A Theory-Informed Conceptual Framework for Sustainable Intangible Cultural Heritage Preservation in the Digital Era through Immersive Information Systems

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Abstract

The preservation of Intangible Cultural Heritage (ICH) faces significant challenges in the digital age, particularly regarding authentic representation, technology acceptance, and sustainability. This research aims to develop a theory-informed conceptual framework to support ICH preservation through immersive information systems. The approach used was conceptual, with a systematic literature review, theory synthesis, and framework development. The literature analyzed included cultural preservation theory, the Technology Acceptance Model (TAM), the User-Centered Design (UCD) approach, and the Culturally Appropriate Design Guidelines (CADG). The research results produced a framework consisting of three main dimensions: Cultural Appropriateness, Technological Acceptance, and Sustainability. These three dimensions lead to the development of Immersive Information Systems that incorporate VR, AR, and AI technologies as key enablers for the documentation, dissemination, and intergenerational transfer of cultural knowledge. The literature synthesis indicates that community engagement, user acceptance of technology, and social, technological, and economic sustainability strategies are key pillars of ICH preservation in the digital age. As an illustration, the case of the Toba Batak demonstrates how immersive technology can be used to document local cultural practices such as tortor, gondang sabangunan, and ulos. The study's conclusions emphasize that ICH preservation cannot be separated from the integration of preservation theory, technology adoption, and sustainable design. The resulting framework provides both theoretical contributions by broadening the horizons of cultural preservation studies and practical contributions as a guide for the ethical, inclusive, and sustainable implementation of immersive technology.

Keywords : Intangible Cultural Heritage; Digital Preservation; Immersive Information Systems; Cultural Appropriateness; Technology Acceptance Model; Sustainability.

I. INTRODUCTION

Intangible Cultural Heritage (ICH) is a crucial pillar in shaping a society's collective identity, encompassing practices, expressions, knowledge, and skills passed down across generations. These values not only reflect cultural diversity but also serve as the foundation for the sustainability of traditions and social cohesion amidst the dynamics of modernity. Academic attention to ICH preservation is increasing in line with the challenges of globalization and digitalization, where non-material cultural practices are often more vulnerable to loss than tangible heritage such as artifacts or buildings (Abdul Aziz et al., 2022; Rahayu & Suryono, 2020). Globalization drives cultural homogenization, while modernization brings lifestyles that tend to displace traditional practices from everyday social spaces. Therefore, ICH preservation requires a new approach that focuses not only on documentation but also on the

sustainability of practices and adaptation to the digital context. Within this framework, the integration of digital technology, particularly immersive information systems, is a potential strategy to ensure that living traditions remain relevant and can be passed on to future generations (Hou et al., 2022; Wu & Liang, 2023).

Digital transformation offers significant opportunities for the preservation of ICH through broader documentation, dissemination, and knowledge transfer mechanisms. Immersive technologies such as Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) can provide multisensorial experiences that approximate real-life interactions with cultural traditions, thereby enhancing user engagement (Sun, 2025; Zhao et al., 2024). However, these opportunities are accompanied by serious challenges related to cultural sensitivity and the authenticity of representation. The literature emphasizes that the

preservation of ICH in digital formats must respect the values, meanings, and contexts of the communities of origin to avoid falling into the trap of cultural commodification (Huang & Gu, 2020; Zhong & Rui, 2022). Digital preservation efforts that fail to consider cultural sensitivity risk producing inauthentic representations, potentially even eroding the symbolic meaning of the tradition itself (Chiquet, 2023). Therefore, digitalization should not be viewed solely as a technical process, but rather as a participatory strategy that engages communities, ensuring they remain the owners and guardians of the tradition (Morozova & M. Morozov, 2018).

In addition to cultural sensitivity, sustainability is a key dimension in ensuring the continuity of ICH in the digital age. Sustainability here relates not only to environmental issues but also encompasses social, technological, and economic sustainability (Jacqueline Kiwa et al., 2023; Pan, 2024). In a social context, sustainability is characterized by active community and intergenerational participation in preserving traditions. From a technological perspective, the information systems used must be adaptive, inclusive, and able to withstand new technological developments (Pendergrass et al., 2019; Yang & Wu, 2016). Meanwhile, from an economic perspective, sustainability requires strategies that allow cultural practices to remain financially valuable without losing their cultural significance (Borin & Donato, 2023; Yeniasır & Gökbulut, 2022). Studies confirm that sustainability in cultural preservation requires a holistic approach that simultaneously integrates social, technological, and economic dimensions (Fenlon et al., 2023; Kim & Lee, 2019). Thus, the success of digital-based ICH preservation is only possible if sustainability is made a key principle in the design and implementation of immersive information systems.

Technology adoption in ICH preservation cannot be separated from the perspective of user acceptance, as explained in the Technology Acceptance Model (TAM), which emphasizes factors such as perceived ease of use, usefulness, and behavioral intention (Davis, 1989; F. Li et al., 2024) In the context of cultural preservation, research shows that younger generations tend to be more receptive to immersive technology when the application is easy to use and has educational value (Liu, 2020). AR and VR have been shown to enhance learning experiences while expanding interactions with cultural heritage (Wang et al., 2024; Zhao et al., 2024). However, the level of acceptance is also influenced by the cultural context, where the technology's compatibility with social norms and expectations is a crucial factor ((J. Li & Kim, 2024). Thus, the success of an immersive information system for ICH preservation is determined not only by technical excellence, but also by the extent to which the technology is perceived as relevant, useful, and aligned with the cultural values of the

user community (Naeem et al., 2022; Suyuti & Setyanto, 2023).

The sustainability and cultural sensitivity dimensions of ICH preservation are also closely related to a participatory system design approach. User-Centered Design (UCD) ensures that user needs and preferences inform system development, while Culturally Appropriate Design Guidelines (CADG) emphasize the importance of design alignment with the local cultural context (Enwin, 2024; Mensah, 2021). This approach emphasizes that digital preservation is not simply a technical issue, but rather a collaborative process that must involve various stakeholders, including traditional communities. Community participation not only enhances the authenticity of representation but also strengthens a sense of ownership of the information system being developed (Rachman, 2024). Studies on accessibility and inclusivity in cultural heritage spaces show that community involvement contributes to the creation of more equitable, representative, and sustainable systems (Al-Belushi & Al-Hooti, 2023; Chauhan & Anand, 2021). Thus, UCD and CADG provide crucial theoretical and practical foundations for developing a conceptual framework for immersive systems-based ICH preservation.

Advances in immersive technology are opening up new opportunities for the documentation, dissemination, and transfer of cultural knowledge. VR can reconstruct cultural narratives in near-realistic virtual experiences (Theoulaki, 2024), AR allows information to be overlaid on physical sites, enriching user interaction (Lu, 2025), and AI offers the potential for artificial intelligence-based interactive storytelling (Sun, 2025). Various studies have confirmed the effectiveness of immersive technologies in enhancing users' emotional and educational engagement with cultural heritage (D. Chen, 2024; Selmanović et al., 2020). However, challenges remain, including high costs, the need for technical skills, and the risk of cultural misrepresentation (Marco Ferrari & Lodovica Valetti, 2021; Oladokun et al., 2024). Therefore, the role of immersive systems should be understood not as a single solution, but as part of a broader preservation ecosystem, requiring interdisciplinary collaboration and community engagement.

Although the literature has extensively discussed aspects of digitalization, cultural sensitivity, sustainability, and technology adoption in the context of ICH, significant research gaps remain. First, existing research tends to address each aspect separately, for example, focusing on immersive technology without integrating socio-economic sustainability principles, or emphasizing cultural sensitivity without considering technology acceptance. Second, theoretical frameworks that combine Cultural Appropriateness, Technology Acceptance, and the Sustainability Dimension are still rare in the literature, even though this integration

is crucial for ensuring the long-term effectiveness of immersive information systems in cultural preservation. The novelty of this research lies in the development of a theory-based conceptual framework that not only combines these dimensions but also positions immersive information systems as a key enabler in bridging theory and practice. Thus, this research contributes both theoretically—by expanding the study of cultural preservation through an information systems perspective—and practically—by offering design guidance for policymakers, cultural institutions, and local communities.

Based on the description above, this research aims to develop a theory-based conceptual framework that can serve as a reference for the sustainable preservation of Intangible Cultural Heritage through the use of immersive information systems. This framework is designed to ensure that cultural digitization is carried out sensitively to local values, is widely accepted by users, and is sustainable in social, technological, and economic dimensions. By integrating cultural preservation theory, the Technology Acceptance Model (TAM), User-Centered Design (UCD), and Culturally Appropriate Design Guidelines (CADG), this research aims to offer a comprehensive approach that can address the challenges of cultural preservation in the digital age. The research problem is: How can we develop a theory-based conceptual framework that can guide the sustainable preservation of Intangible Cultural Heritage through digital immersive information systems?

II. RESEARCH METHODOLOGY

This research uses a qualitative approach with an integrative conceptual design to develop a theoretical framework that can serve as a reference for preserving Intangible Cultural Heritage (ICH) through immersive information systems. This approach was chosen because the issue of ICH preservation in the digital age requires a multidimensional synthesis that encompasses not only cultural preservation theory but also technology adoption and sustainability. As stated by Abdul Aziz et al. (2022), without active community involvement, ICH risks becoming obsolete. Therefore, this study adopts the concept of living heritage (Jacqueline Kiwa et al., 2023), which emphasizes the sustainability of cultural practices in a contemporary context. This conceptual approach allows researchers to utilize literature reviews to formulate theoretical dimensions such as Cultural Appropriateness, the Technology Acceptance Model (TAM), User-Centered Design (UCD), and Culturally Appropriate Design Guidelines (CADG), which are then integrated into a coherent conceptual framework.
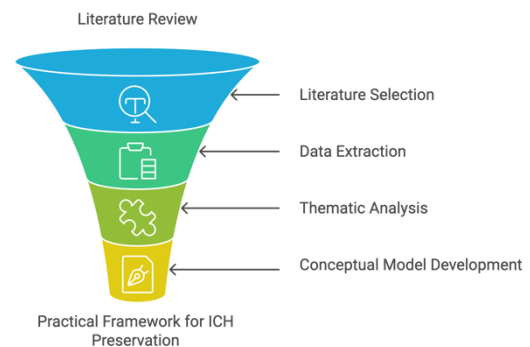

Figure 1. Developing a Conceptual Framework for ICH Preservation

The research process began with a systematic literature review to identify relevant publications on the topics of ICH preservation, sustainability, and the application of immersive technology. Literature was selected based on recency, relevance to the research issue, and a focus on reputable academic publications. For example, Wu & Liang (2023) highlight the potential of multisensory digital interfaces to strengthen user engagement in ICH preservation, while Hou et al. (2022) emphasize the importance of a comprehensive approach to digitizing cultural narratives. Sustainability studies were also a key part of the literature selection, as demonstrated by Pan (2024) regarding digital strategies for building cultural resilience, and G. Chen (2023) who emphasized the need to include community voices in the digitization process. This approach ensured that the literature used supported the development of a comprehensive theoretical framework.

The second stage was theory synthesis, which brought together the theories and models mapped in the literature to build a more integrative understanding. Cultural Heritage Preservation Theory emphasizes the importance of cultural sensitivity in digital representations (Huang & Gu, 2020; Zhong & Rui, 2022), while the Technology Acceptance Model (TAM) provides a framework for understanding factors of technology acceptance, such as perceived ease of use and usefulness (F. Li et al., 2024; Liu, 2020). The TAM perspective is increasingly relevant given the findings of Zhao et al. (2024) and Wang et al. (2024), which assert that immersive experiences can enhance user acceptance of technology within a cultural context. Furthermore, User-Centered Design (UCD) and Culturally Appropriate Design Guidelines (CADG) emphasize the importance of community participation and inclusivity in system design (Ariffin et al., 2018; Enwin, 2024; Mensah, 2021). This participatory approach is supported by Rachman (2024), who emphasizes the importance of community-based

initiatives, and Al-Belushi & Al-Hooti (2023), who highlight accessibility as an inclusive element in digital cultural preservation.

The third stage is framework development, which is carried out by mapping the core components and inter-dimensional relationships from the results of the theoretical synthesis. This conceptual framework consists of three main components: Cultural Appropriateness, Technological Acceptance, and the Sustainability Dimension. These three components synergize in the development of Immersive Information Systems as the main driver of cultural preservation. The Cultural Appropriateness component is guided by the principles of authentic representation and community participation (Cox, 2022; Howell, 2022), while Technological Acceptance is supported by TAM studies on VR and AR adoption (Lai et al., 2025; Naeem et al., 2022; Suyuti & Setyanto, 2023). The sustainability dimension encompasses social, technological, and economic aspects as explained by Fenlon et al. (2023), Yang & Wu (2016), Borin & Donato (2023), and Yeniasır & Gökbulut (2022). The integration of all these dimensions allows the framework to be not only theoretically relevant but also applicable to support cultural preservation practices in the digital age.

The scope of this research focuses on ICH preservation in a global context, with the option of illustrating the example of the Toba Batak. This case study is illustrative to demonstrate how the conceptual framework can be applied to specific cultural contexts, as suggested by Zhang (2023) regarding the role of digital platforms in connecting communities with their heritage. With this approach, the resulting framework is not only universally applicable but also sensitive to local characteristics. Therefore, this research methodology emphasizes continuity between literature, theory, and practice, with the principles of transparency and systematicity, so that it can be replicated by other researchers in developing

III. RESULTS AND DISCUSSION

A. Results

This research produces a literature synthesis, conceptual dimension mapping, and a draft framework for the preservation of Intangible Cultural Heritage (ICH) through immersive information systems. The research results are presented in three main sections. First, the results of the literature synthesis summarized in tables to show the contribution of previous research on each dimension. Second, the results of the conceptual framework that summarizes the interconnections between the dimensions of Cultural Appropriateness, Technological Acceptance, Sustainability Dimension, and Immersive Information Systems. Third, an illustration of the Toba Batak case as an applicable example to provide an overview of the framework's application in a specific cultural context.

1. Literature Synthesis

The results of the literature synthesis indicate that the issue of preserving ICH in a digital context emphasizes three main pillars: cultural appropriateness, technological acceptance, and sustainability. In the Cultural Appropriateness dimension, research confirms that community involvement is a vital element. Abdul Aziz et al. (2022) emphasize that without community participation, ICH risks losing its meaning, while Rahayu & Suryono (2020) emphasize the importance of synergizing traditional and digital media to maintain authenticity. Zhong & Rui (2022) highlight the risk of misrepresentation in cultural digitization, while Morozova & M. Morozov (2018) emphasize the role of communities as primary guardians of cultural narratives.

In the Technological Acceptance dimension, the literature confirms the relevance of the TAM model to explain technology acceptance. F. Li et al. (2024) emphasize ease and usability as drivers of immersive system adoption. Liu (2020) found that younger generations are more open to digital interpretations of heritage sites. Wang et al. (2024) showed that AR increases user intention to purchase cultural products, while Zhao et al. (2024) emphasize that VR enriches authentic experiences and strengthens users' perceptions of authenticity.

The Sustainability Dimension encompasses social, technological, and economic aspects. Jacqueline Kiwa et al. (2023) introduce the concept of living heritage, emphasizing the adaptation of traditions to new contexts as an effort for social sustainability. Pan (2024) emphasizes digital strategies that build the long-term resilience of traditions. Borin & Donato (2023) point out that financial challenges remain a major barrier to cultural digitalization, while Yeniasır & Gökbulut (2022) highlight the potential of digitalization to support cultural tourism as an economic aspect.

The Immersive Information Systems dimension is examined as a key driver in bridging the three previous dimensions. Zhao et al. (2024) and Sun (2025) demonstrate that VR and digital storytelling strengthen emotional connectedness and intergenerational knowledge transfer. Lu (2025) finds that AR enhances interactivity in museums by combining physical and digital aspects. Marco Ferrari & Lodovica Valetti (2021) warn of the ethical risks of VR/AR use that need to be anticipated, while Oladokun et al. (2024) emphasize the need for multi-stakeholder collaboration to avoid cultural misrepresentation.

The following table summarizes the results of the literature synthesis:

Table 1. Literature Synthesis

Dimensions / Themes	Author and Year	Research Focus	Contributions to the Framework
Cultural Appropriateness	Abdul Aziz et al. (2022)	Community involvement in ICH preservation	Emphasizing the importance of community participation
	Rahayu & Suryono (2020)	Synergy of traditional and digital media	Maintaining a balance of authenticity and innovation
	Zhong & Rui (2022)	The risk of misrepresentation in the digitalization of culture	The importance of cultural sensitivity
	Morozova & M. Morozov (2018)	Community engagement practices	Community as the primary guardian
Technological Acceptance	F. Li et al. (2024)	TAM: PEOU & PU	The basis for adopting immersive systems
	Liu (2020)	Digital interpretation at heritage sites	The younger generation is more accepting of technology
	Wang et al. (2024)	AR increases the intention to purchase cultural products	Immersion increases acceptance
	Zhao et al. (2024)	VR enriches the authentic user experience	Strengthening the authenticity factor
Sustainability Dimension	Jacqueline Kiwa et al. (2023)	Living heritage & cultural practices in new contexts	Supporting social sustainability
	Pan (2024)	Digital strategies for traditional resilience	Long-term sustainability aspects
	Borin & Donato (2023)	The financial challenges of digitalizing culture	Aspects of economic sustainability
	Yeniasır & Gökbulut (2022)	Digitalization for cultural tourism	Economic & tourism potential
Immersive Information Systems	Zhao et al. (2024); Sun (2025)	VR & digital storytelling enhance emotional experiences	Intergenerational knowledge transfer media
	Lu (2025)	AR adds interactivity to museums	Physical-digital blending
	Marco Ferrari & Lodovica Valetti (2021)	Ethical risks in the use of VR/AR	The need for an ethical framework
	Oladokun et al. (2024)	The need for stakeholder collaboration	Avoiding cultural misrepresentation

2. Conceptual Framework

Based on the literature synthesis, this research produces a conceptual framework that positions theory as the primary foundation for each dimension of Intangible Cultural Heritage preservation. Three key theories are used to develop the framework's primary dimensions: Cultural Heritage Preservation Theory, the Technology Acceptance Model (TAM), and a combination of User-Centered Design (UCD) and Culturally Appropriate Design Guidelines (CADG). These three theories each serve as a foundation that informs a different conceptual dimension, ultimately leading to the development of Immersive Information Systems as the primary driver of sustainable ICH preservation.

Cultural Heritage Preservation Theory directly underpins the Cultural Appropriateness dimension. This theory emphasizes that the preservation of intangible cultural heritage cannot be separated from the social context, community values, and authenticity of inherited practices. Therefore, the Cultural Appropriateness dimension within this framework focuses on the importance of culturally sensitive digital representation, avoiding misrepresentation, and ensuring active community involvement in the digitization process. Thus, cultural preservation theory provides both academic legitimacy and an ethical framework for the development of immersive systems.

Furthermore, the Technology Acceptance Model (TAM) serves as the foundation for the Technological Acceptance dimension. This model explains the psychological factors that influence technology acceptance, particularly perceived ease of use and perceived usefulness. In the context of ICH preservation, this dimension ensures that immersive technologies such as VR, AR, and AI can be truly adopted by users, both within cultural communities and the wider public. By integrating the TAM, this framework focuses not only on the availability of technology but also on the social

acceptance factors that determine the success of its implementation.

The third dimension, the Sustainability Dimension, is supported by User-Centered Design and Culturally Appropriate Design Guidelines. Both approaches emphasize the importance of user involvement at every stage of system development and the need to ensure that the resulting design aligns with the values, practices, and needs of the community. Sustainability encompasses social, technological, and economic aspects, ensuring that the immersive system developed is not only relevant at a given time but also adapts to changing times and supports the community's long-term sustainability.

These three dimensions then converge in Immersive Information Systems, which act as integration nodes. Immersive systems are positioned as key enablers, uniting cultural sensitivity, technology acceptance, and sustainability within a digital ecosystem. Thus, VR, AR, and AI are viewed not merely as documentation tools, but as mediums that enable authentic, inclusive, and sustainable dissemination, education, and intergenerational knowledge transfer.
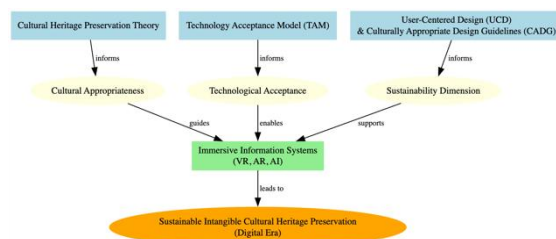
The framework visualization is as follows:

Figure 2. Proposed Conceptual Framework of ICH Preservation Immersive Information System

This framework emphasizes that theory serves as the foundation that informs each dimension, while Immersive Information Systems act as the central node that integrates all dimensions to support the sustainable preservation of ICH.

3. Case Illustration: Toba Batak

To illustrate the application of the framework, this study highlights Toba Batak traditions, specifically the practice of tortor, gondang sabangunan music, and ulos cloth. These traditions play a central role in both traditional rituals and daily life, but face challenges such as declining interest among younger generations, urbanization, and the pressures of modernization. These challenges align with the findings of Jacqueline Kiwa et al. (2023) regarding the importance of adapting cultural practices to new contexts as part of the concept of living heritage.

Within this conceptual framework, immersive systems can play a significant role. For example, documenting tortor through VR can enable young people to learn dance movements through interactive experiences. AR can be used to showcase the symbolic meaning of ulos cloth in educational contexts in museums or schools. Meanwhile, AI can be applied to develop digital storytelling that tells the origins of gondang sabangunan. This approach aligns with literature emphasizing the potential of VR, AR, and AI in strengthening emotional connection and knowledge transfer (Lu, 2025; Sun, 2025). Thus, the illustration of the Toba Batak case provides a concrete picture of how the conceptual framework can be applied to the preservation of local culture.

4. Summary of Results

Overall, this research presents three main outcomes. First, the literature synthesis emphasizes the importance of community engagement, technology acceptance, and sustainability as pillars of ICH preservation in the digital age. Second, the developed conceptual framework visualizes the relationship between theoretical dimensions and immersive systems as the primary drivers. Third, the Batak Toba case illustration demonstrates the potential application of the framework in a local context, demonstrating the framework's relevance both universally and contextually. These results provide a strong foundation for further discussion of theoretical contributions, practical implications, and policy implications, which will be elaborated in the discussion section.

B. Discussion

1. Integration of Theory and Practice in Intangible Cultural Heritage (ICH) Preservation

The results of this study demonstrate how key theories can be integrated into a conceptual framework focused on the preservation of Intangible Cultural Heritage (ICH) in the digital era. The use of Cultural Heritage Preservation Theory, Technology Acceptance Model (TAM), User-Centered Design (UCD), and Culturally Appropriate Design Guidelines (CADG) as theoretical foundations demonstrates that cultural preservation cannot be viewed solely as a technical issue of digitalization, but rather as a multidimensional process involving social, psychological, and cultural aspects. Abdul Aziz et al. (2022) emphasize the importance of community involvement, while Rahayu & Suryono (2020) highlight the need for synergy between traditional and digital media. These results align with the developed framework, which positions Cultural Appropriateness as a core dimension, as the success of cultural heritage digitization depends on the authenticity of representation and respect for community values.

This framework also demonstrates the relevance of TAM in explaining technology acceptance. Ease of use and usability, as outlined by F. Li et al. (2024) and Liu (2020), are key determinants in encouraging users to adopt immersive systems. This is crucial because

technologies like VR and AR will only be effective if they are accepted and used by the target community. Thus, these findings reinforce previous literature emphasizing the importance of user psychological factors in the context of digital cultural preservation (Wang et al., 2024; Zhao et al., 2024). The integration of these theories produces a framework that is not only descriptive but also normative, providing guidance on how ICH preservation should be conducted in the digital age.

2. Significance of the Cultural Appropriateness Dimension

The Cultural Appropriateness dimension in this conceptual framework reaffirms literature findings on the importance of maintaining cultural sensitivity. Zhong & Rui (2022) highlight the dangers of misrepresentation in cultural digitization, which has the potential to transform the original meaning of cultural heritage into mere commodities. These findings are consistent with Morozova and Morozov (2018), who emphasize the role of communities as guardians of narrative authenticity. This framework contributes by emphasizing that Cultural Appropriateness is not simply an additional variable, but rather a core foundation flowing from Cultural Heritage Preservation Theory.

The Toba Batak context provides a concrete illustration: the practice of tortor or gondang sabangunan holds profound spiritual and social significance, so documentation through VR or AR should not be conducted solely as a visual reconstruction, but rather must involve the indigenous community in determining the form of representation. This reinforces the concept of living heritage (Jacqueline Kiwa et al., 2023), where traditions are viewed as living, evolving practices, not static artifacts. Thus, this framework broadens the discourse on cultural preservation by emphasizing the active role of communities while bridging theory and practice through immersive technology.

3. Technology Acceptance and the Relevance of TAM

The research findings also reinforce the significance of Technological Acceptance in the context of ICH preservation. The literature review indicates that VR and AR offer significant opportunities for increasing user engagement, but the success of their implementation depends heavily on the acceptance of the technology. Liu (2020) noted that younger generations demonstrate a higher openness to digital interpretation, while Wang et al. (2024) and Zhao et al. (2024) emphasized that immersive experiences can increase user interest and perceptions of authenticity. This confirms the validity of TAM as a relevant theoretical framework for this study.

The developed framework positions Technological Acceptance as one of the key dimensions leading to the development of Immersive Information Systems. The theoretical contribution of this study is to expand the application of TAM to the realm of cultural preservation, a relatively new area compared to other technology adoption contexts such as e-learning or e-commerce. Thus, this study not only confirms existing theory but also broadens its scope of application to the interdisciplinary realm of information technology and cultural studies.

4. Sustainability as a Pillar of Preservation

The sustainability dimension adds important depth to this conceptual framework. Pan (2024) highlights the importance of digital strategies for building cultural resilience, while Borin and Donato (2023) emphasize the financial challenges that are often a major barrier to cultural digitalization. Yeniasır and Gökbulut (2022) demonstrate how digitalization can support cultural tourism, thereby providing added economic value. These findings are consistent with the views of Fenlon et al. (2023), who stated that social sustainability is also crucial for maintaining community cohesion through digital platforms.

The developed conceptual framework strengthens this literature by positioning sustainability as a core dimension flowing from UCD and CADG. In this way, the framework ensures that the design of immersive systems is not only technologically adaptive, but also socially inclusive and economically viable. A key contribution of this research is emphasizing the close relationship between participatory design and sustainability, where communities become not only users but also managers and owners of their own cultural knowledge.

5. The Role of Immersive Information Systems as an Enabler

Research findings emphasize the central role of immersive information systems in bridging the theoretical and practical dimensions of cultural preservation. Studies by Zhao et al. (2024) and Sun (2025) demonstrate that VR and digital storytelling can strengthen the emotional connection between users and cultural heritage. Lu (2025) adds that AR can enhance museum visitor interactivity, while Ferrari and Valetti (2021) warn of ethical risks in its implementation. Oladokun et al. (2024) emphasize that cross-stakeholder collaboration is essential to prevent cultural misrepresentation.

This framework synthesizes all these findings by positioning immersive systems as a point of convergence for the dimensions of Cultural Appropriateness, Technological Acceptance, and Sustainability. This provides a theoretical contribution by demonstrating that immersive systems are not merely technical tools, but ecosystems that represent cultural values, are widely accepted, and are sustainable in the long term.

6. Theoretical and Practical Contributions

Theoretically, this research broadens the horizons of cultural preservation studies by introducing a conceptual framework informed by interdisciplinary theory. The primary contribution is the integration of cultural preservation theory, TAM, and UCD/CADG into a coherent framework. This framework provides a basis for further research that can empirically test the relationships between these dimensions.

Practically, this research provides guidance for stakeholders—including government, cultural institutions, and communities—in designing sustainable immersive information systems. For example, local governments can use this framework as a reference for cultural digitization policies, while local communities can use it to maintain the authenticity of their traditions in the digital space. The illustrative case of the Toba Batak demonstrates how the framework can be applied to local contexts, demonstrating its strong practical relevance.

7. Research Implications

The implications of this research can be seen from three aspects. First, academic implications: this framework opens up interdisciplinary research that combines cultural studies, information technology, and human-centered design. Second, practical implications: the framework can serve as a guideline for implementing immersive technology in cultural preservation projects, while helping to avoid the risk of misrepresentation. Third, policy implications: the results of this research can be used by policymakers to formulate cultural digitalization strategies that are sensitive to community values, encourage technology adoption, and ensure financial and social sustainability.

8. Research Limitations

While this research makes significant contributions, there are several limitations that should be noted. First, this research is conceptual in nature and therefore has not yet tested the framework empirically. Empirical testing is needed to ensure the validity of the relationships between dimensions in real-world contexts. Second, the scope of the literature used is limited to specific publications, so there may be other perspectives that have not been covered. Third, the Batak Toba case illustration is descriptive and optional, so more in-depth field research is needed to test the framework's applicability to specific cultures.

9. Discussion Summary

This discussion confirms that the developed framework successfully synthesizes theory and practice in ICH preservation in the digital age. By placing Cultural Appropriateness, Technological Acceptance, and Sustainability Dimensions as the foundation leading to Immersive Information Systems, this research makes significant theoretical and practical contributions. These results expand the existing literature, emphasize the importance of community participation, technology acceptance, and sustainability in cultural preservation, and offer practical guidance for the ethical and sustainable implementation of immersive technology.

IV. CONCLUSION

This research produces a theory-informed conceptual framework for the sustainable preservation of Intangible Cultural Heritage (ICH) through immersive information systems. This framework is constructed by integrating three main dimensions Cultural Appropriateness, Technological Acceptance, and Sustainability each supported by a different theoretical foundation: Cultural Heritage Preservation Theory, the Technology Acceptance Model (TAM), User-Centered Design (UCD) and Culturally Appropriate Design Guidelines (CADG). All these dimensions culminate in the development of Immersive Information Systems as the primary enabler for documenting, disseminating, and transferring cultural knowledge between generations.

The research findings confirm that ICH preservation in the digital era is not only a technical issue of digitization, but also a matter of maintaining cultural sensitivity, ensuring user acceptance of the technology, and ensuring social, technological, and economic sustainability. The synthesized literature shows that community engagement (Aziz et al., 2022; Morozova & Morozov, 2018), acceptance of immersive technology (Li et al., 2024; Zhao et al., 2024), and sustainability strategies (Pan, 2024; Borin & Donato, 2023) are complementary pillars in the preservation of ICH. The case of the Toba Batak further strengthens the relevance of this conceptual framework, demonstrating the potential of applying VR, AR, and AI to document local cultural practices such as tortor, gondang sabangunan, and ulos.

The contribution of this research is twofold: theoretically, it broadens the horizon of cultural preservation studies by presenting an interdisciplinary framework linking preservation theory, technology adoption, and sustainable design; and practically, it provides guidance for governments, cultural institutions, and local communities to implement immersive technology ethically and inclusively.

V. RECOMMENDATIONS

This research leaves several areas for further development that can serve as a foundation for further research. First, empirical testing of the

developed framework is needed, both through quantitative surveys based on TAM and qualitative field studies, to validate the interconnections between dimensions in real-world contexts. Second, future research should expand the scope of culture by involving more cases from diverse communities, so that the framework can be tested across traditions and social contexts. Third, aspects of immersive technology itself need further research, for example, the effectiveness of VR, AR, and AI in enhancing cultural learning among younger generations, as well as the potential ethical risks that may arise.

Furthermore, policymakers and cultural institutions are advised to adopt this framework as a basis for developing cultural digitization strategies. These efforts should be directed not only at documentation but also at empowering communities as the primary subjects, so that ICH preservation is truly sustainable and meaningful. Thus, further research and practical implementation can synergize to ensure that intangible cultural heritage remains vibrant, relevant, and pass on to future generations.

VI. REFERENCES

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