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AI-Enabled Eco–Animation and Sustainable Cultural Communication: Reframing Maritime Silk Road Heritage for the Creative Economy

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Abstract

Purpose: This research explores how ecoanimation can support environmental communication and cultural storytelling along the Maritime Silk Road (MSR). It examines the role of AI in shaping sustainable creative practices, identifies the key dimensions involved in MSR-focused ecoanimation, and explains how these elements work together to strengthen cultural continuity and responsible production. **Design/methodology/approach:** The research adopts a conceptual approach, drawing on recent work in animation studies, sustainability, digital heritage, and AI-assisted design. Insights from the literature and two MSR-related cases (2020–2025) are synthesised into the AISAC framework, which outlines five interconnected dimensions: AI mediation, ecoanimation practice, sustainable value chain, audience co-agency, and cultural continuity. **Findings:** The research highlights how the five AISAC dimensions shape ecoanimation projects and shows their relevance for authenticity, environmental responsibility, and participatory cultural interpretation. It also

demonstrates how AI tools can support sustainable production processes and deepen audience engagement in heritage communication. **Research limitations/implications:** As a concept-driven study centred on MSR contexts, it does not include empirical testing. Further work using production data, creator interviews, and comparative regional cases could help validate and extend the AISAC model. **Practical implications:** The research provides useful guidance for animators, cultural organisations, and policymakers aiming to embed sustainability in digital creative work. The AISAC framework offers a reference for developing responsible workflows, protecting cultural integrity, and encouraging low-impact production. It may also serve as a teaching resource for training emerging creators in sustainable and culturally aware design. **Originality/value:** This research brings together ecoanimation, AI-enabled creative practice, and MSR cultural communication within a single framework. It offers a structured foundation for future empirical studies and supports ongoing discussions on sustainable innovation in the creative industries.
Keywords: Eco-Animation, Artificial Intelligence, Maritime Silk Road Heritage

Introduction

Eco-animation has become a major development path for the creative industries. It combines environmental concerns, cultural heritage preservation, and technological advancements. Today, most animation is created, distributed, and viewed digitally. This evolution raises questions about energy consumption, cultural continuity, and the sustainability of production. Researchers and practitioners are increasingly discussing these issues.

New computing tools are sometimes used to support eco-animation. These help reduce material waste and accelerate the development of visual technologies. In regions with a rich heritage, such as those along the Maritime Silk Road, digital tools allow for the accurate reconstruction of cultural elements. These methods enable the production of products with a low environmental impact while maintaining the historical authenticity of the stories.

The Maritime Silk Road (MSR) has profound cultural significance. Historically, it has connected China to Southeast Asia, South Asia, and other regions. Scholars such as Sen (2023) have examined how the Mediterranean (MM) has been reinterpreted in the modern era. Its legacy includes maritime symbols, architecture, rituals, and oral traditions. Ecotourism offers a way to present these elements to an international audience without altering their cultural roots.

At the same time, ethical issues arise. One of the main concerns is the inherent bias in historical databases. Scholars have noted that these databases often represent dominant narratives that can distort minority voices (ALM Center, 2024). Another issue is authenticity. When cultural content is created digitally, audiences may question its authenticity if the creation process is not transparent (Spennemann, 2024). These challenges highlight the importance of public participation. Without it, heritage animation risks being seen as imposed rather than collaborative.

This study proposes a conceptual framework for sustainable heritage communication. This framework focuses on eco-animation as a cultural storytelling strategy. It does not provide new empirical evidence, but rather clarifies theoretical connections to guide future research

and practice. The aim is to help researchers and practitioners address ethical, cultural and environmental issues of heritage animation.

Literature Review

Eco–Animation and Cultural Sustainability

Eco-animation is an animation production method that places environmental factors at the core of its creation. It integrates ecological principles into visual design and minimizes material consumption. Researchers point out that digital workflows require fewer physical resources, thus reducing the waste associated with many traditional technologies (Feng & Yang, 2024). This practice promotes a more sustainable working environment. It also enables artists to tell clear and expressive stories without relying on large amounts of material.

Cultural sustainability explores how communities protect, adapt to, and pass on cultural knowledge. Kádár (2021) points out that cultural systems can only endure if they retain core traditions while remaining open to thoughtful change. Soini and Birkeland (2021) add that cultural practices can only remain vibrant if they respect their origins and respond to social change. Eco-animation aligns with this view. It offers a gentle way to create cultural narratives and provides a controlled digital option for presenting fragile cultural assets.

AI and Computational Creativity

Recent developments in animation, digital design, and cultural heritage work have introduced new computational tools into everyday practice. Researchers describe how these tools support style testing, scene building, motion forecasting, and the early shaping of story ideas （Manovich, 2020; McCosker & Wilken, 2020）. They also note that such methods reduce repetitive tasks and broaden the range of visual references available to creators. Santos et al. (2023) show that many studios now rely on these systems during their initial design stages.

The heritage field reports related shifts. Studies indicate that computational methods can sort visual archives, detect patterns in large image collections, and assist in repairing damaged materials. Thompson et al. (2022) demonstrate that algorithmic image analysis can uncover visual structures in historical sources that people often overlook. Murtiyoso et al. (2021) observe that digital reconstruction techniques make the documentation of built heritage more efficient.

Concerns continue to surface. Several scholars caution that limited training data may lead these systems to misread cultural features or repeat existing distortions. Vincent et al. (2023) point out that such tools may reinforce cultural stereotypes if their outputs are not carefully reviewed. Rodríguez-Miranda et al. (2021) further argue that community participation is vital when working with sensitive cultural materials, as it helps prevent misinterpretation during digital processing.

Maritime Silk Road Heritage and Digital Mediation

The Maritime Silk Road arose from centuries of migration and exchange. Sen (2020) points out that as trade routes shifted and people migrated across the seas, its coastal regions also transformed. This interaction shaped local aesthetics and created visual forms that blended diverse cultural influences. These traces can still be found in many Asian artifacts and images today.

Recent research on cultural heritage has revealed another trend: digital media is playing an increasingly important role in showcasing this diversity. Liu and Gu (2022) illustrate this shift. They describe how Southeast Asian artists utilize maritime imagery and reshape it through contemporary animation.

Digital documentation and animated narratives aid communities in passing down rituals, crafts, and historic spaces. Studies in digital-heritage communication have revealed that immersive media can support tourism, heritage education, and public memory (Sánchez-Martín et al., 2025). AI enhances this trend. It facilitates modelling of artefacts, workflows that are energy saving, and interfaces that reach diverse audiences.Yet, existing scholarship lacks a theoretical understanding of how AI-mediated eco–animation might contribute to MSR cultural sustainability. Current studies tend to explore AI-mediated tools or heritage applications separately. Few studies explore how these intersect. This gap creates a need for a conceptual model that can integrate ecological, cultural, and technological perspectives into an analytical structure.

Hypothesis Development

Eco–animation connects ecological values and creative production. AI-mediated tools now shape this relationship. They reduce environmental impact through virtual assets and automatic optimisation. These changes support sustainability goals..

At the same time, effective cultural communication requires accuracy, authenticity, and community trust. The MSR context provides a robust example. Its patterns, motifs, and visual histories demand sensitive representation.

This study proposes the following hypotheses as conceptual propositions:

Hypothesis 1: AI-enabled cultural transformation positively impacts environmental performance by reducing waste and improving performance.

Hypothesis 2: The use of eco-animation positively impacts cultural dissemination by integrating environmental issues into traditional communication methods.

Hypothesis 3: AI-enabled social transformation promotes social progress by utilizing physical objects and historical information.

Hypothesis 4: Audience engagement positively impacts cultural internationalization by promoting participation and translation work.

Hypothesis 5: Sustainability influences the overall relationship between brand value, distribution, and audience engagement.

These hypotheses serve as the conceptual basis of the AISAC model.

Methods

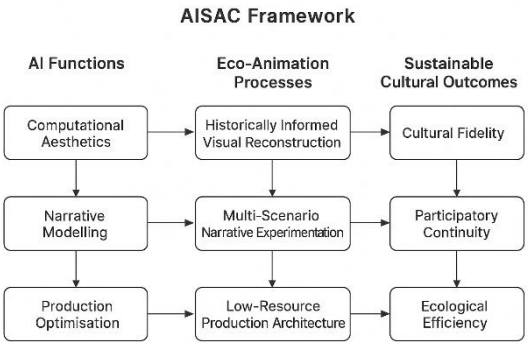
This study employs a qualitative, conceptual method. It methodically reviews scholarship in animation studies, AI ethics, media sustainability, and heritage interpretation. It compares theories across fields. It then blends these theories into a single analytical structure.A focused case illustration is added to illustrate how the concepts emerge in practice. This method supports exploratory understanding rather than empirical measurement.

The method proceeds in three steps: First, it detects current debates on AI and ecological production.Second, it analyses their relevance for MSR cultural communication.Third, it builds the AISAC model to explain their concreteness.

Findings

This study examines how AI-supported approaches can enhance cultural, historical, and ecological representations of ecosystems through cultural representations of the Maritime Silk Road (MSR). Existing studies on cultural sustainability suggest that heritage transmission should be seen as a process of continuity and adaptive reinterpretation in mediated heritage transmission (Soini & Birkeland, 2014). Based on this view, the research articulates three aims.First, the study aims to discover the main ways in which AI can support culturally informed eco-animation, i.e. how it can contribute to the fidelity and sustainability of MSR visual representations in eco-animation. Second, the study aims to explore how embedding AI into eco-animation production can enrich narrative coherence and ecological efficiency in practice. Related results suggest that, through visual analysis, AI-enabled assistance can improve accuracy and lessen labour-intensive, manual work in mediated heritage transmission (Thompson et al., 2022). Third, the study aims to build an integrated conceptual model — the AI-Enabled Sustainable Eco-Animation Communication (AISAC) framework — to explain how AI-driven communication can clarify how sustainable cultural communication can be generated by related creative processes in eco-animation. Overall, the three aims will help the study to bridge from mechanism identification to production analysis and to theoretical model building.

The AISAC (AI-Sustainability-Animation-Culture) project describes how AI-based eco-animation can contribute to sustainability research.



The first component, “AI-based design capabilities,” encompasses automation, cultural design, and biological modification. The use of AI is consistent with recent research showing that machine learning can improve the visualization of traditional models, enabling more accurate and efficient simulations (Thompson et al., 2022).

The second component, “Environmental actions,” focuses on developing effective technologies, identifying environmental challenges, and addressing important cultural issues. These practices inform a discourse on cultural heritage conservation that emphasizes appropriate interpretation, ecological awareness, and the long-term preservation of cultural heritage (Soini and Birkeland, 2014).

The third component, Cultural Sustainability Outcomes, consists of heritage continuity, community engagement and creative-economy value. In addition, community participation is acknowledged as a fundamental condition for successful digital-heritage communication. Interactive and co-creable platforms have been proven to enhance cultural identity and audience engagement (Rodríguez-Miranda et al., 2021). The AISAC model takes these lessons

into account, and it is for this reason that we recognize contextual factors—such as policy environment, technology availability and creators' capacity—moderate the overall performance of AI-enabled eco-animation.

Discussion and Conclusion

This study demonstrates that eco-animation can effectively promote sustainable cultural dissemination. This approach is particularly important in the context of the Maritime Silk Road. The findings reveal how eco-design, cultural narratives, and digital media interact to create new forms of cultural expression. Technology is not merely a tool, but a cultural catalyst, transforming the creation and dissemination of heritage narratives.

In the Maritime Silk Road, preserving cultural authenticity remains paramount. Digital tools can preserve traditional visual patterns and styles, but automated processes can also alter their original meaning. This dual effect underscores the importance of responsible design. Good practices must foster innovation while respecting authenticity. The findings emphasize the necessity of ethical and transparent design processes. These processes help ensure that technology supports cultural sustainability.

This study proposes the AISAC framework, a model that links creative activities, cultural values, and audience engagement. This paper provides a conceptual framework for understanding how eco-animation integrates ecological awareness with cultural expression. Eco-animation combines ecological aesthetics with technological narratives, expanding the creative possibilities for artists, enhancing audience engagement, and reducing production costs. These advantages collectively enhance the long-term transmission capacity of cultural heritage, enabling it to benefit future generations. These combined benefits contribute to the long-term prosperity of MSR cultural heritage from one generation to the next.From a creative and industrial standpoint, this study demonstrates that AI application in eco-animation should not be seen as a means to reduce costs or increase efficiency. Rather, it is an disruptive agent that can alter creative logic. By using AI visual analysis and narrative generation, one can illustrate cultural content with logic and depth in resource-limited scenarios. This transforms cultural animation from "visual representation" into "constructing cultural evidence," and in turn, enhances the explanation and visibility of MSR culture.

From a cultural industry perspective, the combination of AI and eco-animation offers new opportunities to spread folklore, artefacts and stories throughout the region and its role lies in renewal and community more than mere representation. Cultural heritage programs have been developed at different levels to strengthen cooperation between cultural arts and museums, regional cultural institutions and research institutes. Such a collaborative culture allows for the empowerment of actors with different backgrounds to develop interpretive strategies within the MSR network.

From a policy level, this framework analysis shows that sustainable cultural production requires the establishment of solid digital archives and AI ethics mechanisms. Since MSR consists of products from multiple transnational stakeholders, for this framework to work, all parties must cooperate to produce open databases, shared cultural archives, and oversight systems for AI ethics. That means the policy focus should change from providing technological subsidies to building institutional platforms that encourage cultural data sharing, knowledge

verification, and community participation among museums, research institutions, and educational systems. Only by building this kind of cultural infrastructure can we ensure that technological advancement in cultural expression leads to sustainable cultural outcomes.

Overall, by combining resource-efficient animation workflows with algorithmic storytelling tools, a repeatable workflow has been created where meaning, form, and energy consumption are comprehensively evaluated. Previous research has shown that this approach allows MSR (Multidimensional Storytelling) themes to spread faster and have a more lasting impact compared to traditional production methods. Cross-cultural research and multi-year follow-up studies are now needed to examine the universality of these findings in terms of reach, cost, and learning impact.

Theoretical Implications

This study has contributed to the field with a concrete model of how AI, sustainability, and cultural communication interplay in animation studies. It also contributes to the current theory of digital heritage by conceptualizing eco–animation in a broader debate on authenticity and participatory media. The framework extends the understanding of how AI works as a mediator of cultural sensemaking rather than an instrument, it extends the sustainability research on animation studies and it re-links the heritage research to digital media theory.

Practical and Social Implications

Practically, Professionals can implement the AISAC checklist as standard procedure in their studios: render farms must operate at low temperatures, and narrative integrity must be ensured. Museums can use this checklist when digitizing mountain legends; if a local resident wants to change the color of a drum, for example, the system will automatically schedule the change. Design students can practice these steps and then discuss the origin of the story. What began as a memo has become an important policy tool: the heritage agency reports lower energy consumption, increased ticketing, and voters recognizing their faces on screen. Through these cumulative impacts, the research contributes to the formation of a creative ecosystem that is ethically sustainable, environmentally conscious, and socially inclusive.

Limitations and Suggestions for Future Research

This study is more theoretically focused than others. The relationships proposed by AISAC have not been empirically validated. Furthermore, the lack of practical testing limits the generalizability of the results and, consequently, their validity, necessitating further validation through applied research.

Future empirical studies could initially include interviews with animation professionals, analyses of production processes, or case studies of real-world animation projects and digital archives of MSR (Multi-Sensitive Relational Animation). This would allow the theoretical hypotheses of this study to be grounded in concrete situations. Subsequently, reception studies could provide valuable insights into how the public perceives and interprets AI-generated eco-animation projects. Moreover, a cross-cultural comparison would be relevant to highlight cultural differences in public sensitivity and attitudes toward AI. Finally, evaluating technical aspects, such as energy consumption and data diversity, would allow progress in taking into account the ecological and ethical dimensions addressed in this study.

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