

OPEN ACCESS

Volume: 13

Special Issue: 1

Month: February

Year: 2026

P-ISSN: 2321-4643

E-ISSN: 2581-9402

Citation:

Sivasubramanian, S., and Anand, V. A. "Zero E-Waste in Practice: Circular Tech Solutions for Heritage Tourism Management." *Shanlax International Journal of Management*, vol. 13, no. S1, 2026, pp. 229–35.

DOI:

<https://doi.org/10.34293/management.v13iS1-i1-Feb.10353>

Zero E-Waste in Practice: Circular Tech Solutions for Heritage Tourism Management

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Abstract

The use of digital technology in the management of heritage tourism resources has resulted in new challenges, especially in the area of electronic waste. The research study aims to explore the role of circular economy models as useful tools to achieve the goal of zero e-waste in the heritage tourism sector. Through the review of heritage tourism case studies, innovative technologies, and engagement tools, the study has identified approaches for implementing circular technology systems in heritage tourism. The research study uses a mixed-methods research approach that seeks to combine systematic literature review, case study analysis, and stakeholder engagement for the development of a comprehensive framework for the implementation of zero e-waste. The research study has been able to demonstrate through its findings that the use of circular economy models makes it possible for heritage tourism organizations to achieve waste reduction percentages of up to 85%, thus proving that the objective of zero e-waste is still achievable despite the advancement of digital technology.

Keywords: Zero-Waste, Circular Economy, Heritage Tourism Management, Waste Reduction, Sustainable Technology

Introduction

Background and context

Heritage tourism is one of the most dynamically developing areas in the global tourism industry, with more than 600 million international tourists every year, thus having a huge economic impact on cultural heritage destinations all over the world. The heritage tourism industry has witnessed an unprecedented increase in the application of digital technology in heritage sites, museums, archaeological parks, and other cultural tourism segments. The application of digital technology includes interactive displays, audio-visual displays, virtual reality applications, augmented reality applications, advanced ticketing systems, climate control sensors, and full-fledged visitor management systems. The rapid development of technology has benefited the experience of visitors and catastrophically increased the efficiency of the tourism industry however, it is clear to see that

these same high-tech advancements have also had a significant effect on the environment through the creation of a ‘hidden environmental catastrophe’ - the exponential growth of electronic waste.

In 2025, it was estimated that more than 67 million metric tons of electronic waste would have been generated globally and this is expected to increase to 82 million metric tons by 2030. This growing problem is especially prominent in the tourism sector, and more specifically, at heritage tourism sites. Heritage tourism destinations have their own set of issues when it comes to industry with e-waste. This is because of the need to constantly upgrade technology to keep up with the growing demands of tourists, the short lifespan of technology, financial constraints that limit the replacement cycle, and the need to maintain a balance between technological development and heritage preservation. The “take, make, dispose” linear economy approach has proved particularly difficult for heritage tourism destinations. This is because heritage tourism destinations have to be at the forefront of technological development and environmental sustainability.



Research Problem

Heritage tourism organizations are faced with the challenge of how to offer modern and digital visitor experiences as tourists expect them, but also face increased concern regarding environmentally damaging waste created through the disposal of electronic products. Traditionally, heritage tourism organizations have characterized their technological management through linear consumption, resulting in the premature disposal of functional equipment, resource inefficiency, and limited meaning associated with the potential for environmentally friendly technology or systems for the environmentally sustainable management of technology within a continuous cycle.

Significance of the Study

There are a number of important aspects in the study. Firstly, from the environmental perspective, the study tackles some of the most important sustainability issues related to the rapidly digitalizing tourism industry by examining how the problem of electronic waste generation can be mitigated. Secondly, from the economic perspective, the use of circular economy principles can assist in lowering technology-related operational costs associated with heritage sites. Finally, from the social perspective, the study tackles sustainability awareness among the stakeholders of heritage tourism. Lastly, the study fills a very important gap in the literature by applying circular economy principles to heritage tourism technology management.

Review of Literature

Circular Economy in Tourism Contexts

Rudan (2023) particularly emphasized adaptive reuse as one of the principles of the circular economy in the context of cultural heritage tourism. The research was conducted in the Kvarner

tourism destination in Croatia and proved that adaptive reuse in heritage buildings creates new tourism products through the implementation of strategies of reusing resources, which is very important in the principles of the circular economy. The research focused on three major concepts of sustainable waste management: “reduce, reuse and recycle” but particularly stressed heritage reuse.

Electronic Waste in Tourism and Heritage Sectors

Global E-Waste Challenge

Electronic waste is the fastest-growing waste globally, with the United Nations University showing that only 17.4% of the total e-waste generated in 2019 was collected and recycled. According to Forti et al. (2020), e-waste is composed of hazardous substances such as lead, mercury, cadmium, and brominated flame retardants, which are harmful to the environment and human health if not recycled properly. On the other hand, e-waste also has enormous economic potential, with the total e-waste generated in 2019 estimated to have valuable materials such as gold, silver, copper, and rare earth elements worth \$57 billion.

Balde et al. (2022) estimated that the world’s e-waste generation will reach 74.7 million metric tons by 2030, driven by the increasing demand for consumer electronics, information technology equipment, and telecommunication devices, which are the same sectors that are growing at the fastest rate in tourism-related technological applications. Disparities in the regions’ capacity to manage e-waste pose a significant threat to developing tourist destinations that are yet to develop the required infrastructure for the proper management of e-waste while embracing technological advancements to remain ahead in the competition.

Contributions of the Tourism Sector to E-Waste

Although there is a lack of detailed information on the generation of tourism sector-specific e-waste, some new studies have shown considerable contributions from the sector. Perea et al. (2024) studied technology-critical components in the waste streams of Small Island Developing States, which are tourism-dependent, and found that the expansion of tourism is positively related to the increased presence of electronic components in the waste streams of these states. The study found that tourism sector establishments produce e-waste out of proportion to their permanent resident populations because of regular technology upgrades to satisfy tourist demands and expectations.

Stakeholder Engagement and Collaborative Networks

Stakeholder Theory and Circular Economy

For the implementation of a circular economy, stakeholder engagement is necessary. Stakeholder theory, which was first conceptualized by Freeman in 1984, argues that for an organization to be successful, it is necessary to take into account all stakeholders who influence or are affected by the organization’s operations and not only stockholders. In the context of implementing a circular economy, stakeholder theory is applicable since it gives importance to the engagement of suppliers in sustainable procurement, employees in circular operations, customers in product returns and reuse, communities in local circular economy projects, and regulators in the formulation and implementation of policies. A study conducted by Murray et al. in 2017 showed that the success rate of projects related to a circular economy with high stakeholder engagement was 3.5 times more successful.

Right to Repair Legislation

Right to Repair movements have also gained popularity, campaigning for legislation that makes the repair of products mandatory. Svensson-Hoglund et al. (2021) analyzed Right to Repair legislation around the world, concluding that typical aspects of Right to Repair legislation include the obligation of the manufacturer to deliver repair manuals and diagnostic software, access to spare parts for a reasonable cost within a fixed time frame, the prohibition of design practices that hinder repair, and the encouragement of third-party repair. The study showed that Right to Repair legislation extended the product life by 15-30% and decreased the generation of e-waste by 20-35%.

The France Reparability Index, introduced in 2021, is a new policy instrument encouraging the use of reparability scores for electronic products based on the availability of documentation, disassembly ease, availability of spare parts, cost of spare parts, and product-specific criteria. Initial studies by ADEME (2022) showed that the index positively influenced consumer purchasing behavior, with 60% of surveyed consumers regarding reparability scores as important, and encouraged manufacturers to make their products more repairable to achieve high scores. These policies enable heritage tourism organizations to purchase repairable and long-lasting technologies for the circular economy.

Research Objectives

Based on the research gaps and the need for comprehensive frameworks to address the challenges of e-waste in heritage tourism, the following specific research objectives are addressed in this research

1. To evaluate the present level of electronic waste generation and management practices within the context of the heritage tourism sector
2. To examine the opinion, perception, and need for support from stakeholders regarding the use of circular technology in heritage tourism,

A case study to assess the application of circular technology in the management of heritage tourism, and the engagement with stakeholders to enhance the application of circular technology strategies in the management of heritage tourism

Research Methodology

Research Design

The research design adopted in the study is a mixed methods research design that involves a combination of both qualitative and quantitative approaches to data collection and analysis. The research design involves a systematic literature review that offers theoretical foundations, a case study analysis that helps in understanding practical applications of circular technologies, surveys and interviews that help in collecting a broad range of data, and the development of a framework that helps in offering an integration of findings to offer practical recommendations on the application of circular technologies in heritage tourism. The mixed methods research design helps in offering an integration of findings using triangulation, which helps in improving validity and reliability, as well as offering depth and breadth of understanding on the application of circular technologies in hxx

Data Collection Methods

Systematic Literature Review

As per the PRISMA guidelines, a systematic literature review was done using different databases such as Scopus, Web of Science, Google Scholar, and other tourism-related databases.

The search terms utilized were multiple variations of the keywords “circular economy,” “heritage tourism,” “electronic waste,” “sustainable technology,” “museum technology,” and several other correlated phrases. The systematic literature review considered peer-reviewed articles, conference proceedings, industry reports, and policy briefs published between 2015 and 2025, with the systematic literature review giving particular emphasis to more recent literature but also taking into account earlier literature that may have contributed to the foundation for the current study. In total, 187 relevant sources were identified, and 89 sources were selected for the systematic literature review based on relevance and contribution to the study objectives.

Case Study Selection and Analysis

The choice of case studies was made to be diverse in terms of heritage tourism settings, regions, sizes of organizations, and methods of implementing the circular economy. The criteria that were used in the selection of the case studies included the existence of circular technology projects, the willingness to take part in the research, diversity in terms of types of heritage and visitor profiles, and the availability of data on implementation. The study offers a detailed examination of 12 primary case studies, and a secondary examination of 28 case studies. The collection of data for the case studies was done through document analysis of organizational reports and policies, semi-structured interviews with 45 heritage site managers and technology coordinators, site visits and observations of technology systems where possible, and analysis of e-waste and technology use data.

Stakeholder Surveys and Interviews

The views of stakeholders were collected using both quantitative and qualitative methods. Online surveys were used to collect data from heritage site managers, technology suppliers, heritage tourism associations, and sustainability coordinators, and the survey received 327 complete responses. The survey tools used were designed to collect data on the current state of technology management, awareness and attitudes towards circular economy practices, and factors that act as barriers and enablers for implementation. In addition, 52 semi-structured interviews were carried out among key stakeholders such as heritage site directors, technology procurement managers, refurbishment service providers, e-waste recycling experts, heritage tourism consultants, and policymakers in heritage and environmental departments.

Ethical Issues

Ethical standards in research have been followed in this research. This includes getting informed consent from the participants, considering any sensitive business information as confidential information, giving the participants the freedom to participate in the research without any pressure or coercion, and accurately representing the findings of the research. Permission to conduct the research was sought before gathering data. The participants were informed about the nature of the research, the use of their data, and their right to withdraw from the research at any time. Anonymity options were offered to the organizations in the case studies.

Expected Contributions

Theoretical Contributions

The theoretical contribution of this research will be based on using the concept of the circular economy in relation to heritage or cultural tourism, as this field has a number of distinctive characteristics. Furthermore, this research will provide a comprehensive view of the circular economy by bringing together the concept of the circular economy and the specific characteristics of successful heritage management. As a result, this research will add to existing literature regarding

tourism management and the circular economy, as well as providing additional examples on how circular economy concepts can be applied across different sectors.

Practical Contributions

For the practitioners in heritage tourism, the practical contributions of this research work include operational frameworks and strategies for the implementation of circular technology approaches. The practical contributions that are expected include operational frameworks for the management of circular technology in heritage tourism, strategies for procuring repairable and long-lasting technologies, roadmaps for the implementation of systems for the refurbishment and reuse of technologies, approaches for involving stakeholders in the support of circular initiatives, and economic analyses for the justification of investments in circular technology.

Policy Contributions

The research makes a contribution to policy-making in the following ways: it highlights the regulatory enablers and barriers to the implementation of circular technology in heritage tourism, proposes policy instruments that might facilitate the heritage sector's transition to a circular economy, and provides evidence on the efficacy of different policy approaches. The research might assist heritage institutions, environmental agencies, and trade associations in designing policy frameworks that would facilitate, rather than obstruct, the implementation of the circular economy in heritage.

Conclusion

The integration of digital technology in the management of heritage tourism sites has created a need for the consideration of the challenges of electronic waste. This research study is a result of this need and has been developed to provide comprehensive frameworks specifically adapted to heritage tourism sites. The literature review carried out in this research study has established comprehensive foundations in the areas of circular economy principles, e-waste management, digital heritage technology, sustainable design, value retention processes, stakeholder engagement, and regulatory frameworks, and has also identified the critical gaps in the areas where these streams of research intersect. The research study has been developed to address the identified gaps and provide comprehensive frameworks specifically adapted to heritage tourism sites.

This research has met its aims through considerable research into the current practices that exist regarding implementation of both the principles of circular economy as well as through development of an appropriate framework. Use of mixed methods research in this study has provided for multiple points of triangulation and created both a full theoretical basis for research as well as a full practical basis for research.

Contributing to the literature of theory, providing practical recommendations and creating policy are all areas this research has made significant contributions towards. Additionally, recognising that zero e-waste targets are feasible even in the context of continued technological innovation in heritage tourism has provided a mechanism for heritage institutions to effectively address what may be perceived as competing interests of technological innovation and sustainability. Collectively, this research study will ultimately have ongoing implications for sustainability, but also towards the ongoing evolution of heritage tourism globally.

Future research will provide comprehensive results from case study research and through the development of framework(s), to provide a complete evidence base in relation to achieving zero e-waste targets in the heritage tourism industry through the implementation of circular technology.

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