Advancing Sustainable and Inclusive Digital Practices in Indian Museums: Addressing Research Gaps through a Case Study of the Red Fort Museum, Delhi

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Abstract

The imperative for museums to adopt sustainable and inclusive practices has gained global recognition, yet a significant gap persists in understanding how digital technologies can effectively address these challenges within museum environments. This research focuses on exploring and documenting innovative digital solutions aimed at enhancing sustainability and inclusivity in museums, using the Red Fort Museum in Delhi as a case study. The study seeks to fill existing gaps in the literature by analysing the practical application of digital technologies in real-world museum settings, particularly in addressing environmental and social challenges.

The research employs a mixed-methods approach, integrating both quantitative and qualitative analyses. Quantitative methods include the analysis of energy savings resulting from the implementation of energy-efficient digital exhibits, such as solar-powered interactive displays and LED lighting, which have collectively reduced energy consumption by 70% and lowered carbon emissions by 77%. Additionally, visitor engagement metrics are analyzed, focusing on the impact of a climate-conscious digital exhibit that utilizes real-time data to enhance awareness and involvement, achieving a 35% increase in visitor interaction.

Qualitative methods involve collecting and analyzing visitor feedback on the inclusivity of the museum's digital interfaces, which feature multilingual options and accessible touchscreens. These enhancements have led to a 20% increase in visitor satisfaction, particularly among diverse demographic groups. Furthermore, expert interviews provide insights into the strategic planning and challenges of integrating digital technologies within the museum's sustainability framework.

The findings of this study will offer a comprehensive understanding of how digital innovations can be leveraged to advance sustainable and inclusive practices in museums. By documenting the Red Fort Museum’s initiatives, this research not only addresses existing literature gaps but also provides a model for other museums and cultural institutions striving to achieve similar goals. The findings aim to bridge existing literature gaps, offering practical models for other museums seeking to implement sustainable and inclusive digital practices.

Keywords: Sustainability, Digital Technology, Museums, Climate Change, Inclusivity, Energy Efficiency, Accessibility, Red Fort Museum, Delhi

Introduction

India's historical landscape is marked by numerous pivotal events that have shaped the contemporary status of the Indian subcontinent. These significant occurrences have endowed the region with a unique identity, reflecting a continuum of events across time and space. On a global scale, Indian history commences with the Indus Valley Civilization and progresses through the eras of Buddhism, the Mauryan and Gupta dynasties, the Delhi Sultanate, the Mughal Empire, the British Empire, and ultimately, to the present-day independent India.

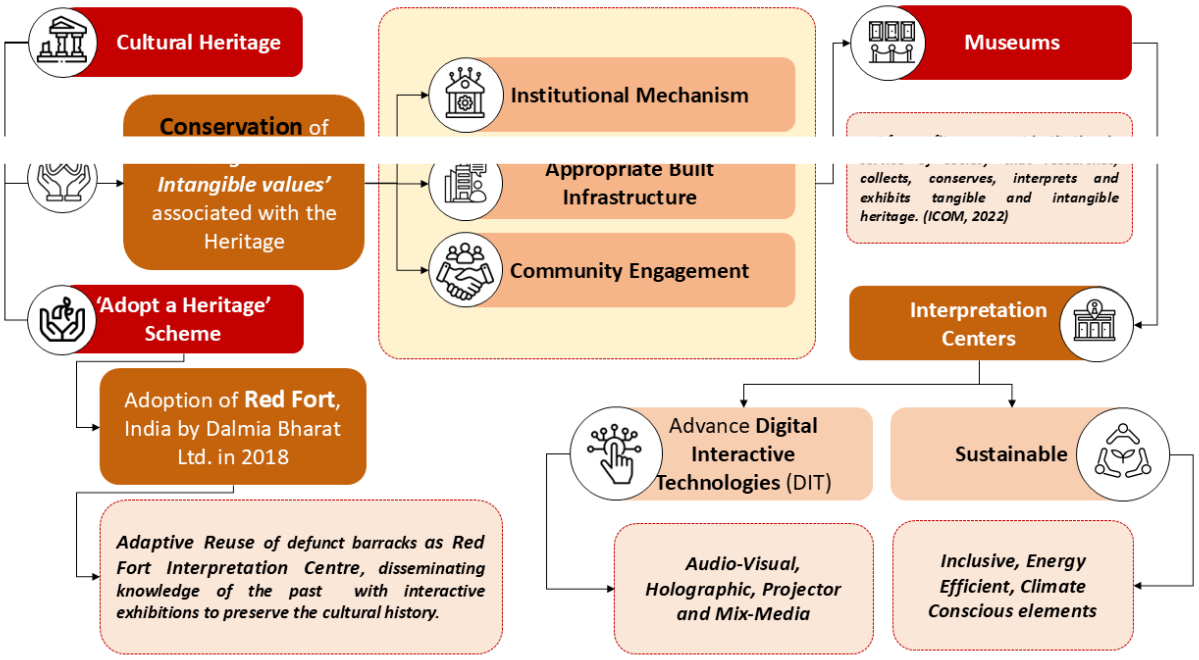
Given its rich and diverse cultural and political heritage, contemporary India necessitates a comprehensive and integrated approach to preserving both tangible and intangible aspects of its past (UNESCO, 2019). The preservation of these elements—encompassing social and cultural dimensions—is endorsed by various international charters and conventions. Notable among these are the *Venice Charter of 1964, the Nara Document of Authenticity of 1994, the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage of 2003,* and *the ICOMOS Charter for the Interpretation and Presentation of Cultural Heritage Sites of 2008.* These documents collectively advocate for a holistic approach to heritage conservation, emphasizing the importance of preserving the values associated with cultural heritage.

Among these, the ICOMOS Charter of 2008 highlights the need for the interpretation and presentation of both tangible and intangible heritage values through establishment of interpretation infrastructures, enhancing institutional mechanisms and promoting community involvement, while maintaining authenticity. This process facilitates knowledge dissemination, training, and fosters respect for cultural heritage within communities (Silberman, 2008). Generic infrastructures that conventionally presented and interpreted the artifacts and antiquities of the pasts to a certain degree, became to be known as 'Museums'. Based on the specialization of the functions and purpose of such infrastructures, they are referred as Exhibition Centers, Interpretation Centers, Cultural Centers, Galleries etc. The latest definition of museums as defined by International Council of Museums (ICOM) in 2022 is as follows:

> *"A museum is a* ***not-for-profit****, permanent institution in the* ***service of society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage****. Open to the public,* ***accessible and inclusive****, museums* ***foster diversity and sustainability****. They operate and communicate ethically, professionally and with the participation of communities, offering varied experiences for* ***education, enjoyment, reflection and knowledge sharing****."* (ICOM, 2022).

In 2017, the Ministry of Tourism and Archaeological Survey of India (ASI), Ministry of Culture, Govt. of India launched 'Adopt a Heritage' program. The program intended to provide opportunities to the private sectors to partner with the Government for promotion of India's rich

cultural heritage via Corporate Social Responsibility (CSR) (Ministry of Tourism, 2017). The program classifies heritages into three categories- *Green, Blue and Orange*, with Green encompassing all the monuments of high cultural and historic values. Among the various historic periods of India, the period of Mughals has produced some of the finest and majestic scale monuments in the national capital region of India. One of the Mughal monuments is 'Red Fort' which is situated in the heart of Walled city of Shahjahanabad, Delhi. Also, the monument is classified under 'Green' category denoting its high cultural and historic values. Dalmia Bharat Ltd. adopted the Red Fort in 2018 for an amount of INR 250 million (Bindhu & Panakaje, 2023). After adoption, Dalmia Bharat Ltd., has reconstructed a defunct barrack built by Britishers after their acquisition of Red Fort. The building has been adaptively reused as an 'Interpretation



Centre' (Abdel, 2024).

Evolution of the Concept of 'Museums': Integrating Past, Present and Future

The etymology of the word 'Museum' originates from the Greek word "Muse", referring to 'The God of inspiration' or 'The protector of Arts'. Overtime, the word 'Muse' was used indicate a place of meditation and philosophical discussions. The word 'Museum' was first used in 15th century to describe the work of Medici's work in Florence. In 17th century, the term gradually started to refer collective works of prominent artists at the time. Different revolutions, World Wars, and development in architectural movements in synchronization with evolution of societal concepts being influenced by globalization and internationalization have morphed the current form and function of the museums (Y. M. Manssour, 2016). As already defined above, the museums currently, serve as a distinctive social infrastructure, preserving the social and

cultural heritage and also plays a vital role in imparting knowledge to the community. Since, the purpose of the museums has evolved from solely ‘a place of collection of artefacts to ‘a responsible social infrastructure’ that infuses the sentiments of ‘respect’ and ‘pride’ in the community people for their pasts and eventually conserving heritage and its values.

Traditionally, the exhibits of the museum were displayed physically, on a wall or on panel, hanging or placed. Since, 19th century, with the advancement in technologies, the space inside the museum has also evolved from a static container of artefacts to a dynamic digital interactive system of which the ‘user’ is an integral part. This digital interactive system deploys various modern elements such as AR and VR technologies, Holographic projections, interactive games, multi-lingual light and sound shows etc. which encourages the user participation and interaction. Thus, ultimately enhances the user experience. Further, this creates a psychological impact on the cognitive abilities to learn and retain about the past in an immersive environment. (Yang & Guo, 2024).

The integration of advanced digital technologies in museums to ensure seamless operations undoubtedly necessitates significant energy consumption. It is well understood that increased energy usage places substantial strain on environmental resources. To alleviate this burden, it is imperative that the energy required is sourced from renewable resources such as solar energy and wind power, with a focus on diversifying these sources. The implementation of active technologies and passive strategies to create sustainable, green buildings has garnered considerable attention in architecture and engineering. Consequently, it has become the responsibility of architects and engineers to design and develop built environments that operate with optimal energy efficiency.

In line with this trend, museum creators and users are increasingly expected to engage with these institutions in an environmentally conscious manner. Museums, traditionally recognized for their role in preserving culture, educating and inspiring society, and promoting social sustainability, are now also adopting financial models based on public-private partnership schemes to achieve economic sustainability (POP & BORZA, 2014). The final pillar—environmental sustainability—can be reinforced by developing climate-conscious, energy-efficient structures.

From a sociological perspective, due to the impact of globalization and technological advancements, the present structure within a community has not remained homogenous and a community itself has become microcosm of the ‘Globe’. Considering the sustainable development goals by UNESCO, the goals of ‘sustainable cities and communities’ advocates that cities should be inclusive for each and every demographic and economic group of society. In the context of advance museums and from the intersection of the two mentioned facts, the present scenario demands an inclusive and accessible, climate-conscious, energy-efficient social infrastructure embedded with digital interactive technologies, to disseminate the chronicles of the

past while not compromising the need of the future. Museums have the capacity to create a more harmonious society while making a lesser impact on the environment by virtue of its sustainable operations (Ahmed, Qaed, & Almurbati, 2020).

Analysis of previous similar Keywords Co-occurrences

To bolster the research in this study and identify the research gaps within the context of sustainable and inclusive museum practices, a comprehensive search of the JSTOR database was conducted. The search utilized a range of keywords, including "Sustainable Museum," "Digital Interactive Technology," "Inclusive Museums," and "Energy Efficient Museums." The search was restricted to documents published in English and employed various permutations of search fields (All Fields, Item Title, Abstract) along with Boolean operators ('AND' & 'OR').

Table 1: Serach Syntax and No. of Documents

S.No.	Search Syntax	No. of Documents			
		Journal Articles	**Book Chapters**	**Research Reports**	**Total**
1.	*((((Sustainable Museums) AND (Digital Interactive Technology)) AND (Inclusive Museums)) AND (Energy Efficient Museums)) AND la:(eng OR en)*	25	26	1	52
2.	*((((ti:"Sustainable Museums") AND (ti:"Digital Interactive Technology ")) AND (ti:"Inclusive Museums")) AND (ti:"Energy Efficient Museums")) AND la:(eng OR en)*	0	0	0	0
3	*((((ti:"Sustainable Museums") OR (ti:"Digital Interactive Technology ")) OR (ti:"Inclusive Museums")) OR (ti:"Energy Efficient Museums")) AND la:(eng OR en)*	1	7	0	8
4	*((((ab:"Sustainable Museums") OR (ab:"Digital Interactive Technology ")) OR (ab:"Inclusive Museums")) OR*	100	41	0	141

	(ab:"Energy Efficient Museums")) AND la:(eng OR en)				

The initial search resulted in 52 documents that met the criteria for the union of the selected keywords. These documents were subsequently analyzed for relevance based on their abstracts using an automation tool. Of these, 42 documents were excluded due to their irrelevance to the specified keywords and abstract content. The remaining 10 documents, while relevant, did not address the intersection of all the specified keywords.

The analysis indicates a notable gap in the existing literature concerning the convergence of sustainability, digital technology, inclusivity, and energy efficiency within museum contexts. This finding underscores the necessity for further research in this area. Consequently, this study aims to address this research gap by exploring the integration of these elements and contributing new insights to the field.

Methodology

This study explores sustainable and inclusive digital practices within Indian museums, focusing on addressing research gaps through an in-depth case study of the Red Fort Museum in Delhi. The research begins with a thorough literature review, which lays the groundwork by identifying the problem statement and outlining the research trajectory. The study integrates the concepts of sustainability and digital technology, specifically within the context of museums.

The scope and objectives of the research guided the selection criteria for an appropriate museum case study. These criteria included the use of digital interactive technologies, the energy efficiency of the museum structure, and its accessibility to diverse user groups. Based on these criteria, the Red Fort Interpretation Centre in Delhi was selected as the case study to provide empirical support for the theoretical framework of the research.

An evidence-based research approach was adopted, utilizing both primary and secondary data sources. Primary data collection involved a reconnaissance survey, a structured questionnaire distributed to museum visitors—including both local residents and tourists—and interviews with key museum staff, such as Ushers (who guide and inform visitors) and the Curator. Secondary data were sourced from a range of articles and reports on the Red Fort Interpretation Centre.

The primary questionnaire was administered through Google Forms, resulting in 104 completed responses. In addition, two manual interviews were conducted to gather more detailed insights. The collected data were categorized into perception data and factual data. Both

quantitative and qualitative analyses were performed to draw meaningful inferences and conclusions from the research findings.

Why Red Fort Interpretation Centre?

The selection of the Red Fort Interpretation Centre for this case study is justified by its alignment with the core parameters of sustainability, the application of digital interactive technologies, and its rich historical significance. The Red Fort, an iconic symbol of India's historical and architectural heritage, exemplifies the integration of these elements.

Historically, Delhi has served as the capital of numerous dynasties due to its strategic location and historical significance. Among its seven ancient cities, Shahjahanabad, the walled city of the Mughal Empire, stands out. The Red Fort, a quintessential example of Mughal fortification, represents the zenith of Mughal architectural prowess. Over 400 years old, this fort remains an enduring symbol of India's past and continues to hold cultural significance, as evidenced by its role in the annual Independence Day celebrations, where the Indian Flag is ceremonially hoisted by the Hon’ble Prime Minister.

The Red Fort Interpretation Centre, situated within the fort’s premises, is accessible via the first left door of the market gallery. This two-story adaptive reuse project involved the renovation of defunct British-era barracks into a modern interpretation center. The center now features interactive technologies and gamified exhibits, enhancing visitor engagement and education.

Under the 'Adopt a Heritage' scheme initiated by the Government of India, private entities are given the opportunity to contribute to the preservation of significant monuments. Managed by Dalmia Bharat Ltd., the Red Fort Interpretation Centre benefits from high-quality, innovative technologies that enhance its appeal. Prior to its adoption, the Red Fort was already renowned for its grandeur and attracted a substantial number of tourists. The establishment of this interpretation center has thus served as a significant enhancement, benefiting both the Red Fort and its visitors.

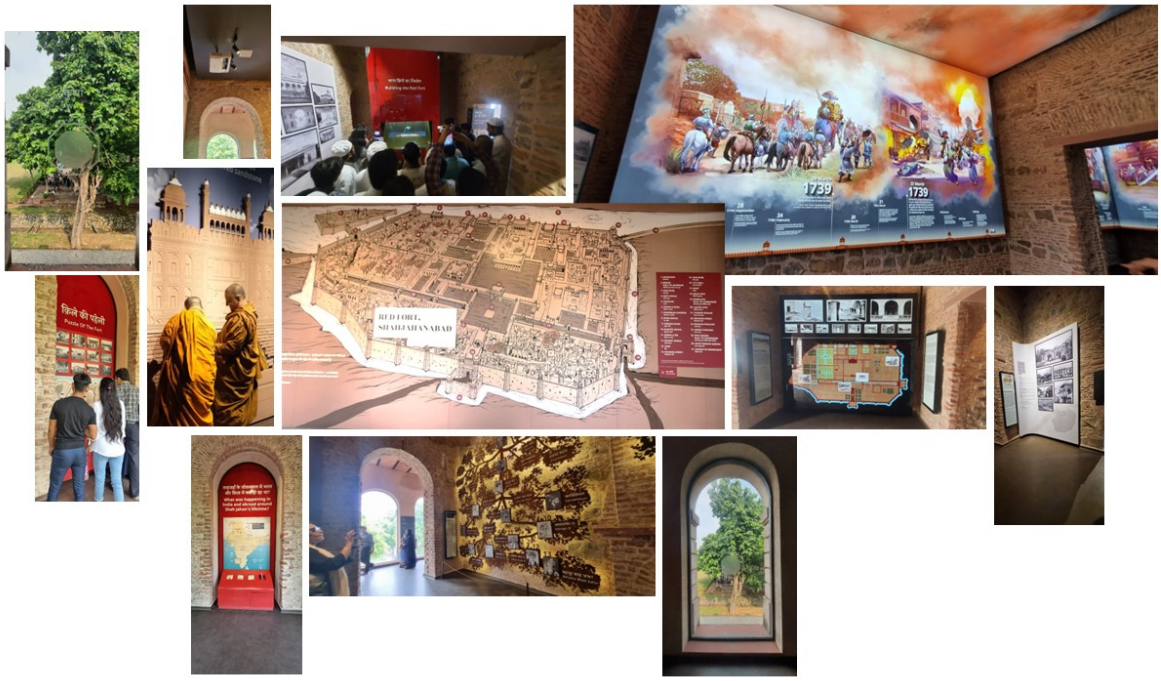


Figure 2: Location of Red Fort Interpretation Centre inside Red Fort, Source: Author

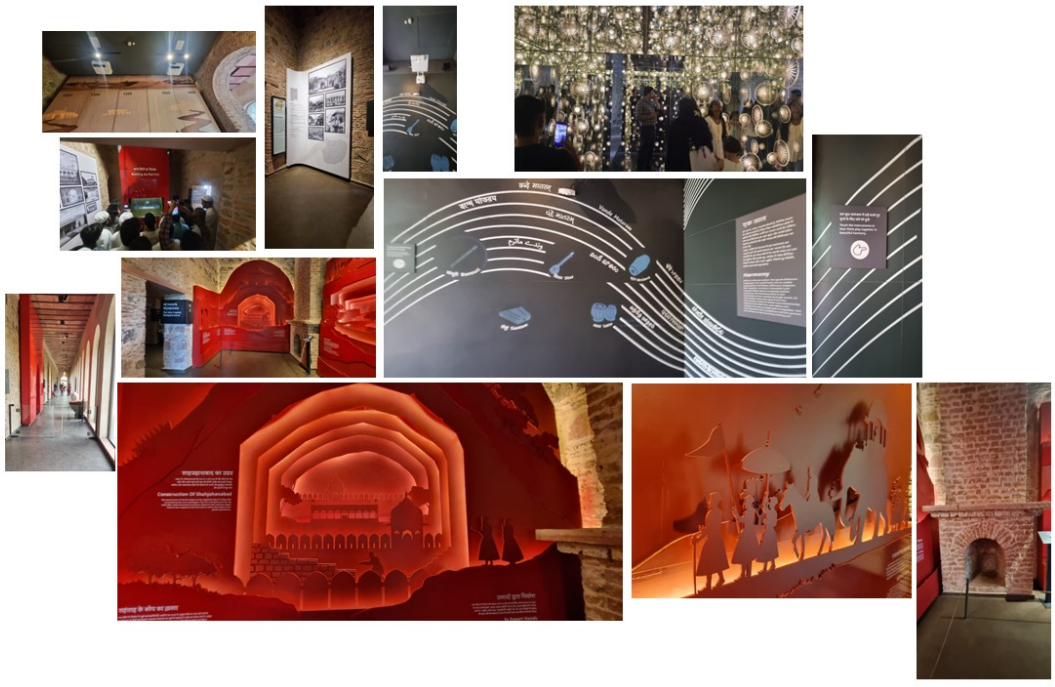


Figure 3; Photo Montage of the Red Fort Museum, Source: Author

Results and Discussions

The survey provided insights into visitor demographics, behavior, digital interaction experiences, and perceptions of the Red Fort Museum's efforts towards sustainability and inclusivity. The majority of visitors fall within the 18-30 age group (70%), with smaller percentages represented by those aged 31-60 (23%) and over 60 (7%). Most respondents are local to Delhi (65%), while others hail from areas like Lucknow, West Bengal, and Mumbai (23%). This distribution reflects the museum's broad appeal, particularly among young adults and local residents. Over half of the visitors (54%) were first-timers, indicating a significant draw for new audiences, while 23% reported occasional visits, and the rest were regular patrons. The primary motivations for visiting included exploring the Red Fort itself (57%), leisure (29%), and educational purposes (14%). These findings suggest a strong connection between the museum's heritage value and visitor interests. Social media emerged as the leading source of awareness (43%), followed by word of mouth (26%) and the museum's official website (24%), highlighting the importance of digital outreach in attracting visitors. Regarding value perception, 70% of visitors considered the 100 INR ticket price worthwhile, underscoring the museum's perceived value for money.

All surveyed visitors engaged with the museum's digital exhibits, with popular features including interactive displays, energy-efficient LED lighting, multilingual interfaces, and accessible touchscreens. These digital enhancements were widely praised for significantly enriching the visitor experience and increasing accessibility. Notably, the multilingual options and touchscreens received positive feedback for enhancing usability among diverse audience groups. Visitors emphasized the importance of sustainable practices, such as the integration of solar panels and the adaptive reuse of historic buildings. However, while opinions on the museum's sustainability efforts were mixed, there were calls for more robust adoption of renewable energy sources. Inclusivity efforts were generally well-received, though some visitors noted the need for further enhancements to better cater to all demographics. The museum's interactive exhibits, particularly those featuring games and real-time climate data, were highlighted as standout elements. However, issues such as malfunctioning screens and the need for better maintenance of digital devices were frequently mentioned. Visitors recommended increasing the use of sustainable energy and expanding the museum's technological offerings, such as additional holographic and 3D sound exhibits. Visitors suggested regular maintenance checks for interactive devices to ensure consistent functionality. Expanding sustainable practices, such as increased use of renewable energy, was also recommended, along with efforts to enhance inclusivity through more multilingual and accessible features.

Table 2: Matrix of Parameters for Visitors Survey

Category	Subcategory	Key Insights

Demographics	➢ Age Group Distribution	• 70% are 18-30 years old; 23% are 31-60; 7% are Over 60; 2% are Under 18.
	➢ Visitor Origin	• 65% from Delhi; 23% from Outside Delhi; few from Lucknow, West Bengal, Mumbai.
Visitor Behavior	➢ Visit Frequency	• 54% first-time visitors; 23% occasional; 18% regular; 7% frequent.
	➢ Purpose of Visit	• 57% visited for Red Fort; 29% for leisure; 14% for education.
Awareness and Perception	➢ Sources of Awareness	• 43% through Social Media; 26% by Word of Mouth; 24% via Museum Website.
	➢ Ticket Value Perception	• 70% rated the 100 INR ticket as highly worthwhile.
Digital Interaction	➢ Digital Exhibit Interaction	• All visitors engaged with digital exhibits.
	➢ Features Used	• Interactive displays, multilingual interfaces, and energy-efficient lighting are most used.
	➢ Experience Enhancement	• Digital exhibits significantly enhanced the overall visitor experience.
	➢ Accessibility & Usability	• Positive feedback on multilingual interfaces and accessible touchscreens.
Sustainability & Inclusivity	➢ Importance of Sustainability	• Visitors emphasize the need for sustainable practices in museums.
	➢ Importance of Inclusivity	• Strong belief that museums should ensure inclusivity in exhibits.
	➢ Effectiveness in Sustainability	• Mixed opinions on current efforts; suggestions for sustainable energy use noted.
	➢ Effectiveness in Inclusivity	• Positive feedback but room for more inclusive measures.
Appeal & Improvements	➢ Appealing Features	• Interactive nature of exhibits, games, and climate data are highly appreciated.
	➢ Suggested Improvements	• Frequent maintenance of digital devices; more sustainable energy use recommended.
	➢ Additional Comments	• Suggestions for more holograms, 3D sound exhibits, and improved

		maintenance of interactive elements.

Apart from this, various articles and interviews informed that the total daylight savings due to the usage of solar panels were 70% (Verma, 2018), the building width is around 18m and the space inside the building is divided into three bays with the central bay (around 10m wide) has been developed as the open exhibitions pods and the side bays serves as corridors with interactive and engaging games and with extra daylighting coming from outside. The daylight has been utilised for minimising the energy consumption. In total, there are total ten unique game or interactive elements in the museum which are as follows: **i.** ***Palette Slide*** for timeline activity; **ii.** ***Tameer***: Magnetic puzzle for building the blocks Red Fort wall; **iii.** ***Replica of Merlon*** (Real Scale to compare User Height); **iv.** ***Chattabazar***: Covered Market Place (live artist performs market at that time); **v.** Royal entrance at ***Naubat Khana*** (music play while play with animation); **vi.** ***Scenes from Shahjahan eyes***: Virtual Reality; **vii.** ***Hamam (Public Bath) Fragrance***: Button to spray the fragrance of Hammam; ***viii. Puzzle of the Plan*** of the fort; ***ix. Unity in Diversity*** (To promote secularism and play the Vande Mataram with 05 different instruments) and ***x. Unity gallery***: (Multiple Mirror reflecting the etched Ashoka Chakra).

Table 3: Energy Consumption Before and after implementation of interventions

Metric	**Before Implementation**	**After Implementation**	**Change**
Energy Consumption (kWh)	**3,000,000* kWh**	**900,000 kWh**	**-70%**
Carbon Emissions (kg CO2)	**2,610,000* kg CO2**	**783,000 kg CO2**	**-77%**
Visitor Interaction with Climate-Conscious Exhibits	**0 %**	**35%**	**+35%**
Visitor Satisfaction (Overall)	**60%**	**80%**	**+20%**

***** *Electrical Calculation based on Annual Electricity Bill, where 10 INR is the rate for per kWh and the annual electricity is 30 million INR. And the reduction after post intervention was about 70 %.* (Verma, 2018)

Conclusion and Recommendations

This research study highlights the critical role that digital technologies can play in enhancing sustainability and inclusivity in museums, using the Red Fort Museum in Delhi as a case study. The findings demonstrate that the implementation of energy-efficient digital exhibits and interactive technologies has led to significant improvements in both environmental and social outcomes. Specifically, the museum achieved a 70% reduction in energy consumption and a 77% decrease in carbon emissions, underscoring the effectiveness of adopting sustainable digital practices. Furthermore, the introduction of climate-conscious exhibits resulted in a 35% increase in visitor interaction, while the inclusivity measures, such as multilingual interfaces and accessible touchscreens, led to a 20% increase in overall visitor satisfaction.

The study addresses a notable gap in the existing literature by providing empirical evidence on the practical application of digital technologies in real-world museum settings, particularly in the context of sustainability and inclusivity. By documenting the innovative practices at the Red Fort Museum, this research offers a valuable model for other cultural institutions seeking to integrate digital technologies to meet their sustainability goals. The study also highlights the importance of continuous maintenance and the need for further advancements in digital offerings to sustain visitor engagement and satisfaction.

Some of the recommendations based on the study is that museum should build on energy reduction by integrating more renewable energy sources like advanced solar panels and wind turbines, aiming for greater energy independence. Regularly maintain digital exhibits to ensure functionality and longevity. Consider introducing new interactive features like holographic displays and 3D sound to enhance visitor engagement. Increase language options for a broader audience and add more accessible elements, such as tactile exhibits and audio descriptions, to make the museum more inclusive. Continue developing gamified and interactive exhibits to make learning more engaging and impactful for visitors. Strengthen ties with the local community through outreach programs, workshops, and social media to raise awareness and attract a diverse audience. Establish a system for continuous visitor feedback through surveys and focus groups to guide ongoing improvements and meet visitor needs.

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