



Preventive Conservation and Risk Assessment of Museum Collections: A Case Study of Lok Virsa Heritage Museum, Islamabad

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Abstract

This paper discusses preventive conservation issues and risk factors of the collections in the Lok Virsa Heritage Museum, Islamabad. Qualitative, diagnostic, research design is the method through which the study will combine field observations, document analysis, and semi-structured interviews to help identify major threats to museum objects and infrastructure. The discussion will be organized based on the Canadian Conservation Institute (CCI) system of agents of deterioration (environmental, biological, and human-induced). The results suggest that dusts, changes in temperature and humidity, exposure to light, and water, pests, and lack of proper security measures are some of the primary risks. These aspects cause material decay, structural erosion, and cultural erosion. The research points at the lack of systematic environmental surveillance and preventive conservation procedures in the institution. Although the research relies on the conceptual support of the previous GIS-based research, it focuses on the practical and low-cost mitigation measures specific to the work of museums in the developing countries. The research will also help improve heritage conservation since it provides a systematic method of risk evaluation that may be used in other cultural institutions.

Keywords: Preventive conservation; Risk assessment; Museum collections; Cultural heritage management; Agents of deterioration

Introduction

The Lok Virsa Heritage Museum in Islamabad represents a significant repository of Pakistan's cultural heritage, showcasing diverse ethnographic materials including textiles, pottery, musical instruments, and traditional crafts. This study contributes by applying a structured risk assessment model in a developing-country museum context, where such frameworks are rarely implemented. Preventive conservation, a proactive approach to heritage preservation, aims to mitigate the deterioration of cultural artifacts by identifying and reducing potential hazards within their surrounding environment (Al-Allaf, 2014; KUZUCUOĞLU, 2017). Geographic information systems (GIS) have become a standard instrument in archeological studies, which allow analyzing spatial relationships, terrain variables, and landscape patterns that can determine site location and maintenance (Ahmad et al., 2025). The concept is a systematic risk assessment, which includes aspects of environmental changes, pollutant exposure, and the vulnerable nature of old buildings (Bahtiyar and Disli, 2022; Elnaggar et al., 2024). An invaluable part of this methodology is risk



quantification of a collection to characterize the most economical way of decreasing the general degeneration (Waller, 1994). This will require a thorough knowledge of all possible hazards and values that need to be preserved as well as an estimation of the effects of past hazards, existing conservation effectiveness, and future change predictability (Bigenwald & Waller, 2004). These evaluations have been more popular in the heritage sector in the last 20 years, commonly based on dose-response functions and algorithms such as preservation metrics to simulate degradation rates and set priorities of intervention (Bertolin et al., 2019). This preventive conservation method is largely based on sound documentation and constant monitoring of environmental parameters and may involve sensor data in addition to documented observations to make conservation decisions of both movable and immovable heritage (Moyano et al., 2023). This is especially important in the light of the growing challenges of climate change, which requires that the risks associated with climate change should be incorporated into the risk assessment frameworks that are currently being used (Dimabayao et al., 2025). Although numerous studies exist on this topic, the creation of a universally accepted approach to the issue of vulnerability assessment, particularly with regard to cultural heritage protection in the face of fluctuating climatic conditions, is a debated issue (Cacciotti et al., 2024). This is exacerbated by the fact that heritage buildings are becoming more susceptible to environmental pressures (air pollution and climate change), which commonly cannot be sufficiently counteracted with conventional forms of preservation (Laohaviraphap & Waroonkun, 2024). The geomorphological processes have been greatly influenced by human activities over the years, and these processes have changed landscapes due to settlement growth and development, agricultural activities, and infrastructure (Ahmad et al., 2025). These interactions are difficult to comprehend, which is why a comprehensive approach that incorporates the identification of hazards, vulnerability analysis, and exposure analysis is needed to develop effective mitigation strategies (Battisti et al., 2024). This combined methodology focuses on the interdependence of risk elements (hazard, exposure, and vulnerability) to assess the risks to cultural heritage assets comprehensively as opposed to the physical losses (Ravan et al., 2023). This is where damage is not only dictated by the changes in material but also by human interpretation of the influence of the changes of the intrinsic values of an object on it (Coppola et al., 2020). The effectiveness of the preventive conservation, in turn, depends on the combination of condition surveys and monitoring with sound risk assessment techniques that can predict the possible performance loss because of particular hazardous events (Lourenco et al., 2022). This specifically applies to various collections found in museums such as the Lok Virsa Heritage Museum where a vast range of artifacts with distinct material compositions and sensitivities needs specific preservation approaches to multifaceted environmental hazards (Cacciotti et al., 2024). The paper will add to the literature on the concept of preventive conservation by offering a qualitative risk evaluation model that can be used in a museum setting in the developing world.

Literature Review

This review integrates the current research on advanced preservation technique, with a focus on integrating artificial intelligence and Internet of Things technologies for better environmental monitoring and risk management in cultural heritage settings (Laohaviraphap & Waroonkun, 2024). Recent



development of AI-driven systems for decision support systems have led to sophisticated tools for analysing complex environmental data and can assist in detecting threats in real time and make proactive intervention strategies to protect cultural artifacts (Kuchar et al., 2025). For example, systems such as GEPReS use geospatial data, IoT sensor networks and meteorological information to provide predictive recommendations about the management of historical buildings for timely conservation interventions such as pre-emptive shutter closure in the event of a heatwave or switching on ventilation under high humidity (Dolinska et al., 2025). This tech integration offers a robust decision support platform to cultural asset owners and managers to continue monitoring and allocating resources to aid the conservation of those assets, especially vulnerable structures and artifacts (Montuori, 2024). Furthermore, the use of artificial intelligence and Internet of Things devices can contribute to a significant improvement in prioritizing the interventions of heritage professionals, thus adding value to the conservation of heritage (Torres-Gonzalez et al., 2021). These technologies allow to process enormous amount of data from many different sources, producing a coherent virtual representation of reality, allowing to map and proactively preserve cultural heritage (Casillo et al., 2024). Archaeological sites are becoming increasingly susceptible to natural and anthropogenic pressures, especially because of urbanisation pressure, transportation networks and environmental degradation (Ahmad et al., 2026). Advanced applications of AI in this area is the application of neural networks for the segmentation and classification of point clouds in heritage edifices to permit the detailed parametric modeling inside a Building Information Modeling framework (Barhoumi and Hajji, 2024). Moreover, the extension of deep learning methods, e.g. convolutional neural networks, to image recognition are used for artifact digitalization and monitoring the physical decay of historic structures so that both accurate documentation and detection of anomalies can be performed early on (Geng et al., 2025). Beyond structural analysis, AI is also an important part of the predictive evaluation of deterioration risks, and by combining high-dimensional data processing, it can predict environmental impacts and detect damage patterns in architectural heritage (Tan et al., 2025).

3. Methodology

3.1 Research Design

This study uses diagnostic and qualitative research design in order to identify and assess the conservation challenges faced in the Lok Virsa Heritage Museum in Islamabad. The research is based on the principles of preventive conservation and risk assessment, specifically in the light of the framework of the Canadian Conservation Institute (CCI), which identifies agents of deterioration that are key in heritage collections . The objective of this methodology approach is to systematically record the risks related to the environment, structure and management and propose practical mitigation strategies. The study combines field-based observations with qualitative data collection techniques that will allow understanding of conservation issues in depth in the museum.

3.2 Field Survey and Observational Analysis

Fieldwork was a primary part of this research. Multiple visits were made to the Lok Virsa Heritage museum to see both the present and the previous conditions of the building and its collections. Direct observation made it possible to identify both visible patterns of deterioration, environmental problems and management deficiencies.



The approach to observation included exhibition galleries and display cases, storage areas and infrastructure, environmental conditions (light, temperature, humidity), visitor interaction and movement patterns. This method has given first hand evidence of conservation problems, in particular those of dust build-up, humidity changes, pest activity and risks of physical damage.

3.3 Data Collection Techniques

A combination of qualitative data collection methods was employed:

3.3.1 Document Analysis

The historical development, structural organization and conservation practices of the museum were researched through published material in terms of brochures, institutional records and secondary literature. Analysis of documents offered context and supported the analysis of what was observed in the field.

3.3.2 Interviews

Conducted semi-structured interviews with 96 museum staff members, including gallery attendants and administrative personnel. Interviews with the deputy director and staff members revealed that:

- Existing conservation practices
- Institutional limitations
- Maintenance routines and challenges

Interviews with internal management to understand perspectives, operational constraints were critical.

3.4 Data Analysis

The collected data were systematically analyzed through classification and comparison. Observed issues were categorized according to the CCI agents of deterioration framework, allowing for structured evaluation of risks.

The analysis involved:

- Identifying frequency and severity of each risk factor
- Linking observed damage to specific environmental or managerial causes
- Developing targeted recommendations for risk mitigation

This analytical approach ensured that the findings were both empirically grounded and theoretically informed.

4. Results and Discussion: Conservation Issues and Risk Assessment

4.1 Framework: Agents of Deterioration

The conservation issues identified in the Lok Virsa Heritage Museum were analyzed using the CCI framework, which outlines ten primary agents of deterioration. These include environmental, biological, physical, and human-induced factors that collectively threaten museum collections.

4.2 Pollution and Dust Accumulation

Air pollution and dust were identified as major contributors to material deterioration. Pollutants such as carbon monoxide, sulfur dioxide, and particulate matter enter the museum through ventilation systems, doors, and windows. Dust accumulation on exposed objects leads to surface abrasion, chemical reactions, discoloration and cracking (See Figure 1, 2 & 3).

This issue is particularly critical for organic materials such as textiles and wood.

Discussion

From a conservation perspective, uncontrolled dust indicates poor preventive conservation protocols. Spatial analysis techniques, such issues can be spatially mapped to identify high-risk zones within galleries, especially near entrances and ventilation points. Previous studies have demonstrated that GIS-based spatial analysis can be used to map risk zones within heritage environments (Idrees et

Recommendations

1. Sealing of display cases
2. Use of dust covers and filtration materials
3. Implementation of controlled cleaning protocols
4. Establishment of trained conservation staff

4.3 Temperature and Relative Humidity Fluctuations

Temperature and humidity fluctuations were found to be among the most damaging factors (Figure 4). High temperatures accelerate chemical degradation, while low temperatures cause embrittlement of materials. Fluctuations lead to, efflorescence and subflorescence, structural cracking, material instability (figure 5). Relative humidity imbalance further contributes to deterioration, particularly in organic materials.

Discussion

The absence of environmental monitoring systems highlights a major institutional gap. Microclimatic mapping of humidity and temperature variations could significantly improve conservation planning. Environmental factors such as moisture infiltration, temperature variation, and salt crystallization play a significant role in the deterioration of historic structures and materials (khan et al., 2026).

Recommendations

- Maintain RH between 45–65% and temperature between 18–22°C
- Use humidifiers and dehumidifiers
- Install environmental monitoring sensors
- Improve ventilation systems

4.4 Light Exposure

Improper lighting conditions, including exposure to ultraviolet (UV) and infrared radiation, were observed to cause, fading of pigments, degradation of paper and textiles, thermal fluctuations (Figure 6).

Discussion

Light intensity management is critical in museum conservation. Spatial analysis tools can be used to model light exposure patterns within exhibition spaces.

Recommendations

- Maintain light levels between 50–70 lux
- Use UV filters
- Employ indirect lighting systems
- Protect sensitive objects with enclosures

4.5 Water and Moisture Damage

Water infiltration due to leakage, poor drainage, and rainfall was identified as a significant risk. Moisture leads to material weakening, mold growth and structural damage (Figure 7 & 8).

Discussion

Water-related risks often result from infrastructural neglect. spatial analysis approaches (future application) could help identify drainage patterns and moisture-prone zones around the building.

Recommendations

- Repair roof and drainage systems
- Elevate objects above floor level
- Apply waterproof coatings
- Regular inspection of plumbing systems





4.6 Biological Agents (Pests and Microorganisms)

Pest infestation, particularly termites and insects, poses a severe threat to organic materials. High humidity conditions promote mold growth, biological degradation and structural damage (figure 9 & 10).

Discussion

Integrated Pest Management (IPM) is essential. Spatial monitoring of infestation zones can improve early detection and control.

Recommendations

- Install traps and monitoring systems
- Conduct regular fumigation
- Control humidity levels
- Isolate newly acquired objects

4.7 Theft and Vandalism

Human-induced risks such as theft and vandalism were observed, including graffiti, physical damage by visitors and lack of security measures (Figure 11).

Discussion

This reflects weak institutional control and visitor management. Behavioral mapping (GIS-based visitor flow analysis) can help identify vulnerable areas.

Recommendations

- Install surveillance systems
- Restrict access to sensitive areas
- Improve security protocols
- Enforce visitor regulations

4.8 Physical Forces

Mechanical damage caused by improper handling, vibrations, and structural instability includes cracks and fractures, deformation of objects and structural stress (Figure 12 & 13).

Discussion

Improper display and storage systems increase vulnerability. Spatial planning of storage layouts can minimize risk.

Recommendations

- Secure objects with supports
- Maintain adequate spacing
- Use stable display structures
- Conduct structural assessments

4.9 Fire Risk

Fire hazards pose a catastrophic risk to both collections and infrastructure (Figure 14). Observations indicate inadequate fire prevention systems.

Discussion

Emergency preparedness is lacking. Risk mapping can help identify high-risk zones within the museum.

Recommendations

- Install fire detection systems
- Maintain electrical wiring
- Ensure emergency exits
- Develop fire response plans

4.10 Biological Growth (Vegetation and Microorganisms)

Uncontrolled plant growth and microbial activity in figure 15 & 16 were observed around the building, contributing to structural deterioration .



Recommendations

- Regular maintenance of surrounding areas
- Use of chemical treatments
- Monitoring of external environmental conditions

4.11 Dissociation (Loss of Information)

Dissociation refers to the loss of object-related data due to poor documentation practices. This affects research value, cultural significance and collection management

Discussion

This is a critical issue in many museums in developing countries. Digital documentation systems geospatial methods (in future research) can significantly improve data management.

Recommendations

- Develop comprehensive documentation systems
- Implement labeling and cataloguing standards
- Digitize collection records

5. Conclusion

This study highlights the critical conservation challenges faced by the Lok Virsa Heritage Museum, emphasizing the urgent need for systematic preventive conservation strategies. Through qualitative analysis grounded in the CCI framework, the research identifies multiple agents of deterioration, including environmental instability, biological threats, and human-induced risks, all of which significantly affect the integrity of museum collections. The findings demonstrate that inadequate environmental control, poor maintenance practices, and limited institutional capacity contribute to ongoing deterioration processes. The study underscores the importance of adopting a proactive, risk-based approach to conservation, integrating regular monitoring, staff training, and improved infrastructure management. Although this research does not employ primary GIS analysis, it acknowledges the potential of spatial technologies in enhancing future conservation planning and risk mapping. Ultimately, this research provides a practical and adaptable framework for improving conservation practices in museums, particularly in developing countries, where resource constraints often limit preservation efforts. Implementing the recommended measures can significantly enhance the long-term sustainability and protection of cultural heritage assets.

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Fig.1 D-2 Pottery through the ages: Open from above & have no gate existing dust problem (Source: by Researcher)



Fig.2 D-41 dust on painted wood of tazia (Source: by Researcher)



Fig.3 D-32 (Silk thread) Dust problem on traditional textile due to partially cover (Source: by Researcher)



Fig.4 D-09 (ballads & romance): Efflorescence inside diorama due to RH & temp fluctuation on ceiling (Source: by Researcher)

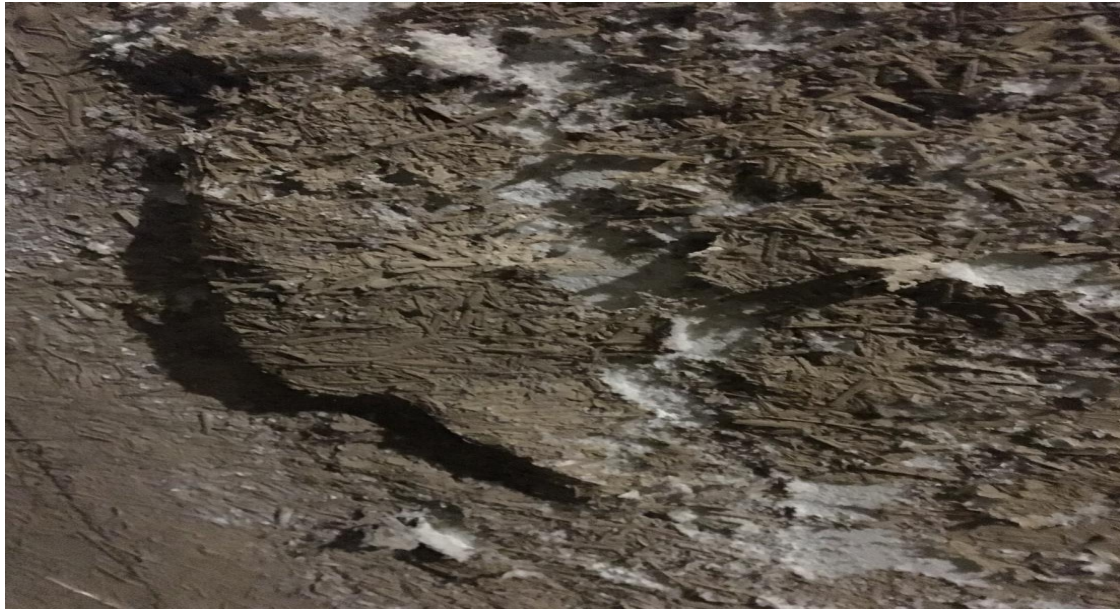


Fig.5 D-41 humidity near floor in left of emergency exit of block #4 (Source: by Researcher)

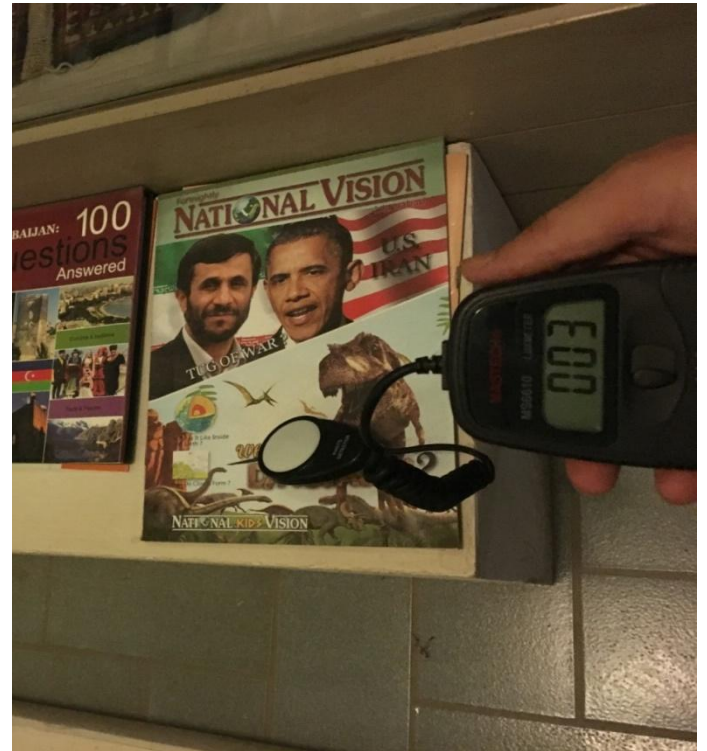


Fig.6 D-01 Living Mohenjo-Daro and Books in front of D-25(Azerbaijan) (Source: by Researcher)



***Fig. 7 Water ponding at left side on Roof due to grass growing
(Source: by Researcher)***



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Fig.9 Termites attack on Royal Kingdom of Saudi Arabia internal tent (Source: by Researcher)





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Fig.14 Manual glass breakers are not working (Source: by Researcher)



Fig.15 Biological growth Wild plant growth around building (Source: by Researcher)



Fig.16 Biological growth Wild plant growth around building (Source: by Researcher)