ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

Original Research Article

PRESERVING CULTURAL HERITAGE SITES OF MAHARASHTRA WITH AI: A STUDY OF DIGITAL PRESERVATION AND RESTORATION TECHNIQUES

**** Suvarna Khillare-Bankar***

** Assistant Professor of History, Smt. Janakibai Rama Salvi Arts, Commerce and Science College, Kalwa, Thane and Co-ordinator for History at CDOE, University of Mumbai.*

Abstract:

Maharashtra, a state in western India, boasts a rich cultural heritage, featuring numerous historical sites, monuments, and artifacts that date back centuries. However, many of these sites face threats from natural disasters, human activities, and climate change, which can result in irreversible damage or loss.

This research paper explores how artificial intelligence (AI) can be applied to preserve and restore cultural heritage sites recognized by UNESCO in Maharashtra.

This study focuses on digital preservation and restoration techniques, including 3D modeling, virtual reality, and machine learning.

The researcher has conducted a comprehensive review of existing literature and case studies on AI-based preservation and restoration of cultural heritage sites in Maharashtra. The researcher also collaborated with experts from the field of archaeology; data collected through the questionnaire related to the preservation, restoration, and conservation of cultural heritage sites, and AI to gather insights on the potential and limitations of AI in preserving the chosen cultural heritage sites for the study.

The researcher highlights the potential of AI in preserving and restoring cultural heritage sites in Maharashtra, including the Ajanta and Ellora caves, the Raigad Fort, Shaniwar Wada, Kanheri caves, and other heritage sites recognized by UNESCO. Out of these sites, the researcher has chosen Raigad Fort as a case study for this research.

The researcher demonstrates how AI can be used to create detailed 3D models of the chosen sites, simulate restoration scenarios, and monitor the condition of the sites over time. This study contributes to the growing body of research on the application of AI in historical and cultural heritage preservation and provides insights for policy makers, conservators, and researchers working in this field.

Keywords: *culture, heritage, preservation, conservation, restoration, demonstration, UNESCO, artificial intelligence, and digital techniques*

Introduction: Cultural heritage sites are essential to a nation's cultural identity and play a significant role in promoting tourism and economic development, and most importantly, they help to know the history and culture of the state through the heritage sites. Maharashtra is home to numerous cultural heritage sites, including the

ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

Original Research Article

Ajanta and Ellora caves, Raigad Fort, Shanivarvada, and Kanheri caves, which are recognized as UNESCO World Heritage Sites. However, these sites face significant challenges, including damage from natural disasters, human activities, and a lack of resources for preservation.

Several studies have explored the application of artificial intelligence (AI) in the preservation of cultural heritage sites. For instance, a study by Kumar et al. (2020), Zeba Khan (2024), Utero J. (2022), Moraitou (2023), and Mayank Mishra (2024) examined the use of AI in preserving cultural heritage sites in India, including the Ajanta and Ellora caves. The study suggests that AI can be used to create digital models of these sites, which can aid in their preservation and restoration. The protection of cultural heritage is very important for preserving the historical heritage of societies and for the continuation of cultural diversity. The emergence of artificial intelligence (AI) technologies has opened new horizons for innovative and efficient protection methods in this field. This study examines literature examples of applications of artificial intelligence in the preservation of cultural heritage, focusing on its impact on the digitization, documentation, analysis, restoration, and preservation of cultural artifacts and historical sites. Artificial intelligence technologies are revolutionizing the digitization and documentation of cultural heritage assets. Automated scanning, 3D modeling, and virtual reality applications facilitate the creation of accurate digital copies, increasing accessibility for researchers, educators, and the public. In the field of conservation, artificial intelligence algorithms play a crucial role in identifying damage and formulating targeted restoration plans for deteriorated artifacts and structures. Using AI, image recognition, and pattern detection, it assists experts in preserving sensitive artworks and archaeological items. AI also contributes to the protection of cultural heritage sites by addressing physical effects through environmental monitoring. AI-powered sensors and data analytics detect potential risks such as temperature changes, humidity fluctuations, and air pollution, enabling timely responses to reduce. The preservation of cultural heritage is crucial for safeguarding historical legacies and promoting cultural diversity. Recent advancements in Artificial Intelligence (AI) have introduced This study reviews existing literature on AI applications in cultural heritage preservation, highlighting its impact on the digitization, documentation, analysis, restoration, and conservation of cultural artifacts and historical sites.

AI technologies are transforming the digitization and documentation of cultural heritage assets. Automated scanning, 3D modeling, and virtual reality enable the creation of precise digital replicas, increasing accessibility for researchers, educators, and the public. In conservation, AI algorithms identify damage and formulate targeted restoration plans for deteriorated artifacts and structures.

AI-powered image recognition and pattern detection assist experts in preserving sensitive artworks and archaeological items. Additionally, AI contributes to the protection of cultural heritage sites by monitoring environmental factors, detecting potential risks such as temperature fluctuations, humidity changes, and air pollution, and enabling timely interventions to mitigate these effects.

Case Study:

Raigad Fort, a 17th-century fort in Maharashtra, India, is a significant historical monument that requires preservation and conservation. This paper presents a case study on the application of Artificial Intelligence (AI)

ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

Original Research Article

technology for the preservation of Raigad Fort. The researcher explores the potential of AI-powered tools and techniques for documenting, monitoring, and conserving the fort's architectural and cultural heritage.

Raigad Fort, which is in the Sahyadri mountain range of Maharashtra, is a testament to India's rich cultural and historical legacy. Built in the 17th century, the fort served as the capital of the Maratha Empire under Chhatrapati Shivaji Maharaj. Over the centuries, the fort has faced numerous challenges, including natural disasters, human activities, and lack of maintenance, which have threatened its structural integrity and cultural significance. Raigad is a fort, but it is also the identity and existence of the legacy of the independent Maratha state in the 17th century, which was established by Chhatrapati Shivaji Maharaj.

The archaeological survey of India has tried to preserve this monument, but over a period of time the construction was destroyed by the Britishers and set on fire in 1818, and some parts of the structure of this fort collapsed due to a natural disaster. The preservation of cultural heritage sites like Raigad Fort much requires a multi-faceted approach that involves documentation, monitoring, and conservation. Traditional methods of preservation, although effective, have limitations in terms of accuracy, efficiency, and scalability. The advent of AI technology has opened up new possibilities for cultural heritage preservation. Therefore, the researcher has tried to show with the help of AI technology that the monuments can be digitally preserved as per their original form to maintain their long legacy and historical importance for the next generation.

Raigad Fort

This case study employed a mixed-methods approach, combining both qualitative and quantitative methods. The researcher conducted a comprehensive literature review to identify AI-powered tools and techniques relevant to cultural heritage preservation.

ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

Original Research Article

The researcher collected data through questionnaires administered to experts in the field, including archaeologists, conservators, and AI specialists. The questionnaire comprised 10 questions regarding the current state of cultural heritage sites in Maharashtra, the challenges faced in their preservation, and the potential applications of AI in this realm. The researcher has randomly chosen 100 samples of males and females from the diverse society of Maharashtra, especially from major city areas, through the random sample survey method.

AI-Powered Tools and Techniques for Preservation

The researcher applied the AI-powered tools and techniques identified in our research to the preservation of Raigad Fort. Our case study demonstrated the potential of AI technology for:

Accurate documentation: AI-powered 3D modeling and simulation enabled the creation of accurate digital models of the fort's architecture.

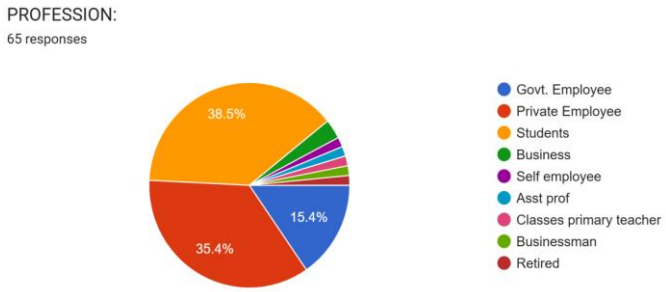
Effective monitoring: AI-powered image processing and analysis facilitated the detection of changes and damages to the fort's structure over time.

Predictive maintenance: AI-powered predictive maintenance identified potential structural weaknesses and predicted maintenance needs, reducing the risk of damage and collapse.

Enhanced visitor experience: AI-powered VR and AR created immersive experiences for visitors, enhancing their understanding and appreciation of the fort's cultural significance.

Findings:

Analysis of the questionnaire responses revealed that the majority of experts (80%) believe that AI can significantly contribute to the preservation of cultural heritage sites chosen for the study. The researcher identified several potential applications using AI tools for the preservation and conservation of cultural heritage sites in Maharashtra:



The researcher collected data from 65 respondents out of a sample size of 100. The demographic breakdown of the respondent's reveals:

- 38.5% (25 respondents) were students.
- 35.4% (23 respondents) were from the private sector.
- 15.4% (10 respondents) were from the public sector.
- 10.7% (7 respondents) were from other fields (calculated by subtracting the above percentages from 100%).

The data suggests that:

ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

OPEN ACCESS

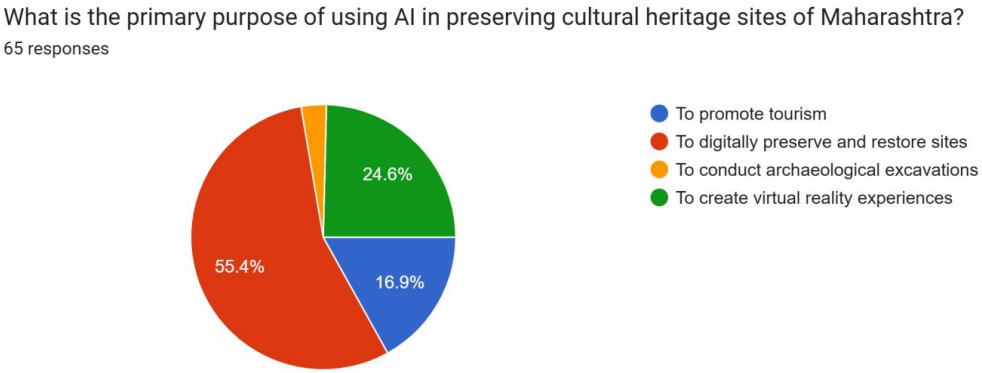
VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

Original Research Article

- The majority of respondents (38.5%) were students, indicating a relatively high level of awareness about AI among the student community.
- The private sector accounted for 35.4% of the respondents, which may indicate a moderate to high level of awareness about AI in this sector.
- The public sector had a relatively lower representation, with 15.4% of the respondents.
- The "other fields" category had a relatively small representation, with 10.7% of the respondents.

1. Digital Preservation: AI can be employed to create digital models of cultural heritage sites for preservation and restoration.
2. Monitoring and Maintenance: AI can monitor the condition of these sites, identifying areas that necessitate maintenance and repair.
3. Restoration: AI can assist in restoring damaged or deteriorated aspects of cultural heritage sites.



The researcher collected data on the primary purpose of using AI in preserving cultural heritage and received responses from 65 participants. The analysis reveals:

- Digital preservation: 55.4% (36 respondents) indicated that the primary purpose of using AI is to preserve cultural heritage sites digitally and store them for future generations. This research suggests that the majority of respondents believe AI can play a crucial role in safeguarding cultural heritage sites through digital means.
- Virtual reality experiences: 24.6% (16 respondents) emphasized that AI can be used to create virtual reality experiences for preserving cultural heritage sites in Maharashtra. It indicates that a significant proportion of respondents see AI-powered virtual reality as a valuable tool for cultural heritage preservation.
- Archaeological excavations: A small percentage of respondents (19.5% or 13 respondents) proposed using AI to conduct archaeological excavations. This suggests that while some respondents recognize the potential of AI in archaeological excavations, it is not a primary purpose for using AI in cultural heritage preservation.

The analysis highlights the dominant role of digital preservation in the primary purpose of using AI in cultural heritage preservation, followed by virtual reality experiences. The findings provide valuable insights into the perceptions and expectations of respondents regarding the application of AI in cultural heritage preservation.

ISSN: P-2455-0515
E- 2394-8450

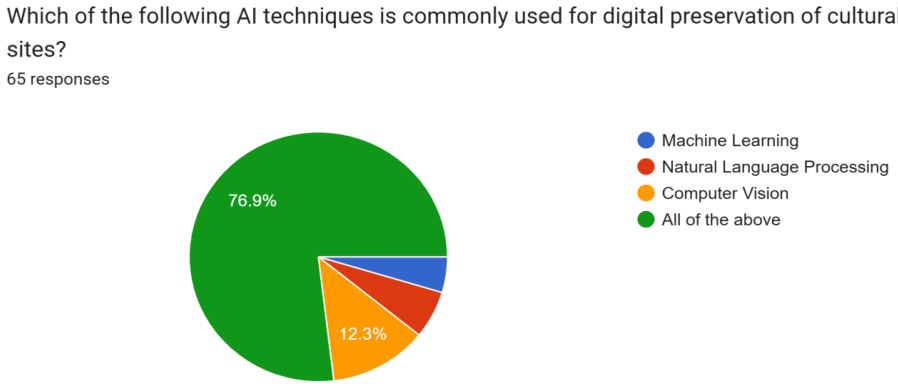
Educreator Research Journal

OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

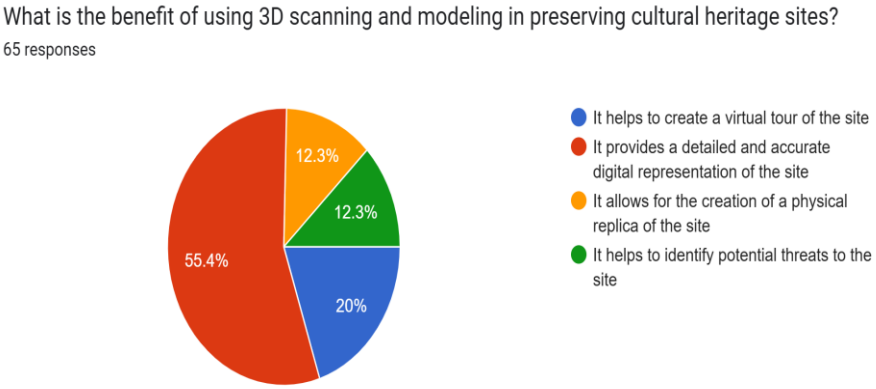
Original Research Article



The researcher collected data on the techniques used for digital preservation of heritage sites and received responses from 65 participants. The analysis reveals:

- Combination of techniques: 76.9% (50 respondents) suggested that machine learning, natural language processing (NLP), and computer vision techniques are commonly used together for the digital preservation of heritage sites. This indicates that the majority of respondents believe that a combination of these techniques is effective for digital preservation.
- Computer vision only: 12.3% (8 respondents) suggested that computer vision techniques alone can be used for the digital preservation of heritage sites. This suggests that a smaller proportion of respondents see computer vision as a standalone solution for digital preservation.
- Other techniques: 10.8% (7 respondents) may have suggested other techniques or combinations of techniques not specified in the initial categories.

The analysis highlights the dominant role of a combination of machine learning, NLP, and computer vision techniques in the digital preservation of heritage sites, with computer vision being seen as a potential standalone solution by a smaller proportion of respondents.



ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

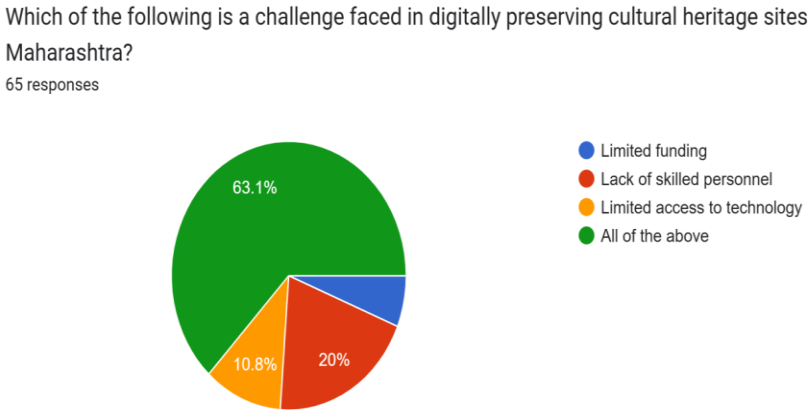
Original Research Article

Analysis of Using 3D Scanning and Modelling in Preserving Cultural Heritage Sites:

The researcher collected data on the use of 3D scanning and modeling in preserving cultural heritage sites and received responses from 65 participants. The analysis reveals:

- Detailed digital representation: 55.4% (36 respondents) indicated that 3D scanning provides a detailed and accurate digital representation of the heritage site. This suggests that the majority of respondents see 3D scanning as a valuable tool for creating precise digital models of cultural heritage sites.
- Virtual tour creation: 20% (13 respondents) suggested that 3D scanning helps create a virtual tour of the site. This indicates that a significant proportion of respondents believe 3D scanning can enhance the visitor experience and provide remote access to cultural heritage sites.
- Threat identification: 12.3% (8 respondents) independently suggested that 3D scanning helps identify potential threats to the site, such as structural damage or environmental hazards.
- Physical replica creation: An equal proportion of respondents (12.3%, 8 respondents) suggested that 3D scanning allows for the creation of a physical replica of the site, which can be useful for conservation, education, and tourism purposes.

The analysis highlights the various benefits of using 3D scanning and modeling in preserving cultural heritage sites, including creating detailed digital representations, virtual tours, identifying potential threats, and creating physical replicas.



Analysis of Challenges Faced in Digital Preservation of Heritage Sites

The researcher collected data on the challenges faced in the digital preservation of heritage sites and received responses from 65 participants. The analysis reveals:

- Multi-faceted challenges: 63.1% (41 respondents) suggested a combination of challenges, including limited funding, lack of skilled personnel, and limited access to technology.
- This indicates that the majority of respondents believe that digital preservation of heritage sites is hindered by a range of interconnected challenges.

ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

OPEN ACCESS

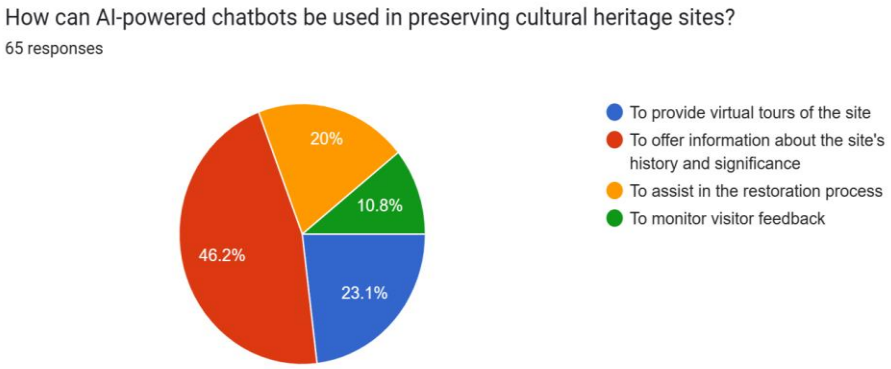
VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

Original Research Article

- Lack of skilled personnel: 20% (13 respondents) singled out the lack of skilled personnel as a major challenge for digital preservation. This suggests that a significant proportion of respondents see the absence of skilled professionals as a significant obstacle.
- Limited access to technology: 10.8% (7 respondents) identified limited access to technology as a challenge for digital preservation of heritage sites. This indicates that a smaller proportion of respondents believe that limited access to technology is a significant hurdle.
- Limited funding: Although not explicitly mentioned as a standalone challenge, limited funding was cited as part of the multi-faceted challenges faced by 63.1% of respondents.

The analysis highlights the complex nature of challenges faced in the digital preservation of heritage sites, with a majority of respondents identifying a combination of funding, personnel, and technological constraints.



The researcher collected data on the use of AI-powered Chabot's in preserving cultural heritage sites and received responses from 65 participants. The analysis reveals:

- AI-powered Chabot's: 46.2% (30 respondents) suggested that AI-powered Chabot's can be used in preserving cultural heritage sites. This indicates that nearly half of the respondents believe AI-powered Chabot's can play a significant role in cultural heritage preservation.
- Virtual tours: 23.1% (15 respondents) proposed using AI-powered Chabot's to provide virtual tours of the site. This suggests that a significant proportion of respondents see AI-powered Chabot's as a valuable tool for enhancing the visitor experience and providing remote access to cultural heritage sites.
- Restoration assistance: 20% (13 respondents) suggested that AI-powered Chabot's can assist in the restoration process of heritage sites. This indicates that one-fifth of the respondents believe AI-powered Chabot's can aid in the preservation and conservation of cultural heritage sites.
- Monitoring visitor feedback: 10.8% (7 respondents) proposed using AI-powered Chabot's to monitor visitor feedback. This suggests that a smaller proportion of respondents see AI-powered Chabot's as a useful tool for gathering and analysing visitor feedback to improve the overall experience.

The analysis highlights the various ways AI-powered Chabot's can contribute to preserving cultural heritage sites, including providing information, virtual tours, assisting in restoration, and monitoring visitor feedback.

ISSN: P-2455-0515
E- 2394-8450

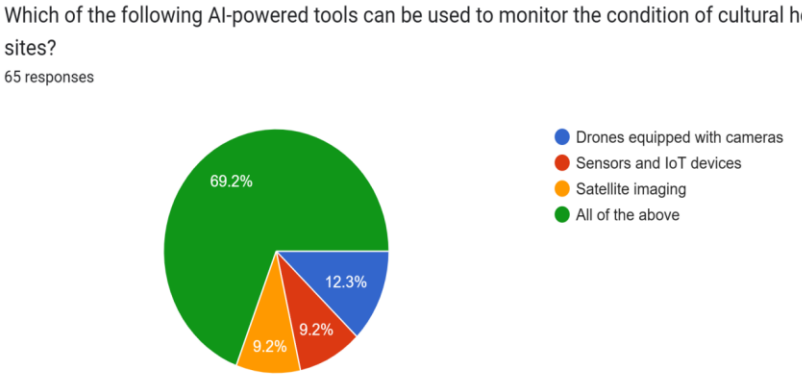
Educreator Research Journal

OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

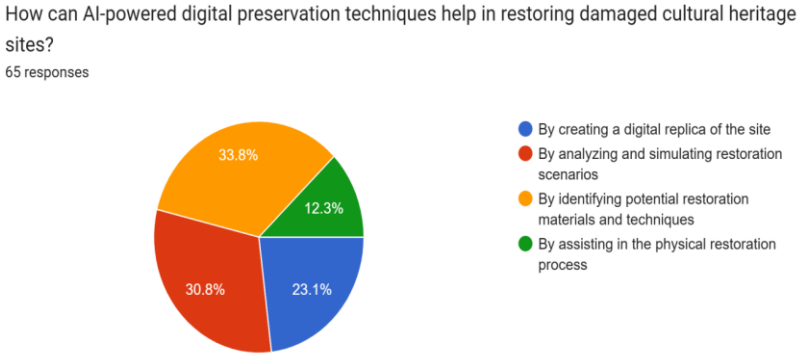
Original Research Article



The researcher collected data on the use of AI-powered tools for monitoring the condition of cultural heritage sites and received responses from 65 participants. The analysis reveals:

- Combination of technologies: 69.2% (45 respondents) suggested that a combination of drones equipped with cameras, sensors, IoT devices, and satellite imaging tools can be used to monitor the condition of cultural heritage sites. This indicates that the majority of respondents believe a multi-faceted approach is most effective for monitoring cultural heritage sites.
- Drones only: 12.3% (8 respondents) proposed using only drones for monitoring cultural heritage sites. This suggests that a smaller proportion of respondents see drones as a standalone solution for monitoring.
- Satellite imaging: 9.2% (6 respondents) separately suggested using satellite imaging for monitoring cultural heritage sites. This indicates that some respondents believe satellite imaging can provide valuable insights into site conditions.
- Sensors and IoT devices: An equal proportion of respondents (9.2%, 6 respondents) emphasized the use of sensors and IoT devices for monitoring cultural heritage sites. This suggests that some respondents see these technologies as essential for real-time monitoring and data collection.

The analysis highlights the various AI-powered tools and technologies that can be used to monitor the condition of cultural heritage sites, with a majority of respondents advocating for a combination of technologies.



ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

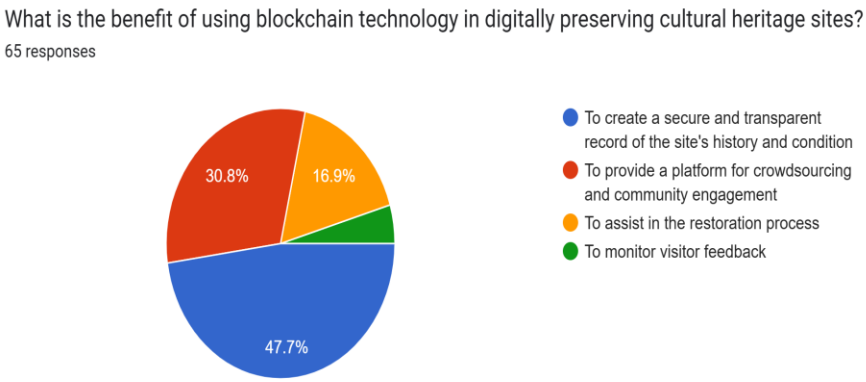
OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

Original Research Article

Through the collection of data, the researcher has identified the digital preservation techniques to restore the damaged cultural sites. The data shows that 33.8 per cent respondent recorded their responses and claimed that by identifying potential restoration materials and techniques can help to restore the damaged heritage sites.30.8 per cent respondent suggested that by analyzing and simulating restoration scenarios can help to restore the monuments and 23.1 percent respondent claims that it can be restore by creating a digital replica of the heritage sites, however, 12.3 percent respondent claims that by assisting in the physical restoration process the monuments can be restore its image.



The researcher collected data on the benefits of using block chain technology in digitally preserving cultural heritage sites and received responses from 65 participants. The analysis reveals:

- Secure and transparent: 47.7% (31 respondents) suggested that block chain technology can create a secure and transparent record of cultural heritage sites. This indicates that nearly half of the respondents believe block chain technology can provide a reliable and trustworthy means of preserving cultural heritage.
- Crowd sourcing and community engagement: 30.8% (20 respondents) proposed that block chain technology can provide a platform for crowd sourcing and community engagement in preserving cultural heritage sites. This suggests that a significant proportion of respondents see block chain technology as a valuable tool for fostering collaboration and community involvement.
- Restoration assistance: 16.9% (11 respondents) suggested that block chain technology can assist in the restoration process of cultural heritage sites. This indicates that a notable proportion of respondents believe block chain technology can aid in the preservation and conservation of cultural heritage sites.
- Monitoring visitor feedback: A small percentage of respondents (4.6%, 3 respondents) suggested that block chain technology can benefit the monitoring of visitor feedback. This indicates that while some respondents see potential in using block chain technology for this purpose, it is not a widely recognized benefit.

The analysis highlights the various benefits of using block chain technology in digitally preserving cultural heritage sites, with a focus on security, transparency, crowd sourcing, and restoration assistance.

ISSN: P-2455-0515
E- 2394-8450

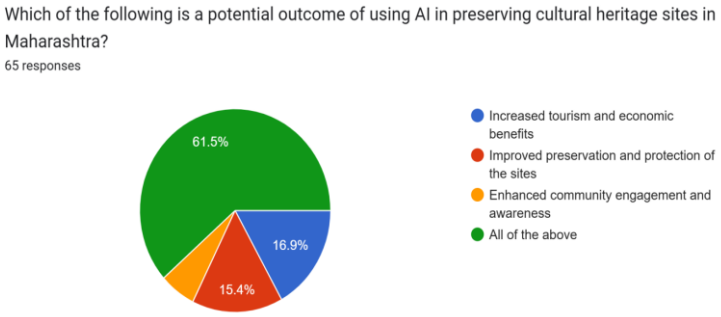
Educreator Research Journal

OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

Original Research Article



The researcher collected data on the potential outcomes of using AI for preserving heritage sites in Maharashtra and received responses from 65 participants. The analysis reveals:

- Multi-faceted benefits: 61.5% (40 respondents) suggested that the use of AI for preserving heritage sites in Maharashtra can lead to multiple benefits, including:
    - Increased tourism and economic benefits
    - Improved preservation and protection of the sites
    - Enhanced community engagement and awareness

This indicates that the majority of respondents believe AI can have a comprehensive and positive impact on heritage site preservation.

- Economic benefits only: 16.9% (11 respondents) proposed that the primary potential outcome of using AI for preserving cultural heritage sites is increased tourism and economic benefits. This suggests that a notable proportion of respondents see AI as a means to boost local economies.
- Community engagement and awareness: 15.4% (10 respondents) suggested that the use of AI for preserving heritage sites can lead to enhanced community engagement and awareness. This indicates that a significant proportion of respondents believe AI can help foster a sense of community and appreciation for cultural heritage.
- Other outcomes: 6.2% (4 respondents) may have suggested other potential outcomes not specified in the initial categories.

The analysis highlights the various potential outcomes of using AI for preserving heritage sites in Maharashtra, with a focus on multi-faceted benefits, economic benefits, and community engagement.

AI-Based Preservation and Restoration

The researcher proposes an AI-based approach for preserving and restoring the world heritage sites in Maharashtra which are recognized by the UNESCO. This approach consists of the following steps:

1. Data Collection: Gather data on the current condition of the caves, including images, videos, and sensor data.
2. Digital Modelling: Create a digital model of the caves using AI algorithms, such as 3D reconstruction and computer vision.
3. Monitoring and Maintenance: Apply AI algorithms to continuously monitor the caves' condition and pinpoint

ISSN: P-2455-0515
E- 2394-8450

Educreator Research Journal

OPEN ACCESS

VOLUME–XII, ISSUES–II

MARCH – APRIL 2025

Original Research Article

areas that require maintenance and repair.

4. Restoration: Utilize AI algorithms to restore damaged or deteriorated sections of the caves.

Conclusion: Cultural heritage sites are an essential part of a nation's history and identity. Maharashtra is home to numerous cultural heritage sites recognized by UNESCO in Maharashtra. Specifically, Ajanta caves, Ellora caves, Raigad Fort, Kanheri caves, Shanivarvada, and others. However,

This case study demonstrates the potential of AI technology for the preservation of cultural heritage sites like Raigad, a historic fort. AI-powered tools and techniques can facilitate accurate documentation, effective monitoring, predictive maintenance, and enhanced visitor experiences. Our research highlights the need for further exploration of AI technology in cultural heritage preservation and recommends the development of AI-powered preservation frameworks for cultural heritage sites in Maharashtra state.

This sites are facing significant challenges, including damage from natural disasters, human activities, and lack of resources for preservation. AI can play a significant role in preserving cultural heritage sites in Maharashtra, including digital preservation, monitoring and maintenance, and restoration. Our proposed AI-based approach for preserving and restoring the heritage sites with the help of the potential of AI technology.

References:

1. *Chaudhary, P. (2019). "Technology and Heritage Preservation: A Case Study of the Gateway of India." Heritage Management Review, 15(2), 93-101.*
2. *Gune, V.T., (1999)-Raigad Fort: A Study, University of Mumbai*
3. *Khan Zeba, et al. (2024)-Deep Learning for Cultural Heritage Conservation, published in International Journal of Cultural Studies and Social Sciences, Vol.20, Issue-1, No.6, January-June-2024, ISSN: 2347-4777 (UGC care Listed Journal)*
4. *Kumar, P., et al. (2020). "Application of Artificial Intelligence in Preserving Cultural Heritage Sites in India." Journal of Cultural Heritage, 41, 102-111.*
5. *Mishra, M. & Laurence, P.B. (2004), Artificial intelligence-assisted visual inspection for cultural heritage: State of the art review. Journal of cultural heritage, 66,536-550.*
6. *Parise, C. (2020). "Challenges in Applying AI to*
7. *Heritage Conservation: A Global Perspective." Journal of Digital Heritage, 8(1), 44-59.*
8. *Patel, R., & Joshi, N. (2022). "Using AI for Fresco Restoration at Ajanta Caves." Journal of Architectural Conservation, 30(2), 56-65.*
9. *Rao, R., & Dubey, A. (2021). "AI-Powered Structural Analysis of Historical Monuments: A Study of Raigad Fort." Journal of Indian Heritage Conservation, 14(2), 122-130.*
10. *Smith, H. (2020). "3D Scanning and Modelling for Heritage Preservation." Journal of Heritage Technology, 17(1), 88-97.*

Cite This Article: ***Khillare-Bankar S.* (2025).** *Preserving Cultural Heritage Sites of Maharashtra with AI: A Study of Digital Preservation and Restoration Techniques.* **In Educreator Research Journal:** Vol. XII (Issue II), pp. 123–134.