




# Technology, Communication, and Sustainable Tourism: Exploring New Approaches for Heritage and Research

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## Abstract

*This paper investigates how digital technologies can foster more sustainable cultural tourism by addressing key challenges such as overtourism, limited accessibility, and disengagement with lesser-known heritage. As tourism places increasing pressure on cultural and natural resources, digital innovation offers new strategies for enhancing access, redistributing visitor flows, and enriching interpretive experiences through immersive storytelling and participatory design.*

*Three case studies have here been identified to illustrate distinct technological solutions, virtual reality, hybrid web-based collaboration, and mobile gamification, each contributing to sustainable tourism in unique ways.*

*A Night in the Forum is a VR narrative game set in the reconstructed Forum of Augustus in Rome, that immerses users in ancient Roma through interactive storytelling. It enhances cultural literacy and reduces physical impact on archaeological sites, especially by engaging younger, digitally native audiences. Brancacci POV is a hybrid web3D application focused on Florence's Brancacci Chapel, allowing remote and onsite participants to explore a detailed 3D model collaboratively, guided by experts. Ozan 1982 is a mobile game designed to redirect tourism from Salento's crowded coast to the inland town of Ugento, through a fictional mystery grounded in local history.*

*Together, these projects show how digital tools can support sustainable tourism by transforming heritage encounters into immersive, inclusive, and educational experiences. They highlight the importance of design strategies that are not only technologically innovative but also culturally and socially responsive.*

## CCS Concepts

• **Applied computing** → Education; Media arts; • **Social and professional topics** → Sustainability;

## 1. Introduction

The concept of sustainability applied to Cultural Heritage is based on an integrated approach that responsibly values territorial resources, promotes the participation of local communities and ensures the transmission of heritage to future generations [HD18]. This model conceptualises culture not only as a heritage to be preserved, but also as an active driver of social development, cohesion and innovation [ANR12]. From this perspective, the sustainable interaction with heritage is not confined to visiting sites, but rather transforms into a journey of discovery and conscious appropriation, capable of generating emotional engagement, strengthening sense of belonging and fostering responsibility. In this context, the utilisation of digital technologies assumes a fundamental role, overcoming its conventional function as a mere provider of information. Instead, it emerges as a strong narrative instrument, capable of improving connections between visitors and the heritage they represent. In recent years, there has been a growing focus on sustainable tourism practices, which has led to a more profound reflection on the dynamics that involve the enjoyment of cultural heritage. One of the most prominent concepts to emerge is that of

overtourism [MU17], which was introduced into international debates around 2016 to describe the negative effects that excessive tourist flows can have on cultural destinations. These effects include overcrowding, loss of cultural authenticity, negative environmental impact and disruption of the social fabric. It is mandatory to recognise the inherent value of tourism as a catalyst for economic and cultural enrichment. However, it is equally crucial to acknowledge the necessity of strategic management in this regard. Failure to implement effective strategic management measures can potentially compromise the same heritage that tourism is intended to preserve and enhance.

## 2. Digital Approaches as a Trigger for Sustainable Tourism

In this context, an approach that promotes decentralized and conscious forms of tourism is progressively gaining more ground, directing flows toward lesser-known yet historically, artistically, and culturally rich destinations. In this perspective, when developing a project to promote and enhance cultural heritage, technology must be used consciously to create digital experiences that actively en-

gage the visitor and encourage alternative, sustainable tourism experiences while alleviating pressure on already heavily visited sites.

In this direction, the use of digital technologies represents not only a tool to support the more balanced management of tourist flows but also an opportunity to rethink how we experience cultural heritage [MU17]. Through engaging, personalized, and remotely accessible experiences, new digital solutions can enhance lesser-known places, stimulate visitor curiosity, and foster a more direct and participatory relationship with heritage. A mindful and aware use of technology can create tools that go beyond being merely informational supports and instead become true cultural mediators, capable of storytelling, evoking emotions, and making the tourist protagonist of a journey of discovery.

New technologies, when integrated into design processes that are sensitive to the identity of places, facilitate access to content and enrich the cultural experience, making it more immersive and participatory. Mobile apps, augmented reality, emotional mapping, smart localization systems, and interactive digital platforms can contribute to [Pri17]:

- Creating personalised narratives based on context, user profile, and visit duration;
- Engaging the senses and emotions through paths that combine voice, image, sound, and interaction;
- Connecting places and stories non-linearly, allowing the visitor to build a unique and meaningful experience;
- Providing enhanced accessibility, both in terms of remote use and in overcoming physical and cognitive barriers.

At a time when the very concept of "visiting" is evolving into "living and understanding," new technologies become key allies in building cultural experiences that are participatory, multisensory, and inclusive [VSM\*20]. The challenge is not only to preserve heritage but to activate it, bringing it into people's lives, reconnecting it to daily experiences, and stimulating new forms of knowledge and belonging. The cultural experience of the future will increasingly be an interplay of memory, emotion, and technology: narrative paths that do not merely inform but engage, inspire, and transform visitors, enhancing the experience, making it open, accessible, and alive.

When integrated with thoughtful and place-sensitive design, new technologies have the ability to transform visits into active, participatory experiences deeply connected to context, memory, and the identity of places. Despite their potential, good Italian practices of information technology in the tourism and cultural sectors remain limited and mainly concentrated in large urban centres. A strategic and coordinated approach is essential to fully exploit the opportunities offered by smart cities in supporting innovative and sustainable enjoyment of cultural heritage. Public administrations can play a key role in producing and making territorial information accessible through different media, while also soliciting user feedback for territorial marketing. It is important to consider that the creation of digital content must be approached consciously to avoid imbalances in the representation of places.

Moreover, the design and use of these digital tools must be based on solid scientific research and consider the specificities of cultural heritage, avoiding the sacrifice of content quality for superficial

technological solutions. The goal should be to create integration between various disciplines for a way of experiencing heritage that is innovative, accessible, and conscious.

### 3. Rethinking sustainable cultural tourism through digital media in three case studies

To delve into the analysis of how digital media can foster sustainable tourism, we present three applications developed over the years by the CNR Institute of Heritage Science (ISPC), which show three different methods of interaction with the public but share a common goal: encouraging people to experience places in new ways, more consciously and immersively.

*A Night in the Forum* [Son19], *BrancacciPOV* [CNR25], and *Ozan 1982* [Con25] are the three projects here taken into account, and they have been selected not only for their technological diversity but also for their shared commitment to engaging visitors in meaningful and socially conscious cultural experiences.

Each case uses a distinct technological approach: a serious game in virtual reality (VR), a collaborative web3D application for hybrid experience, and a mobile serious game. Despite their differences, they all pursue common goals: promoting less visited cultural sites, enhancing access for diverse audiences, and fostering emotional and educational connections with heritage. These initiatives exemplify how storytelling, interaction, and remote accessibility can transform tourism practices, expanding cultural participation and reinforcing the value of local resources. Together, they show how thoughtful digital design can balance conservation with engagement, turning tourism into a more inclusive, decentralized, and transformative activity.

#### 3.1. Case Study 1: *A Night in the Forum*: Immersion and Serious Gaming

*A Night in the Forum* ("Una notte nel foro") is a 3D environmental narrative videogame for Sony PlayStation 4 VR [PFF\*20], developed as part of the EU-funded REVEAL project (ID 732599) and published in 2019 [Son19]. Produced by VRTRON and co-designed by CNR ISPC in collaboration with the Imperial Forum Museum of Rome, the game responds to growing interest in videogames as tools for cultural education and engagement, particularly for younger audiences [PMP22].

Set in the Forum of Augustus in Rome, the game begins with a tourist locked inside the site after hours, who discovers a Roman helmet and is transported back to Ancient Rome. As the Forum's night guard, he must complete a series of tasks before sunrise. Through environmental storytelling, object interaction, and voice guidance, players explore a fully reconstructed 3D space, learning about the architecture, politics, and symbolism of the Forum. Historical accuracy is blended with immersive gameplay to foster engagement and contextual learning. Grounded in archaeological data, the game incorporates 35 learning concepts from academic research and museum interpretation practices, seamlessly integrated through spatial storytelling, audio hints, and interactive objects. Head tracking and simple interaction mechanics make the experience user-friendly, while the narrative ensures cultural immersion. It allows comparisons between ancient and modern views

of the site, supporting intuitive interaction and encouraging cognitive engagement by allowing users to absorb historical information naturally while playing.

Designed to be played at home or in informal educational settings (as the museum), *A Night in the Forum* contributes to sustainable tourism by offering a digital alternative to visiting a heavily frequented archaeological site, helping reduce erosion and physical degradation. Moreover, it expands access to heritage via a globally available, well-known game platform, widening the accessibility to the site and promoting historical literacy in an engaging, intuitive format tailored to modern audiences. By leveraging immersive virtual reality technologies, the project expands the potential of cultural visits and learning, making tourism more accessible, scalable, and aligned with heritage conservation needs. Through storytelling, the inclusion of historical and archaeological facts, objects, and characters, and game mechanics, it becomes possible to foster cultural innovation. It supports learning and curiosity about Roman history, potentially influencing future travel decisions and encouraging off-site engagement that lowers peak tourist pressures. The immersive design promotes responsible appreciation of cultural value while offering scalable, low-impact dissemination of heritage content.

### 3.2. Case Study 2: *BrancacciPOV* – A Hybrid XR Experience

*BrancacciPOV* reinvents the visit to Florence's Brancacci Chapel through a hybrid web3D experience that allows users worldwide to explore a high-fidelity 3D reconstruction of the site, either individually or in small, collaborative groups. Developed by CNR ISPC with the Municipality of Florence, the scientific advice of the Soprintendenza Archeologia Belle Arti e Paesaggio for the metropolitan city of Florence and the provinces of Pistoia and Prato and the Opificio delle Pietre Dure, the experience is designed to deepen engagement with this under-visited yet culturally significant Renaissance landmark [PCD\*23]. Its multiplayer version, up to five users—remotely or on-site—are guided by a live expert as they explore the frescoes by Masaccio, Masolino, and Filippino Lippi. Participants assume the roles of characters from the frescoes and interact via various devices (smartphones, tablets, PCs, or HMDs) to solve tasks, uncover hidden narratives, and access scientific insights. The experience emphasizes perspective-taking, storytelling, and collaborative interaction, blending immersion with human connection to promote cultural awareness and social cohesion. A distinctive feature includes visual tools like the "Grazing Lens" and "Ultraviolet Lens", which reveal otherwise invisible fresco layers and diagnostic data, offering insights beyond what is perceivable during a physical visit. The experience is designed as to be as similar and authentic as possible to physical experiences, therefore the presence of an expert who acts as a narrator and moderator, talking to participants, prompting tasks and encouraging discussion. While the multiplayer version requires booking, a freely accessible single-user version is available online [CNR25]. Both are built on the open-source ATON framework, and a new remote VR multiplayer version is in development, adding game mechanics and automatic audio narrator, further enhancing accessibility for audiences unable to travel due to financial, physical, or geographic constraints.

As with *A Night in the Forum*, *BrancacciPOV* aligns with sus-

tainable tourism goals by offering an alternative to in-person visits at a fragile heritage site. It reduces physical impact while expanding both cognitive and emotional accessibility, enabling a more informed and appreciative engagement with the frescoes. By showing hidden diagnostic details and enabling magnifications and interpretive exploration, the project overcomes limitations of traditional visits and fosters a more conscious and informed tourism that is more likely to respect and value cultural heritage, contributing to its cultural sustainability.

*BrancacciPOV* exemplifies how digital cultural experiences can be designed to be authentic, inclusive, and aligned with conservation goals while raising awareness of a culturally significant but under-visited destination and encouraging spatial and cognitive decentralization and broader geographic outreach, redirecting interest away from the city's overloaded core to a lesser-known, though highly significant, cultural location. Promoting social engagement and reducing the distance between citizens and cultural institutions, *BrancacciPOV* is designed to not only foster social cohesion but also to create a mediated dialogue between participants and cultural institutions [PBM23], improving local community involvement and sense of belonging towards their local heritage.

### 3.3. Case Study 3: *Ozan 1982* – Connecting Coastal Tourism with Cultural Heritage

*Ozan 1982* is a serious game for mobile phones, designed by CNR ISPC, developed by ELIF, in collaboration with the Municipality and Museum of Ugento, as part of the PNRR Musei Aperti project [Com25]. It aims to counteract the seasonal concentration of tourists on Salento's beaches by attracting them inland through a narrative-driven, gamified cultural experience [BCF\*nt]. Set between the present and the 1980s, a period of key archaeological discoveries, the game follows Maia, a woman returning to Ugento after her parent's passing, to uncover a family mystery rooted in the town's past. Players are tasked with accompanying and helping Maia in her investigation between the beach and the museum, listening to her stories and solving puzzles that will let them earn five different clues. These clues will only make full sense during the final narrative, which takes place at the Archaeological Museum of Ugento. The initial triggers for the players (the target audience is the summer tourists) to start the game, are five large 'pop-colored' 3d-printed copies of museum objects, inspired by the artistic trend of the *Cracking Art*, placed along the Ugento coast to arouse the curiosity and interest of visitors [Red25], who find the QRcodes on these strange coloured objects and, through them, they can start to meet and receive messages with Maia. Each clue unlocks a free museum entry, reducing economic barriers and incentivizing visits to the recently renovated inland site. In this way, the project promotes a more balanced distribution of tourist flows and helps protect the fragile coastal ecosystem. Moreover the choice of printing the 3d copies in sustainable materials also aims to provoke reflection on man's impact on the environment and the split between nature and the artificial, fostering tourists' awareness and promoting more responsible behaviours. Through immersive storytelling and mobile interaction, *Ozan1982* invites users to explore Ugento's heritage in a format more accessible to audiences who might not engage with traditional museums. By intertwining play, history, and place-

based learning, it supports more conscious and informed tourism. It shows how hybrid gamified experiences, storytelling and smartphone interaction can transform tourism, encouraging longer and more meaningful engagement with local culture while addressing ecological and social dimensions of sustainability.

#### 4. Challenges and Future Prospects

Communication plays a pivotal role in fostering sustainable tourism. Not only does it raise awareness, but it also guides tourists and operators toward more responsible behaviors that respect natural, cultural, and economic resources. Its importance is evident across various areas, from planning responsible development to promoting practices that protect the integrity of places and local traditions. Through a strategic, integrated, and multi-channel communication approach, it is possible to drive real change in travel habits, encouraging more ethical and sustainable choices [CFGL23].

The innovative experiences of *A Night in the Forum*, *BrancacciPOV*, and *Ozan 1982* show that digital technologies can serve as catalysts for real change, not only by enhancing accessibility and engagement but by helping to decentralize tourist flows, promote local heritage, and support conservation. While these projects employ different tools, they share a common commitment to transforming cultural visits into participatory, and inclusive experiences. This shift—from passive observation to active engagement—suggests an evolving paradigm in cultural tourism where design must prioritize narrative depth, multisensory immersion, and contextual relevance.

In this perspective, scientific communication has also a decisive role. It ensures methodological rigor in transmitting content, preventing oversimplification and trivialization. At the same time, it can inspire tourists and local communities to develop a more attentive and conscious analysis of heritage, making it accessible and comprehensible to diverse audiences. The integration of technologies—from Augmented Reality to smart maps—enables the development of more balanced tourist flow management strategies, reducing the pressure on heavily visited sites and promoting lesser-known yet culturally significant destinations. One key aspect that emerges is that scientific communication goes beyond narrating the past: it actively contributes to building a more sustainable future. The ability to use digital tools and social media to disseminate reliable information based on data and research is essential for promoting responsible behaviors, reducing environmental impact, and supporting heritage preservation.

Our ongoing research aims to further examine how these digital and narrative strategies can be scaled and adapted to diverse cultural contexts, particularly those at risk of marginalization or overexposure. It is essential to monitor the real-world impact of such interventions and integrate cultural, educational, and social dimensions into the design process. Effective communication—accessible yet scientifically rigorous—is a crucial resource for guiding tourism toward models that respect the environment, local communities, and the memory of places. Only through shared planning and collective commitment can we ensure a future where tourism and sustainability coexist harmoniously.

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