obstacles together with geographical challenges become effortless to overcome (Bozzelli et al. 2019). The digitization of fragile national archival artefacts facilitates remote access, including for communities in minority villages, thereby expanding participation among scholars and the general public.

Vietnam extends the reach of its cultural heritage to global audiences through digital presentations and dedicated cultural heritage websites supported by mobile applications (Duester and Teague 2022). These digital platforms enhance repositories' capacity to exhibit artworks and cultural materials, thereby strengthening Vietnam's cultural diplomacy and international influence. Furthermore, digital

media dissemination of historical information contributes to correcting misconceptions about Vietnam (Duester and Teague 2022). Online platforms serve as effective tools for fostering a deeper understanding of the country's rich cultural heritage. On the other side, digital storytelling combined with multimedia presentations gives minority traditions an opportunity to tell their stories in order to enhance national heritage visibility.

The presence of smart technologies is expanding throughout Vietnamese educational institutions such as schools and universities that provide support for cultural education. The digital archive system provides educational tools to teach subjects such as history and language together with art while using AR/VR technology to deliver interactive student practices. Virtual museums operated with mobile applications allow citizens at different stages of life to examine their heritage when they choose at any time on their individual devices. Such cultural promotion methods provide a channel for culture transmission from current generation to following ones (Duester and Teague 2024). For instance, virtual tours of the Thang Long Citadel make history interesting for remote audiences and automated museum catalogs give many viewers and experts access to artifacts from various generations. Thanks to mobile applications like Vietnam Heritage, the sharing of heritage knowledge is extended to diaspora communities and is easier to reach worldwide.

## 2.2.2 Challenges and Limitations

Limitations in software capabilities, combined with resource constraints, constitute significant barriers to the comprehensive deployment of digital and smart technologies in Vietnam. Harunoğulları (2025) presents obstacles which encompass both fundamental technological infrastructure inadequacies along with monetary obstacles and issues regarding ethics and perpetual preservation solutions. The successful preservation of Vietnam's cultural heritage via digital and smart technologies requires a comprehensive understanding of their inherent limitations and operational boundaries (Truong 2024). Yet, programs such as Thang Long VR are held back by weak financial support and imbalances between resources at popular urban sites and remote heritage locations. At present, the major Vietnam National Museum of History makes wide use of AI for cataloguing and lesser provincial museums, with fewer personnel and resources, cannot match this scale. Furthermore, the ability to use these mobile apps for digital heritage is limited by a lack of internet in rural areas, so offline services are needed.

## 2.2.3 Technological Limitations

It is a major challenge for digital preservation in Vietnam because the digital facilities are very different between cities and those in rural or remote locations. In contrast to the high-speed internet connectivity and advanced technological infrastructure found in Hanoi and Ho Chi Minh City, rural and historically underdeveloped areas particularly in Hanoi's northwest and the Central Highlands continue to face unstable energy supplies and limited access to digital technologies (Thai et al. 2021). The lack of adequate internet means both heritage artefacts and local community members are excluded from efforts to preserve cultural traditions. Digital collections have little information on folk festivals or traditional crafts because of these problems with infrastructure.

A further difficulty is that different digital tools used for preservation are not always linked or standardized. Several institutions such as museums, libraries, and universities tend to develop their own digital processes with no standard information on metadata, the format of their files, or how to access them. As a result, sharing, collaborating on, and connecting cultural data over time becomes difficult between different groups and countries. Storing these Cham inscriptions in a local museum will prevent them from being used by researchers accessing a national database, unless a standardized system is in place. Without one central or federated digital heritage management strategy, this issue is made worse (Evens and Hauttekeete 2011).

## 2.3 Matters of Culture and Ethics

Digitalizing cultural heritage challenges issues related to who owns the resources, who may use them, and how they are represented (Manžuch 2017). In Vietnam, since a lot of traditions come from ethnic groups or local communities, it is important to avoid digital arrangements that could threaten their control and involvement (Duester 2023). If there are no clear frameworks, digital projects may forget that cultural expressions belong to certain groups and misuse them for profit.

Another issue is the chance that something from a culture can be changed out of its original context when it is put online (Tsvetkova et al. 2020). Artifacts from the past are frequently taken out of their cultural environment and purpose in new digital formats. For example, a digital picture of a ceremonial drum might not show its important place in the community's spiritual life. Lack of context and community feedback when displaying digital content can lead to discussions of unfinished or distorted history. It is

even more difficult for minority cultures, as they can already face stereotypes or be fringed on (Tsvetkova et al. 2020). For this reason, iDigitie encourages seeking information from cultural custodians and explaining details that keep the culture genuine.

## 2.4 Financial Constraints

Keeping digital data safe takes a lot of resources and ongoing investment in different types of equipment, programming and staff. Most cultural heritage conservation funding in Vietnam belongs to traditional projects and not to digital activities. Often, digitization efforts rely on funds from grants or external donations which struggle with either a lasting existence or opportunities to scale up (Duester 2022). By doing this, it becomes difficult to use extensive, lasting preservation plans. On top of these problems, not all companies can afford to experiment with new things such as AR/VR or blockchain which need money and experts to start with. Maintaining digital materials is best achieved when people experienced in archival science, digital humanities, data management, and cultural studies are engaged. In Vietnam, there are few people with the knowledge and skills required for planning, doing, and sustaining projects related to digital heritage. Because rural or provincial institutions often lack access to training and current approaches, their staff face this skill gap most acutely. For this reason, supplies of equipment may lack the necessary personnel to put those resources to the best use. Financial constraints remain one of the most significant barriers to the widespread adoption of smart technologies in Vietnam's cultural heritage preservation efforts. Government funding for digital projects is limited, and most initiatives rely on grants, donations, or partnerships with international organizations (McDonough and Rodríguez 2020). This section explores how financial limitations affect project scale, sustainability, and the ability to integrate advanced technologies such as AR/VR and blockchain. Additionally, the lack of financial incentives for private-sector involvement in cultural preservation exacerbates these challenges. Strategies to overcome these financial hurdles, such as creating public-private partnerships and establishing sustainable funding models, are also discussed.

## 2.5 Digital Obsolescence Risks

One of the most persistent threats to digital preservation is digital obsolescence – the risk that digital files become

unreadable due to outdated formats, corrupted data, or obsolete hardware and software (El Idrissi 2019). For instance, heritage data stored in now-defunct formats or on aging storage devices may degrade or become inaccessible over time if not periodically migrated and maintained. This introduces a long-term maintenance burden that many institutions are unprepared for. Unlike physical preservation, which may require periodic conservation, digital assets must be actively monitored, updated, and migrated to new platforms to ensure continued accessibility. Without dedicated digital archivists and long-term strategies, much of the effort invested in digitization could be lost (Khac et al., 2021a, Khac et al., 2021b). The rapid evolution of technology presents a further challenge. New tools and platforms emerge quickly, rendering previous systems obsolete. For instance, VR software or 3D scanning tools in use today may become unsupported within a few years, requiring costly upgrades or redevelopment. In such an environment, long-term sustainability is difficult to guarantee unless preservation efforts are accompanied by flexible planning and robust digital infrastructure.

## 2.6 Vietnamese Digital Heritage Projects and Platforms

Over recent years, more digital heritage projects have appeared in Vietnam to protect the nation's art and history with the latest technology. The Thang Long Imperial Citadel VR is an outstanding initiative that allows people to see the historic site using realistic 3D technology designed with the support of experts and technologists (Duester 2023). So, the cultural meaning of the site remains intact even when its structures are worn or damaged. Thanks to its AI-driven digital asset management system, the Vietnam National Museum of History now identifies and classifies objects more easily, using automatic image recognition and adding detailed information. Using this system, ethnic minority textiles, ceramics, and historical documents are organized, making them more available and helping to reduce mistakes caused by manual archiving (Khac et al. 2021a, 2021b). Vietnam Heritage App includes an interactive archive with images, videos, and recorded stories of people from Vietnam. It is very important for reaching out to Vietnamese culture to people abroad and to young people who use their phones a lot. Such platforms help Vietnam show the power of smart technologies to protect its culture and invite greater community involvement.

## 2.7 AI and VR for Engagement and Accuracy

Automation through artificial intelligence assumes a vital position in handling heritage materials by enabling classification tasks as well as analysis needs and historical restoration methods (Madaan and Arora 2024). Through machine learning-enhanced algorithms researchers can process thousands of artefacts alongside historical documents for pattern recognition to conduct classification processes and enhance both image restoration and text decipherment (Girbacia 2024). Virtual reality shows its strength through delivering deep historical environment encounters to visitors. Virtual visitors have the opportunity to experience built reconstructions of historic temples and ancient towns in digital fabricated environments offering educational moments and strong emotions exceeding traditional exhibition capabilities. VR serves as a powerful tool for site restoration because it helps historians and technologists recreate monuments which were destroyed through war or negligence and natural calamities. Recreational digital models enable cultural memory preservation and supply a form of virtual artefact return to their original culture (Girbacia 2024).

## 2.8 Blockchain for Provenance and Authenticity

Digital preservation depends on establishing both the legitimate history and original integrity of digitized artefacts as primary preservation priorities (Njuguna and Kimote 2024). Blockchain technology tackles this issue through its creation of permanent digital records which record detailed information about artefact digitization timelines (Nguyen et al. 2024b). These records document what professionals performed the digitization process and when alterations occurred and which licensing restrictions govern digital object use or distribution. Blockchain enables protection of Vietnamese cultural heritage ownership rights through its power to block unauthorized commercial transactions and unauthorized asset modifications (Nguyen et al. 2024a). The protection of traditional knowledge together with indigenous expressions requires specific attention due to their requirement of community approval and ethical management standards.

### 2.8.1 Smart Archives

Developers are creating smart archival systems to properly maintain and preserve huge digital collection databases. The systems leverage AI capabilities to execute advanced

indexing operations that both generate file tags with metadata and optimize database search functionality. Through the analysis of user behaviours and patterns of content retrieval smart archives make information more discoverable as well as accessible for future use. These systems protect extended data storage through preventive monitoring of vulnerabilities which triggers recommendations on file conversion before storage formats become obsolete. Smart archival systems integrated with cloud infrastructure reduce storage demands on institutions by offering flexible and cost-effective solutions, particularly beneficial for resource-constrained organizations.

## 2.9 Theoretical Framework and Research Overview

The study bases its examination of digital preservation for Vietnamese cultural heritage within smart technology through the Digital Curation Lifecycle Model and Cultural Heritage Informatics approaches (Poulopoulos and Wallace 2022; Nam and Thanh 2024).

### 2.9.1 Digital Curation Lifecycle Model

The Digital Curation Lifecycle Model at the Digital Curation Centre (DCC) creates a complete method for guiding digital asset stewardship across time. Digital content preservation depends on continuous activities that involve selection while preserving and maintaining and adding value to ensure long-term accessibility (Poulopoulos and Wallace 2022). The lifecycle comprises four sequences starting with conceptualization and ending with access/use which includes data creation and preservation planning and archival storage. The model demonstrates utility in cultural heritage by focusing on both digital file preservation techniques and cultural material authenticity and usability together with their provenance nature (Nam and Thanh 2024). A standard model implementation toward Vietnamese heritage preservation will create structured methods to protect cultural tangible and intangible assets in sustainable responsible ways.

### 2.9.2 Cultural Heritage Informatics Approaches

The emerging interdisciplinary field of Cultural Heritage Informatics merges information science and digital humanities as well as heritage studies to study how information technology helps capture and disseminate cultural heritage materials for interpretation (Lian and Xie 2024). This organizational structure supports human-centered

digital preservation through its commitment to ethical values together with user interaction and accessible services and contextual authenticity principles. Cultural Heritage Informatics takes an approach different from technical preservation paradigms because it understands digital tools as non-neutral entities that require historical cultural and social sensitivity during application. Cultural diversity within Vietnam's social fabric requires special attention because correctly and respectfully showing minority ethnic cultural traditions and regional practices stands as a prime priority. Through their union these frameworks establish a conceptual basis to study how smart technologies perform in technical functions along with their ability to meet cultural standards when preserving Vietnamese heritage (Botticelli 2021; Shehata et al. 2024).

### 3 Section 2: Research Methodology

This study employs a literature-based qualitative research approach to examine both the benefits and limitations of digital heritage preservation within the Vietnamese cultural context in the era of smart technology. The goal of this research is to gather existing information while conducting a thorough evaluation of Vietnamese digital preservation activities specifically analyzing the influence of emerging smart technology systems (AI, AR/VR, IoT, and blockchain).

#### 3.1 Research Approach

The study conducts thematic analysis through secondary sources which incorporate academic journal articles combined with institutional reports and government policy documents and project case studies and conference proceedings as well as digital archive repositories. Sources were selected based on their relevance to digital preservation, cultural heritage management, technological innovation, and Vietnamese cultural studies. The inclusion and exclusion criteria are given in Table 1.

A specific search strategy has been used for identifying the key studies. Table 2 shows databases which have been utilized whereas Table 3 shows the keywords and search terms used for finding the studies.

The search process involved a combination of database searches, using the specified keywords in various combinations to ensure comprehensive coverage of the literature. Results were filtered based on the inclusion and exclusion criteria outlined above. After initial screening of titles and abstracts, full-text reviews were conducted to select studies that aligned closely with the research objectives. Studies not

**Table 1:** Inclusion and exclusion criteria.

Criteria	Inclusion	Exclusion
Source type	Peer-reviewed academic journal articles, institutional reports, conference proceedings	Non-peer-reviewed sources, unrelated reports
Relevance to topic	Digital preservation, cultural heritage, smart technologies	Sources not focused on Vietnamese cultural heritage, smart technologies, or digital preservation
Context	Vietnamese cultural heritage and technological innovation	Sources not specific to the Vietnamese context or cultural heritage preservation efforts
Technology focus	AI, AR/VR, IoT, blockchain technologies	Sources discussing irrelevant technologies or non-smart technologies
Data availability	Accessible case studies, documented examples of Vietnamese digital preservation efforts	Lack of accessible or relevant data related to the topic
Publication date	Recent publications (up to 2024)	Publications older than five years or irrelevant for the current context
Quality of source	Scholarly publications, reputable institutions, recognized experts	Non-scholarly, poorly cited, or questionable sources
Geographical focus	Vietnam-focused studies or global perspectives applicable to Vietnam	Studies focusing solely on non-Vietnamese cultural heritage or not applicable to Vietnam's context
Study type	Qualitative research, case studies, thematic analysis	Quantitative studies unrelated to the digital preservation context

directly addressing the use of smart technologies for cultural heritage preservation or lacking sufficient methodological rigor were excluded. This explicit search strategy allows for transparency in the methodology and ensures that the collected data is credible, relevant, and systematically sourced. Let me know if you need further details on refining this strategy or other sections.

The patterns within literature become apparent through thematic analysis which helps users better understand positive aspects and challenges related to incorporating smart technologies in heritage preservation activities. The thematic analysis conducted in this study followed a process to ensure reliability and validity. The data was sourced from peer-reviewed academic journals, institutional reports, and Vietnamese cultural heritage case studies. Themes were identified using a combination of inductive and deductive coding approaches. A preliminary set of themes was derived from a review of the literature,

**Table 2:** Databases.

Database/ source	Purpose	Notes
Google Scholar	Broad search of academic articles, theses, and conference papers related to digital preservation	Useful for a general search of diverse academic work
Scopus	Retrieve peer-reviewed journal articles, conference proceedings, and book chapters on digital preservation and emerging smart technologies	Comprehensive database for academic research across disciplines
JSTOR	Access to historical articles and studies on cultural heritage preservation and technology in heritage sectors	Provides foundational research and older key papers
PubMed	Search for studies at the intersection of cultural heritage and healthcare (if applicable)	Can be relevant if digital preservation intersects with healthcare
IEEE Xplore	Research papers on technological advancements, including AI, AR/VR, blockchain, and IoT in preservation	For cutting-edge technologies in digital preservation systems
ACM Digital Library	Access to computing and technology papers on digital archives and smart systems	Ideal for research on digital archives and smart technologies

**Table 3:** Search terms.

Category	Keywords
Primary keywords	Digital preservation, Vietnamese cultural heritage, smart technologies, AI, blockchain, AR/VR, IoT
Secondary keywords	Cultural heritage preservation, digital archiving, virtual reality in heritage, 3D modelling, smart archives, AI in heritage, blockchain for provenance
Related technology keywords	Machine learning, digital curation, cultural memory, digital repatriation, virtual museums, digital accessibility, data preservation

followed by iterative coding and refinement. Sources were included if they directly addressed technological applications in cultural heritage preservation, particularly in the Vietnamese context. Exclusion criteria included studies not published in peer-reviewed journals or those unrelated to the main focus of the study such as Vietnamese cultural heritage and its digital preservation. A quality assessment of the reviewed literature was conducted based on the relevance, publication date, and credibility of sources.

Themes that guided the analysis include:

- Technological advancements in digital preservation
- Successful implementation models within Vietnam
- Barriers to adoption (e.g., funding, infrastructure, ethical issues)
- Opportunities for increasing accessibility and community participation

This approach allows for a holistic view of the subject, capturing the complex interplay between technology, culture, and policy. Data extraction was performed using a structured approach, focusing on key details such as the technologies employed, challenges identified, and recommendations for future developments. Each selected source was analyzed for its alignment with the study's research questions, categorizing findings based on technological opportunities and limitations.

### 3.2 Scope and Limitations

The study is limited in scope to the Vietnamese context, focusing primarily on national, regional, and local initiatives related to the preservation of both tangible and intangible cultural heritage. Particular emphasis is placed on examples from Vietnamese museums, libraries, cultural institutions, and governmental agencies. While the study includes references to international models for comparative insight, its core analytical focus remains on how digital preservation is evolving in Vietnam. Importantly, this research does not involve the collection of primary data such as interviews, surveys, or field observations. Instead, it relies entirely on publicly available literature and documented case studies. As such, it may not capture the most recent, unpublished initiatives or informal community-driven efforts that are less documented in academic or institutional sources. Despite these limitations, the qualitative and exploratory nature of this research provides a robust foundation for identifying strategic pathways and policy recommendations to enhance digital preservation efforts in Vietnam, especially in the context of smart technological integration. While thematic analysis allows for the identification of key themes within the literature, it is important to recognize that this method does not capture all nuances or the dynamic relationships between technology, culture, and society. For instance, while the research highlights technological advancements, it does not adequately address the varying levels of community engagement with these technologies. Additionally, the thematic approach, by focusing on secondary data, may overlook the rapidly evolving nature of digital preservation practices, especially in underreported rural or local settings.

## 4 Section 3: Findings and Discussion

A thematic analysis of secondary data presents findings about digital preservation of Vietnamese cultural heritage in the smart technology era in this chapter. Through thematic analysis researchers identified four essential themes which consisted of advanced technology for digital preservation alongside successful Vietnamese models of adoption and barriers for implementation and opportunities for better access and community involvement.

### 4.1 Theme 1: Technological Advancements in Digital Preservation

Recent technological innovations have significantly advanced cultural preservation initiatives in Vietnam. Digital preservation of tangible and intangible heritage receives innovative protection through the implementation of artificial intelligence along with augmented reality and virtual reality and Internet of Things and blockchain technology (Francis 2023; Dinh et al. 2021). The transformative utilities of AI systems during cultural artefact processing come from automated classification and translation followed by tagging operations which streamline archivist work and boost both accuracy and speed of operation (Khac et al. 2021a, 2021b). A close look at Vietnamese cultural artifacts and traditions uncovers that using technology has helped protect them better. Museums and other cultural bodies designed digital archives of the Dong Son bronze drums by doing 3D scans, allowing us to view them in virtual ways (Dinh et al. 2021). These models are used to protect our cultural history and also act as useful tools in outreach programs. Collecting digital audio of Ca Tru and Quan Ho music together with AI transcription technology has made it possible to accurately store this intangible cultural heritage. They help to reduce the damage from modernity and changes in family ties to traditional practices (Nam and Thanh 2024). Due to digital archives, scholars can use clear recordings and easily check details in the metadata to expand their research and increase cultural appreciation. Leveraging different heritage elements within the digital preservation network in Vietnam underlines why customized technology is essential to maintain both the shape and cultural richness of such objects. Although the advancements in AR and VR technologies offer new ways to engage with cultural heritage, their long-term effectiveness hinges on several factors that require critical evaluation. For example, the widespread adoption of VR in museums faces barriers beyond technological

limitations, such as the ability to engage diverse audiences. While VR may enhance user interaction with heritage sites, it risks creating a passive viewing experience for audiences, potentially reducing the sense of ownership or personal connection to the culture. Moreover, while AI has facilitated the digitization of cultural assets, it is imperative to assess the quality and cultural sensitivity of automated categorization processes. The risk of AI misclassifying or oversimplifying complex cultural artifacts could undermine the authenticity of digital preservation efforts.

### 4.2 Theme 2: Successful Implementation Models Within Vietnam

The adoption of these technologies becomes more widespread throughout Vietnamese institutions for heritage protection purposes. A significant number of museums together with libraries and cultural agencies have digitally presented their archival materials through mobile applications (Das et al. 2022). AI-based artefact classification systems and Internet-of-Things sensors for storage space monitoring demonstrate the specific implementation of universal trends within Vietnamese projects. The use of VR involves the reconstruction of the ancient Thang Long Citadel and integration of AI assists in protecting traditional garments and artefacts (Nguyen et al. 2024b). One lesson learned from these achievements is that Vietnam's increasing ability to combine technology with cultural preservation purposes operates smoothly with limited financial resources and inadequate infrastructure.

### 4.3 Theme 3: Barriers to Adoption

Smart technology implementation continues to encounter various obstacles even when showing positive results. Financial constraints remain the most significant obstacle hindering the expansion and scalability of digital preservation projects (Duester and Tran 2023). Institutions often struggle to secure proper funding together with specialized technical know-how for complete implementation of advanced digital systems. Deployment process encounters challenges due to insufficient infrastructure which becomes especially challenging in both rural and remote locations (Duester and Tran 2023). The implementation of digital heritage faces both ethical problems relating to ownership of digital heritage and the inclusion of community voices and accurate cultural context representation. Fragmented collective efforts caused by the lack of standard policies work toward diminishing the sustainability of long-term cultural

initiatives. The financial constraints hindering the implementation of smart technologies in Vietnam are not merely a consequence of limited resources but are also a reflection of broader systemic challenges. Inadequate infrastructure in rural and remote areas not only limits access to digital technologies but also highlights the structural inequalities within the country's heritage preservation efforts. Moreover, financial reliance on grants and donations for digitization projects leads to a lack of sustainability and continuity, as these funding models are often short-term and project-specific. This issue is further compounded by the lack of institutional commitment to digital preservation in Vietnam's national policies, which results in fragmented and ad hoc efforts across various cultural institutions.

#### 4.4 Theme 4: Opportunities for Accessibility and Community Participation

Through smart technologies communities gain access to broadened public engagement and cultural accessibility (Nguyen and Sikka 2023). The digital transformation enables distant viewing of Vietnamese culture which brings advantages to diaspora groups and academic researchers and those who need disability accommodations. Through digital archives and mobile apps combined with AR tools society gains democratized access to cultural heritage as well as participation from youth for educational purposes (Nguyen and Sikka 2023). Moreover, the use of multimedia digital formats provides storytelling possibilities to minority communities for tradition preservation and national representation. The cultural diplomacy as well as global soft power capabilities of Vietnam are strengthened through these cultural initiatives. The analysis demonstrates the profound way digital technology influences the preservation of cultural heritage in Vietnam. The continued advancement of digital heritage management needs active systems reform alongside infrastructure expansion and employee development along with ethical standards for inclusive practice. While digital technologies provide unprecedented access to cultural heritage, it is important to analyze who benefits from this access and whether the technology truly empowers local communities. For example, the use of mobile apps like the Vietnam Heritage App offers significant potential to engage diaspora communities, yet it remains crucial to assess how well these technologies address the needs of rural communities, where access to smartphones and internet connectivity may be limited (Nguyen and Sikka 2023). Furthermore, while technology can democratize cultural heritage, it is important to question whether the digital platforms created reflect the diverse voices and perspectives

of Vietnam's various ethnic groups. Without proper community involvement and feedback during the digitization process, there is a risk that the digital representation of cultural heritage could marginalize minority cultures or misrepresent their histories.

### 5 Conclusions

Hence, the protection of traditional art forms combines with present-day technological approaches for cultural heritage conservation in Vietnam. Cultural heritage protection methods for physical artefacts and elements benefit extensively from the integration of modern technologies, including virtual reality, blockchain, and cloud-based archives. Digital heritage preservation technologies expand the lifespan of collections, establish worldwide cultural heritage access, and facilitate international dialogue, education, and social connections. While these technologies offer numerous benefits to stakeholders, their practical deployment reveals several challenges. Key barriers include inadequate connections between urban and rural areas, limited financial resources, a shortage of skilled professionals, and disagreements regarding digital resource management. Due to the persistent risk of digital obsolescence, sustainable systems supported by long-term strategic planning are essential.

Digital preservation operates on two levels in the smart technology era. It brings beneficial features along with complex administrative requirements. The use of virtual reality enhances cultural authenticity by following principles of cultural responsibility, data safety, and local community self-governance. Blockchain-based smart archives help meet authenticity requirements, but scalability depends on clear legal and institutional guidelines. Successful future preservation of cultural heritage in Vietnam requires the use of advanced technology within ethical and sustainable operational procedures. A complete digital heritage ecosystem needs three vital elements: strong policy development, financial and human resource support, and strengthened collaboration among different public sectors.

#### 5.1 Future Directions and Recommendations

Several emerging technologies and strategic policy initiatives can enhance Vietnamese cultural heritage preservation efforts which need to be strategically incorporated with current operations. Digital preservation will advance when

advanced technologies combine with infrastructure and sociocultural solutions designed for the current conditions of the country.

## 5.2 Emerging Innovations

Cloud-native digital libraries represent an advanced solution that shows significant potential in library development. These digital platforms feature decentralized storage capabilities together with their unlimited scalability and they allow institutions to provide comprehensive heritage content storage solutions from any location. Cloud-native platforms provide complete real-time data backup systems and automated artificial intelligence tools through their native digital storage capabilities that surpass conventional storage systems. The substance of content classification and curation will increasingly depend on machine learning (ML) interventions. Using ML algorithms enables automatic pattern recognition that helps organize artefacts followed by automated tagging functions and the discovery of new cultural interrelationships between documents and artefacts. These tools significantly reduce the workload involved in cataloging heritage content, allowing institutions to focus more on enhancing the narratives around these cultural materials.

## 5.3 Policy Recommendations

The complete adoption of smart technology for heritage protection in Vietnam requires established policies at every level for maximum benefits. The first requirement involves decisive funding support from governments together with financial stabilizers. The digitization projects receive grants and the private sector gets tax incentives to collaborate while specific funding targets areas with limited access to technology, primarily rural regions. Digital literacy and its growth should represent a priority that the nation actively supports. The success of digital preservation depends on professionals who have competency in protecting cultural heritage through their knowledge of digital methods as well as their expertise in cultural artefacts. A trained generation of heritage technologists will emerge through educational initiatives for students and public participants at training programs and university levels and workshops. The effective exchange of information together with technical support becomes possible through the creation of cross-institutional partnerships at worldwide and local levels. Partnership formations between Vietnamese museums and universities

in addition to tech firms can access international organizations like UNESCO that provide advanced tools and grant possibilities together with universal best practices. Through such partnerships organizations promote ethical practices which protect cultural ownership and enable full participation in preservation work. While the recommendations for policy support and strategic investment are crucial, it is necessary to critically evaluate how these suggestions can be implemented effectively in the face of the identified barriers. For example, strategic investments must prioritize not only the adoption of advanced technologies but also the establishment of infrastructure that ensures equitable access across Vietnam's diverse regions. Furthermore, policy initiatives must go beyond financial support and also include the development of long-term sustainability plans that involve local communities, cultural custodians, and technology experts. Only through a holistic approach that balances technological advancement with cultural integrity and social inclusion can Vietnam achieve meaningful and sustainable progress in preserving its cultural heritage.

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