



## Scientific and Ethical Considerations in Sampling Artefacts in Archaeological Sciences

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### Abstract

Sampling historical-cultural artefacts from museums and excavation sites is a delicate and critical phase in archaeological research and the conservation of cultural heritage. This process, essential for generating scientific data, must follow established scientific principles as well as pertinent ethical guidelines in the field. Adhering to these principles is crucial to prevent damage to the artefacts and preserve their cultural and historical significance. Employing a descriptive-analytical approach, this study systematically examines the scientific and ethical challenges involved in this process, utilising library resources and the authors' field experiences. The findings revealed that ethical and optimal sampling of historical-cultural artefacts requires the integration of three key dimensions: 1) Technical dimension, involving the selection of minimally invasive, high-precision methods and the development of standardised protocols for sampling; 2) Ethical dimension, encompassing adherence to the five core principles of minimum intervention, scientific justification, transparency, accountability, and respect for stakeholders' rights; and 3) Managerial dimension, which includes establishing controlled sample repositories. These findings underscore the necessity of formulating national scientific and ethical sampling guidelines. Furthermore, they demonstrate how implementing such a framework can safeguard artefacts from physical damage, enhance the purposefulness and accuracy of sampling, prevent resource waste, reduce the frequency of sampling through improved access to collected data (via sample databases), and most importantly, ensure the satisfaction of current and future stakeholders.

**Keywords:** Cultural Heritage, Sampling, Ethical Guidelines, Archaeological Sciences, Archaeometry.

**Article Type:** Review Article

### Introduction

Sampling from historical artefacts and archaeological sites constitutes an integral part of the research process focused on conserving, restoring, and collecting archaeological data. This process is essential for understanding the history, culture, and civilisations of the past. It involves collecting samples from various materials, such as soil, pottery, metals, bones, and other cultural remains. To undertake this task effectively, using appropriate tools and methods is vital to avoid damaging historical artefacts, while ensuring the collection of reliable data (Renfrew and Bahn 2016: 77). In the

archaeometry investigation of cultural heritage, sampling is the first practical and arguably most critical operational step after formulating research questions (Razani *et al.* 2017). This procedure plays a key role in assessing and preserving historical artefacts, facilitating the identification and documentation of associated values, whether related to objects or sites. This, in turn, informs decisions about conservation strategies and the transmission of heritage to future generations (Arizpe 2000: 13-15). The methods used for sampling can influence all stages of archaeological research, including the types of cultural materials recovered, the quality



of recorded data, and subsequent interpretations of sites and cultural assemblages (Orton 2000:1). As such, sampling is both a practical and ethical approach for managing a large quantity of data that require analysis.

In the fields of conservation, restoration, and archaeology of historical-cultural artefacts, it is often not feasible to excavate an entire site, survey a complete region, or analyse all artefacts obtained from excavations or housed in museums. Within a scientific framework, sampling necessitates understanding the artefact in question, clearly defining the data sought, determining the required sample size, and establishing a methodology for sample collection. Thus, sampling involves both scientific principles and skilled judgment.

From an ethical standpoint, various considerations must be addressed, including respect for the physical integrity of artefacts, cultural ownership, and the preservation of their aesthetic, historical, and other associated values. In many instances, leaving portions of a site or object unexcavated and unsampled, under the hope that sampling techniques or non-invasive research methods will improve in the future, is deemed an ethical choice. Therefore, when research needs and available resources necessitate a sampling approach, it is imperative to design a sampling strategy that adheres to ethical boundaries. This strategy, known as the sampling protocol, involves determining and identifying sample types, assessing feasibility, and defining the location, collection methods, and preservation techniques tailored to the nature of the artefact or its contextual matrix.

In recent decades in Iran, research approaches in disciplines related to cultural heritage have shifted toward the integration of technical and engineering knowledge, particularly in the field of archaeometry, owing to the diverse range of topics and complex technical dimensions involved (Razani *et al.* 2021). While this approach primarily focuses on the material aspects of artefacts, it raises a critical question: Given the historical, social, and cultural significance of these artefacts, as well as our responsibility toward their custodians, can such an approach adequately safeguard the material and immaterial interests of this heritage and its stakeholders? The answer is no. A research approach rooted in the humanities offers an alternative perspective. It emphasises the supra-material values of artefacts and

stakeholders' expectations. This perspective is not only essential for studying historical and cultural heritage but also serves as a prerequisite for engaging in technical and engineering research. Ethics, as a branch of the humanities and social sciences, examines human behaviour and character. One of its key functions is to explore commendable traits and their acquisition, as well as undesirable traits and their avoidance across all domains of human activity (Shomali 2010). Ethics informs us about what is good and bad (Holmes 2007: 45). As a normative science, it establishes rules and guidelines—akin to logic and aesthetics—for action and value-based judgments. This stands in contrast to descriptive sciences like physics and chemistry, which provide factual descriptions and inform us about what exists. In normative sciences, there exists a constant tension between good and bad values. Given that human existence is inherently tied to actions and behaviour, no individual can escape ethical considerations in any endeavour. However, the criteria and standards for right and wrong may vary among individuals. In professional contexts, these standards are typically established through consensus among practitioners and are tailored to specific issues within the framework of professional conduct in that field, with all members adhering to these principles (Gharamaleki 2017: 69-71).

Ethical considerations in sampling historical-cultural artefacts form an integral part of professional ethics in conservation and restoration, archaeology, and archaeometry. Given the imperative to preserve the multidimensional values (material and immaterial) of these artefacts, this process faces complex challenges that have, to date, received limited systematic study. This research gap underscores the significance of the present study. This study aims to develop an ethics-oriented and contextually grounded framework for sampling historical-cultural artefacts in various contexts, including laboratories and workshops, field surveys, archaeological excavations, and museums. It will also identify the ethical challenges associated with sampling practices in Iran. The methodology is based on an explanatory-analytical approach within the humanities, with data collected through two primary methods: library-based research (which involves a review of documents, texts, and national and international standards) and empirical observations (drawing on the authors' lived experiences in conservation and archaeometry projects). In this regard, the present

study seeks to establish a structured framework for responsible and culturally adapted sampling of cultural heritage in Iran. This will be achieved by systematically reviewing practical sampling experiences, particularly challenging case studies, analysing their causes, and proposing solutions; conducting a comparative study of ethical principles and criteria found in reference documents; and integrating these findings with the philosophical foundations of professional ethics. The outcomes of this research could serve as a foundation for critiquing, developing, and formulating a ‘National Ethical Sampling Document for Historical Artefacts.

### Literature Review

As mentioned earlier, sampling in scientific research involves both scientific methodology and skilled judgment, guided by a set of scientific principles and ethical guidelines that apply regardless of the research subject. These principles are applied within a specific framework when dealing with historical artefacts and archaeological remains, as these often represent unique samples that reflect a community’s heritage at local, national, or global levels. In recent decades, sampling-based studies have garnered significant attention from international researchers. Evidence suggests that sampling methods have evolved considerably, moving from early destructive techniques to modern minimally invasive approaches (Artioli 2010). Despite increased awareness of the sensitivity surrounding this issue, and perhaps due to the assumption that these principles are self-evident, few studies and resources specifically address the challenges, methods, and approaches to sampling historical artefacts (Razani and Rajabi, 2025). This gap highlights the importance of further exploration of this topic, drawing upon the authors’ experiences discussed in this article.

In the first half of the twentieth century, the sampling of historical artefacts was primarily conducted using destructive methods that did not consider conservation. Studies indicate that during early excavations in Mesopotamia in the 1920s, numerous clay tablets were sampled without systematic documentation, resulting in significant challenges for subsequent data interpretation (Lloyd 1984: 104). However, a fundamental shift occurred in the 1970s, with the emergence of preventive conservation concepts and archaeological ethics. A review of the literature reveals that there are few

scientific articles and notes providing guidelines for sampling historical artefacts, particularly from archaeological sites (Quye 2019; Tartaron 2003). Additionally, various scientific articles occasionally reference sampling techniques in their materials and methods sections, often emphasising minimal and vaguely specified sample collection from sites (Gueli *et al.* 2017; Thomsen *et al.* 2009; Olivares *et al.* 2009). Orton’s (2000) *Sampling in Archaeology* is one of the most comprehensive resources in this field, focusing mainly on the statistical and technical aspects of sampling at various scales, from regional to microscopic. While this work addresses the significance of sampling theory in archaeological interpretations, its field applications, and post-excavation studies, it—like many texts in this area—neglects the ethical considerations involved in handling historical artefacts (Orton 2000: 27-29). Similarly, Scarre and Scarre (2006), in their edited volume *The Ethics of Archaeology: Philosophical Perspectives on Archaeological Practice*, explored ethical challenges such as the rights of indigenous communities and the repatriation of human remains, but entirely overlooked the ethics of scientific sampling (Scarre and Scarre 2006).

In contrast, Shackley (2011), in *X-Ray Fluorescence Spectrometry (XRF) in Geoarchaeology*, highlighted that approximately 40% of analytical errors in archaeometry studies stem from improper sampling methods. Renfrew and Bahn (2016), in their classic reference *Archaeology: Theories, Methods and Practice*, elucidated theoretical frameworks for systematic sampling in archaeology. These instances have prompted the development of sampling standards, within which ethical principles are addressed to a limited extent. Notable examples include the British Standard on Sampling Methodology for Cultural and Historical Property (BS EN 16085:2012), which also served as the basis for Iran’s standard (ISIRI 20034)(National standard of 2006). Among the more recent contributions is a comprehensive guide to ethical sampling arising from the ICON Heritage Project (Quye and Strlič 2019), which includes decision-making frameworks for selecting sampling methods, considerations for stakeholders’ rights, and documentation protocols.

In recent studies, ethical issues in archaeology have gained greater prominence. For instance, the book *Ethical Approaches to Human Remains*, regarded as an authoritative reference in bioarchaeological ethics, examines the ethical challenges

associated with human remains. By compiling international perspectives, the editors of this volume analyse contemporary ethical issues and challenges related to the excavation, research, conservation, sampling, and display of human remains in both physical and digital environments (Squires *et al.* 2019). Recent studies in professional ethics further indicate that sampling historical artefacts must adhere to five key principles: minimum intervention, scientific utility, respect for the artefact's authenticity, responsibility toward future generations, and transparency (ICOM Code of Ethics 2021). However, fundamental questions remain unanswered: Why do we sample? What are the basic principles of sampling related to cultural heritage, particularly historical-cultural artefacts and sites? Why should sampling solutions be sought? What problems arise for artefacts and the research process if sampling is not conducted properly? What is our responsibility as researchers, conservators, and archaeological scientists in this regard? These and similar questions stem from research gaps surrounding this topic, which have yet to be fully addressed.

### **Ethics and Sampling: Concepts and Findings**

As previously outlined, precise and scientific sampling of historical artefacts and archaeological sites is of paramount importance. Beyond preventing redundant actions, excessive costs, and—most critically, damage to historical artefacts, it provides reliable and credible data for scientific analysis (Renfrew and Bahn 2016: 120). This process requires systematic and question-driven sampling for extracting accurate information. This sampling may involve the artefact itself or its context, such as the excavation site or structure, and it can be conducted in various ways. According to Oddy, many academic or field scientists collect excessively large samples or samples from altered (and unrepresentative) layers (Oddy 1984: 480- 486). Oddy's observation underscores the importance of taking preparatory steps before sampling to ensure that it is purposeful, appropriately sized, and representative of the artefact under study.

As noted, some information derived from sampled materials pertains to the artefact's material structure and environment, while other data relate to its immaterial values. These include technical data (e.g., material identification, damage assessment, and construction techniques), environmental conditions (e.g., geological features, temperature/

light/humidity levels, and proximity to human or animal remains), as well as social, cultural, and historical characteristics. Sampling approaches can be classified into three main categories: 1) research approach-based sampling, 2) research objectives-based sampling, and 3) sampling based on the degree of intervention in the artefact. These categories are elaborated below.

### **Research Approach-Based Sampling**

*Scientific and Purposeful Sampling:* This method involves collecting a comprehensive and objective sample from specific areas of historical or cultural significance to provide detailed information about the object. It is particularly suitable for studying distinct features of historical artefacts or archaeological sites (Hester *et al.* 2009: 20). Recent studies have demonstrated that systematic sampling of soil and various sediment layers, combined with precise recording of depth and geographic location, enables the reconstruction of climatic changes over millennia (Shaikh Baikloo Islam 2023).

*Representative/Systematic Sampling:* This method begins with a thorough inventory of all components to be studied, followed by selecting a subset for sampling and analysis based on the research questions posed. Samples are collected according to a regular pattern, such as grid-based sampling. This approach is effective for examining spatial variations in archaeological sites or large artefacts, like textiles with multiple components (Renfrew and Bahn 2016: 42- 43).

*Random Sampling:* A key principle of random sampling is the need to understand all parts of a site or structure, not just those that appear more intact or richer in material. This requires constructing a framework of questions to avoid unnecessary sampling or biased outcomes. In this method, samples are randomly selected from a collection of historical artefacts or archaeological sites. It is particularly useful when samples belong to a single historical period, a specific assemblage with similar visual evidence, or when a site is too large for a comprehensive study (Hester *et al.* 2009: 23).

*Stratified Sampling:* This method involves collecting samples from different soil or sediment layers to study temporal changes in archaeological sites (Orton and Hughes 2013: 71-80).

According to archaeological sampling principles, a general approach to obtaining samples involves

collecting at least one representative sample from each context present at a site and for each chronological period. Known as the “coverage strategy” (Pearsall 2000: 66), this approach allows researchers to conduct more detailed laboratory analyses if necessary. However, a notable challenge in this strategy is the potential for generating an excessive number of samples at large sites, which can lead to prolonged laboratory engagement.

### **Research Objectives-Based Sampling**

*Archaeometry:* Archaeometric analyses of cultural and archaeological materials heavily rely on several key factors, including effective sampling, the selection of appropriate laboratory techniques and methods, and the time and costs associated with laboratory analyses, data processing, and interpretation (Artioli 2010: 15). Without precise sampling, archaeometric data hold little scientific value (Razani and Rajabi 2025). Proper sampling is as critical as the accuracy of analytical tools, a principle that applies universally across all cultural and archaeological materials, whether mineral or organic (Shackley 1998).

*Archaeological samples,* particularly human remains, serve as vital sources of information for disciplines such as archaeology, bioarchaeology, anthropology, archaeogenetics, archaeoethnology, zooarchaeology, and forensic sciences. These samples can be analysed using various scientific methods. (Max Planck Institute for Evolutionary Anthropology, n.d.).

*Conservation and Restoration:* Purposeful sampling in the conservation and restoration of historical artefacts is a systematic process aimed at identifying the artefact’s primary materials, the nature

and extent of damage, and the mechanisms of deterioration. This scientific approach ultimately leads to the development of sustainable conservation and restoration strategies, directly influencing the selection and optimisation of materials and methods used in treatment. Moreover, the results of sampling and the identification of constituent materials and damage play a decisive role in determining appropriate conditions for storage, display, and presentation. All of these stages are designed and implemented to preserve authenticity and ensure the continued survival of cultural-historical artefacts (Figure.1).

### **Sampling Based on Degree of Intervention in the Artefact**

*Destructive:* Some sampling methods are destructive, meaning they involve invasive processes that result in the permanent alteration or destruction of part or all of the sample. Users of destructive methods must carefully balance the potential analytical benefits against the loss of portions of the artefact for other scientific purposes—some of which may not be foreseeable at present but could become feasible in the future. In the broader field of archaeology, many advanced analyses rely on destructive methods (Figure.2), including genetic analysis, proteomics, metabolomics, microscopy, isotopic analysis, and absolute dating techniques (e.g., dendrochronology, radiocarbon dating, and other dating methods). However, in the fields of conservation and restoration, where the primary focus is preservation, there is a growing movement within the international community to identify and employ non-destructive methods for achieving analytical results.



**Figure. 1:** Types of Purpose-based Sampling: Left) Sampling residues from historical pottery to investigate the usage of the artefact; Middle) Sampling sediments and corrosion from the bronze statue of Nader Shah Afshar in Mashhad to identify and analyse corrosion mechanisms; Right) Non-destructive sampling from the surface of the Persepolis stone plinths to identify biological contaminants.

**Nondestructive:** In practice, the concept of “nondestructive sampling” can be somewhat paradoxical, as the act of removing any material inherently implies intervention in an otherwise intact and pristine context. Nevertheless, in archaeological field studies, some practitioners believe it is possible to collect certain types of samples (such as soil from a general context or pollen) from a site with minimal impact, thereby deeming the process ‘non-destructive’ regarding primary artefacts or features. In the contexts of conservation, restoration, and archaeometric studies, truly non-destructive approaches typically rely on advanced technologies such as imaging, 3D scanning, and indirect chemical analysis, none of which require physical sampling. Thus, these methods are more accurately classified as “non-destructive study methods” rather than “non-destructive sampling”.(Figure.3)

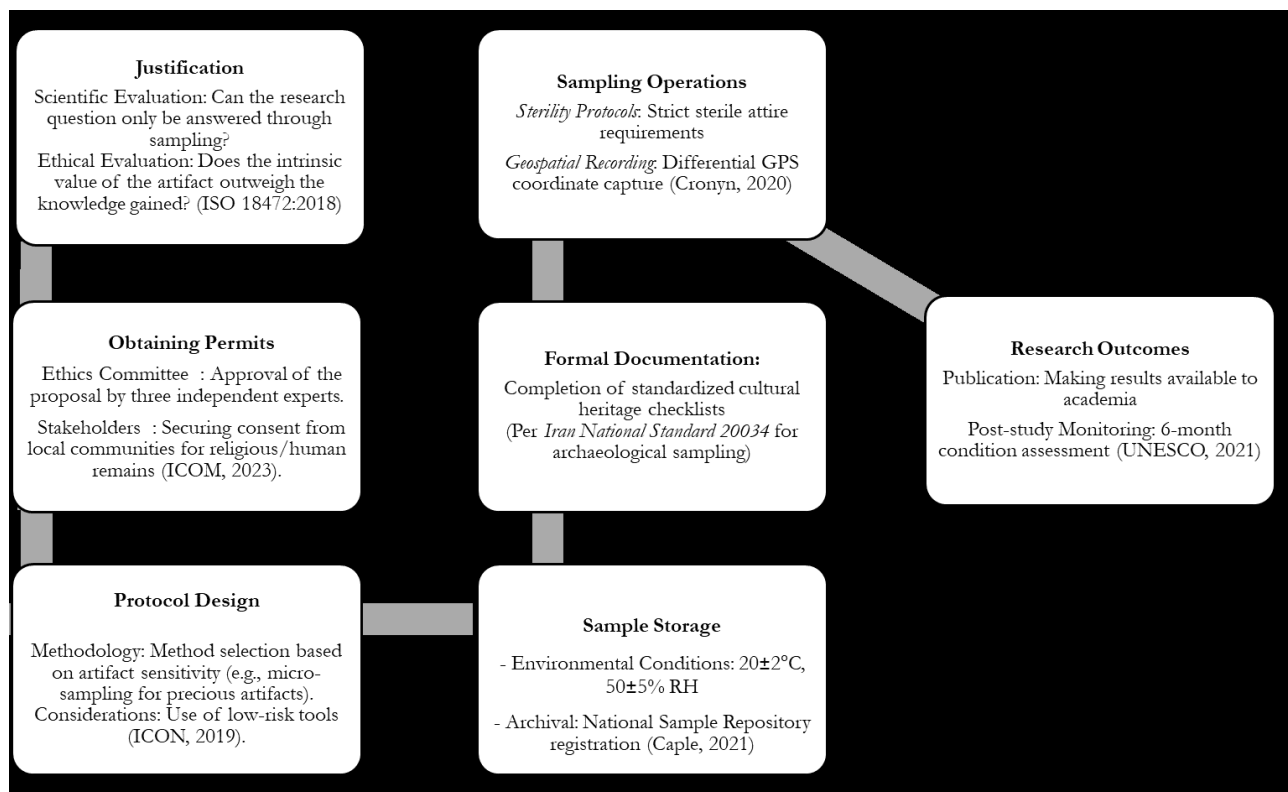


**Figure. 2:** Destructive Sampling of Historical Artefacts  
(After: <https://sciencephotogallery.com/featured/2-neanderthal-dna-extraction-volker-steger.html>)

### Scientific and Ethical Challenges and Errors in Sampling

Sampling from archaeological sites and historical artefacts is a complex and sensitive process that requires high precision and adherence to scientific principles. Any error in this process can result in valuable information loss, damage to historical artefacts, and the generation of inaccurate results

(Carver and Hummler 2024: 27). For instance, a charcoal sample taken from an archaeological layer can yield precise dating only if it remains uncontaminated by environmental factors or is unaffected by layer displacement. Similarly, metal samples must be collected using non-destructive or minimally invasive methods to preserve the authenticity of the artefact while ensuring that the chemical data reflect the original composition of the material at the time of production (Adriaens 2005). Errors at this stage, such as the use of inappropriate tools or failure to record the exact location of the sample,



**Figure. 3:** Scientific-Ethical Sampling Process for Historical-Cultural Artefacts.

can undermine the entire research outcome and may lead to erroneous historical interpretations (Razani and Rajabi 2025).

The following are the scientific and operational challenges and errors encountered during the sampling process:

*Challenges in Protecting Samples from Environmental Conditions and Contaminants:* Environmental factors such as humidity, temperature, and erosion can affect sample quality. For example, organic materials such as bones and wood degrade rapidly under the influence of moisture and temperature (Cronyn 2003: 15), while metals can corrode due to exposure to humidity and oxygen. Thus, precise control of environmental conditions and the use of dry environments or anti-corrosion materials can help mitigate these issues for such samples (Caple 2021: 155). In addition, samples may become contaminated by external substances over time. Appropriate packaging and controlled storage environments can prevent such problems (Goldberg and Macphail 2022).

*Inappropriate Use of Sampling Tools and Lack of Skill or Expertise:* One of the greatest challenges in sampling is the risk of unintentional damage to historical artefacts owing to the use of unsuitable tools or incorrect methods, which can compromise their physical structure (Banning 2020: 67). For instance, poorly executed excavations can disrupt archaeological layers and destroy valuable information related to historical sequences.

*Errors Due to Inappropriate Sampling Method Selection:* Random or systematic sampling may sometimes result in the collection of samples that are not representative of the entire site. This error

can skew research findings and lead to misinterpretation (Orton and Hughes 2013: 24-38). To minimise this risk, stratified or purposeful sampling methods should be employed.

*Technical and Equipment-Related Challenges:* The use of inadequate or outdated equipment can reduce sampling accuracy. For example, certain tools or devices may contaminate samples or damage their structures (Hester *et al.* 2009: 32).

*Human Errors:* Human errors, such as carelessness in data recording, incorrect sample labelling, or mistakes in selecting sampling methods, can compromise research outcomes (Banning 2020: 74). Proper training and adherence to standardised protocols can reduce these errors.

The following are the ethical challenges encountered during the sampling process:

*Conflict of Interest:* Scientific interests may sometimes conflict with the cultural and historical values of artefacts. In such cases, preserving cultural heritage should take precedence (Walker 2022: 27-30).

*Lack of Stakeholder Involvement:* Failure to involve local communities or responsible institutions in the sampling process can lead to distrust and resistance. Therefore, it is essential to ensure active stakeholder participation in decision-making (Colwell-Chanthaphonh and Ferguson 2020: 178-179).

*Destruction of Artefacts:* Improper sampling methods can destroy historical-cultural artefacts. Using non-destructive methods, or, when necessary, semi-destructive techniques, is critical for ethical sampling (Lynott and Wylie 2021: 46) (Table. 1).

**Table. 1:** Operational Checklist for Ethical Sampling (Adapted from ISO 18472-2018)

| Stage           | Ethical Action   | Monitoring Tool              |
|-----------------|--|------------------------------|
| Pre-Sampling    | <ol style="list-style-type: none"> <li>1. Assess the necessity</li> <li>2. Identify stakeholders</li> <li>3. Select a low-risk method</li> </ol> | Ethical Risk Assessment Form |
| During Sampling | <ol style="list-style-type: none"> <li>1. Minimise intervention</li> <li>2. Simultaneous documentation</li> <li>3. Use sterile tools</li> </ol>  | Field Supervision Checklist  |
| Post-Sampling   | <ol style="list-style-type: none"> <li>1. Compensate for damage</li> <li>2. Archive samples</li> <li>3. Disseminate results</li> </ol>           | Sample Tracking System       |

## Discussion of Research Findings

A review of heritage sciences reveals that disciplines reliant on material-based sampling can be categorised as follows:

*Archaeometry:* As an inherently research-driven discipline, archaeometry critically depends on high-quality sampling and the integrity of study samples. Its scientific foundation lies in analysing ancient materials to address historical issues.

*Conservation and Restoration:* This interdisciplinary heritage science, while autonomous in its practice, draws on fields such as archaeometry, environmental physics, microscopy, sociology, and anthropology. In certain cases, sampling is necessary to identify damage and its causes, understand the historical characteristics and events affecting an artefact, and gather data regarding its burial period. *Archaeology:* In many instances, archaeology relies on sampling to provide logical interpretations of excavations at a site or region. This need often arises from the intensive and costly nature of fieldwork, as well as limited budgets, which may prevent comprehensive excavation and data collection. Additionally, there is an assumption that restricting excavation, anticipating more advanced excavation techniques, improved study conditions, and better preservation methods in the future—might yield more favourable outcomes for artefacts and data extraction. Consequently, sampling is preferred in scenarios where limited excavation can maximise information yield. Furthermore, when encountering artefacts that need urgent initial intervention during excavation, sampling is crucial to preserve data from the time of discovery before any further action is taken.

## Ethics in Sampling

Professional ethics, a branch of ethical studies, is often context-specific and governs the behavioural norms of practitioners, regulating their conduct within a profession. In addition to the ethical duties of individuals and practitioners, professional ethics also address the ethical responsibilities of organisations and institutions. However, attributing responsibility to an organisation or institution in any field raises philosophical questions, as responsibility and duty stem from agency (the capacity to act and make choices). At first glance, organisations or institutions may seem to lack such agency, leading to the argument that it is the individuals working within them who possess agency and, consequently, bear responsibility (Gharamaleki 2017: 62). Sampling ethics, a subset of professional ethics in fields such as conservation, restoration, and archaeology, pertain to research and operational processes that depend on accurate and precise sampling. Ultimately, the responsibility for actions related to sampling lies with the individual conservator or archaeologist (Table. 2).

### Professional and Practical Considerations in Sampling Cultural and Historical Artefacts

Sampling in archaeology and conservation transcends a mere mechanical process; it requires a deep understanding of site geology, the sequence of cultural layers, and the spiritual and material values of artefacts. Additionally, it is important to be aware of the limitations of laboratory methods. Proper sampling entails selecting a small yet meaningful representative portion of an artefact or site, which serves as the first and most determinative step in the research process. This process involves the following steps:

*Table. 2: Ethical Framework for Sampling Historical Artefacts (Based on ICOM and UNESCO Standards)*

| Ethical Principle        | Practical Requirements                  | Evaluation Criteria                | Practical Example   |
|--------------------------|---|------------------------------------|---|
| Minimum Intervention     | Use of the smallest possible sample     | Sample size < 1% of the artefact   | Micro-sampling with a sterile needle                            |
| Informed Consent         | Obtain permission from all stakeholders | Written consent forms              | Securing local community approval for sampling human remains    |
| Transparency             | Full documentation of the process       | Photographic report + spatial data | Recording precise sampling coordinates in GIS                   |
| Accountability           | Ensure sample preservation              | Standard storage conditions        | Storing samples in temperature/humidity-controlled environments |
| Scientific Justification | Prove research necessity                | Ethics committee evaluation        | Submitting a research proposal before sampling                  |

-Comprehensive Pre-Sampling Studies: Before sampling cultural and historical artefacts, thorough and precise studies must be conducted to ensure that sampling is necessary and appropriate. Sampling should only proceed when supported by robust scientific justification and when it is confirmed that the required information cannot be obtained through non-destructive analytical methods alone. These preliminary studies also help prevent redundant research, thereby avoiding resource wastage and damage to artefacts.

-Use of Modern Tools and Precise Methods: Employing advanced tools and accurate sampling techniques enhances the precision of the process (Carver and Hummler 2024: 12).

-Training for Archaeological Teams: Archaeological teams should receive training in sampling methods and equipment usage to minimise human error (Banning 2020: 51).

-Adherence to Standardised Protocols: Standardised guidelines for sampling should be closely followed. Additionally, proper data recording and sample storage should be implemented to prevent contamination and analytical errors (Goldberg and Macphail 2022).

-Comprehensive Documentation: Before sampling, artefacts must be fully documented. Documentation includes photography, mapping, and recording details about the artefact, its site, the surrounding environment, and the conditions in which it is situated. Documentation can be broadly categorised into three subtypes: descriptive, graphic, and visual (see Razani and Batter 2024). All types of documentation must be meticulously conducted in relation to the sample.

-Preservation of Archaeological Samples: Archaeological samples, including pottery, metals, bones, soil, and other cultural materials, are inherently susceptible to degradation by environmental, chemical, and physical factors. Therefore, proper preservation is essential to ensure their long-term survival and availability for future studies (Caple 2021: 72). One of the most critical factors in sample preservation is controlling environmental conditions such as temperature, humidity, and light. Samples should be stored at low, stable temperatures, ideally between 18 °C and 22°C, to prevent the decomposition of organic materials and chemical alterations. Also, relative humidity should be maintained between 45% and 55% to inhibit fun-

gal growth and material degradation. Furthermore, samples must be shielded from direct sunlight and strong artificial light, as light exposure can cause discolouration and material breakdown. Storing and archiving samples in a manner that ensures future accessibility while preventing degradation or loss of material and immaterial value is crucial (Caple 2021: 155-157). This careful preservation allows for future experiments, replication of results, application of new methods, and extraction of additional information. Such practices are particularly significant given advancements in technology and analytical techniques, as samples may address new research questions in the future (Razani *et al.* 2017; Razani and Rajabi 2025).

-Careful Packaging of Samples: Samples should be packaged carefully to prevent physical and chemical damage. The use of neutral, acid-free materials, such as acid-free cardboard boxes and polyethylene, is recommended for packaging. Additionally, samples should be separated with soft materials, such as acid-free sponges or fabrics, to avoid abrasion and physical damage. Sensitive samples require storage in controlled environments such as dark rooms, refrigerators, or vacuum chambers. For instance, bones and other organic materials need low temperatures and controlled humidity to prevent decomposition, whereas metals must be kept under dry, humidity-free conditions to avoid corrosion (Cronyn 2003: 30-69). Some samples require chemical preservatives. Pottery samples may require stabilisation with chemicals like Paraloid B-72 to prevent cracking and deterioration, while bone samples might need treatment with polyethylene glycol (PEG) to inhibit decay (Goldberg and Macphail 2022; Caple 2021: 107; Cronyn 2003: 45-52). Finally, all collected samples should be meticulously labelled and catalogued.

-Prioritising Safety and Health: The safety and health of specialists involved in sampling cultural and historical artefacts must be prioritised. The professionals are consistently exposed to health risks from sample-borne contaminants and to injuries caused by sampling tools. Archaeological samples may contain contaminants, hazardous microorganisms, or toxic and radioactive elements, all of which pose health risks to individuals. Moreover, the sampling process itself, which may involve sharp tools, chemicals, or advanced equipment such as lasers, introduces physical and chemical hazards. Therefore, strict adherence to safety protocols, including

the use of appropriate personal protective equipment (PPE) such as gloves and masks, conducting operations in standardised and controlled environments, and following professional Health, Safety, and Environment (HSE) guidelines—is essential to mitigate these risks.

### ***Ethical Considerations in Sampling Historical-Cultural Artefacts***

Heritage professionals worldwide have sought to establish an ethical framework as a guiding principle to navigate the expanding scope of their profession. This framework not only incorporates operational methods and standards but also emphasises ethics in areas such as oversight, professional conduct toward artefacts, relationships with colleagues, and accountability to others (Beaudry 2009). Although ethical considerations are often sidelined in favour of seemingly more “objective” scientific concerns, they cannot be disregarded (Martens 2015: 1; Ashley-Smith 1982). This is because interactions with historical artefacts, such as sampling, frequently involve complexities that necessitate thoughtful adherence to ethical guidelines and sustainable approaches. As noted earlier, to achieve such adherence, several key elements must be taken into account: 1. Context-specific strategies: Strategies should be tailored to the specific context and condition of the artefact, 2. Clear understanding of objectives: A clear understanding of the sampling or research objectives is crucial, 3. Comprehensive information gathering: Researchers should have the ability to extract precise and comprehensive information about the artefact and its history; and 4. Practical application: The information must be practically applied in ways that not only engage contemporary communities but also safeguard the rights of future generations.

The key ethical considerations include the following:

*-Respect for Object Integrity:* Sampling must be conducted in a manner that preserves the physical and historical integrity of the artefacts (AIC, n.d.). This principle underscores that any intervention involving cultural objects should maintain the primary evidence and components essential for their interpretation.

*Minimum Intervention:* When invasive sampling is unavoidable, it should cause the least possible damage to the artefact’s physical and aesthetic dimensions (Cronyn 2003: 11). The amount of sample required and the value of the obtained information

must be weighed against the potential impact of sampling on the cultural object. Sample size should be the minimum necessary to achieve the research objectives, as the quantity and volume of the sample also influence the type of analysis feasible (Razani *et al.* 2017).

*Stakeholder Consent and Participation:* Sampling should only proceed with the informed consent and active involvement of relevant stakeholders, including local communities, responsible institutions, museum administrators, and religious authorities (Colwell-Chanthaphonh and Ferguson 2020: 143; Lynott and Wylie 2021: 135).

*Transparency and Accountability:* Researchers must uphold transparency and accountability throughout all stages of sampling and research. This includes providing detailed and clear reports of the sampling process and research outcomes. Researchers are also accountable for the impact of sampling on artefacts and cultural heritage, ensuring that the knowledge gained from sampling ultimately contributes to their preservation and maintenance.

*Avoidance of Commercialisation:* Sampling must not be conducted for the purpose of commercialising artefacts or associated data (Colwell-Chanthaphonh and Ferguson 2020: 165; Lynott and Wylie 2021: 87; Walker 2022: 21-23).

*Stewardship:* Sampling cultural and historical artefacts is a sensitive process that demands stewardship. This involves preserving these artefacts as shared societal treasures while taking active measures to prevent harm to their myriad values.

*Proper Storage of Samples:* Collected samples must be stored under appropriate conditions to ensure their integrity and viability for future research (Caple 2021: 162).

*Sampling by Qualified Specialists:* The sampling process should be performed by experienced and qualified specialists to minimise damage to artefacts. Standardised and validated methods endorsed by reputable scientific and cultural institutions should be employed, with priority given to non-destructive and minimally invasive techniques (Caple 2021: 93). Researchers lacking sufficient expertise in specific areas should seek assistance or consultation with specialists to prevent errors due to inadequate knowledge and enhance the quality of sampling operations. Utilising high standards and expert experience enables researchers to achieve their goals with greater precision.

*Avoidance of Offense:* Sampling must be conducted in a way that does not offend the religious beliefs or sentiments of relevant communities. This is especially significant when sampling religious or ritual artefacts and human remains, which are often fraught with ethical and cultural challenges. Failure to adhere to this principle can lead to the destruction of cultural heritage, offense to religious beliefs, and harm to local communities. Thus, the sampling of religious and ritual artefacts must be carried out with full respect for the associated religious and cultural beliefs.

*Respect for Human Remains:* Human remains must be preserved and studied with utmost respect for human dignity and the cultural rights of related communities. In one notable case study, an unethical individual involved in sampling inscribed their name on an ancient skull with resin as a memento, thereby violating ethical standards (see Figure.4).

*Minimally Invasive or Non-Destructive Approaches:* When sampling is deemed necessary, it should be performed in a manner that minimises damage to the structure of human remains (Walker 2022: 25), the constituent materials, decorative elements, or the foundational aspects of the cultural and historical artefacts under study. Non-destructive study methods should always be prioritised whenever possible.

*Education and Awareness:* Researchers and local communities should be educated about, and made aware of, the ethical principles of sampling and the importance of preserving cultural heritage (Lynott and Wylie 2021: 72-76).

*Community Engagement:* Local communities should be encouraged and empowered to actively participate in all stages of research, from planning and implementation to the dissemination of results (Colwell-Chanthaphonh and Ferguson 2020: 245-251).

The data presented suggests that the core ethical challenge in sampling historical artefacts lies in the tension between their intrinsic value, as emphasised in Article 2 of the ICOM Code of Ethics, and the research needs within the field, as highlighted in Article 5 of the ICCROM Charter. This constitutes a dual dilemma common in professions related to cultural heritage (Ashley-Smith 1982). Within this context, several key principles, derived from general and professional ethical codes regarding the conservation of historical artefacts, have been identified and proposed as ethical guidelines for ethical sampling practices:

*Accountability:* Aligned with the broader framework of accountability in professional ethics (Gharamaleki 2017: 63), this principle emphasises the multilayered responsibility of heritage professionals (e.g., conservators and archaeologists) toward artefacts (technical responsibility), the scientific community (research responsibility), and future generations (intergenerational responsibility).

*Transparency:* Concrete applications of this principle in professional ethics, as outlined for instance in Section 3.2 of the AIC Standard, include the meticulous recording of geographic locations, environmental conditions, and precise methodologies employed.

*Minimum Intervention:* In line with Principle 4 of the Venice Charter, this principle is operationalised through strategies such as micro-sampling and the use of non-contact analytical methods whenever possible.

*Stakeholders' Rights:* Based on "Stakeholder Theory" in professional ethics (Freeman 1984: 24-27), this principle encompasses the acknowledgement and respect for the rights of local communities, future generations, and artefact owners or custodians.



**Figure 4:** Unethical Action by a Sampler Involving Human Remains – Ancient Skeleton at the Iron Age Museum Site, Tabriz.  
(Photograph by Fariba Majidi 2017(personal archive))

**Professional Competence:** Reflecting the "competence" principle central to conservation ethics (e.g., Section 2.1 of the ICOM-CC Standard), this stresses the necessity of specialised training, appropriate certification, and timely consultation with experts.

**Balance of Interests:** Drawing from frameworks like the "Ethical Balance Model" (Beauchamp and Childress 2019), this principle involves a careful assessment of potential benefits versus harms, the establishment of ethics review committees where appropriate, and the adoption of a hierarchical decision-making system.

Thus, sampling historical-cultural artefacts, as a scientific and professional endeavour, necessitates the careful integration of specialised knowledge, robust ethical considerations, and a strong sense of social responsibility. Sampling approaches based solely on material analyses (e.g., laboratory investigations) without adequately accounting for the cultural, historical, and spiritual dimensions of artefacts risk failing to address comprehensive research objectives and may lead to irreversible damage to this irreplaceable heritage. Consequently, developing a nuanced, ethics-oriented framework for sampling, particularly tailored to Iran's unique cultural-historical context, emerges as an undeniable necessity.

Considering the proposed ethical principles derived from national and international codes related to cultural heritage, an effective ethical decision-making framework for sampling implicitly follows a four-step model: 1) identifying potential ethical issues, 2) reviewing relevant ethical standards and guidelines, 3) consulting with all relevant stakeholders, and 4) selecting the least harmful and most ethically sound option. This model largely aligns with established ethical decision-making frameworks in conservation (Caple 2021: 60-64) and can serve as a valuable foundation for ongoing discussions and refinements of sampling practices within all heritage-related disciplines.

### **Comparative Analysis of Ethical-Scientific Challenges in Sampling Historical Artefacts in Iran: Case Studies and Systematic Insights**

In 2020, the Conservation and Restoration Research Institute analysed the glaze composition and manufacturing techniques of underglaze tiles from Hazrat Abdulazim Shrine in Rey. A large moulded tile with intricate, damaged decorations was stud-

ied to compare its chemical composition with materials used by Qajar-era tilemaker Ali Mohammad Esfahani. Due to inconclusive results from non-destructive portable XRF and after scientific committee approval, micro-destructive sampling (1 mm<sup>2</sup>) was conducted on damaged areas. In 2022, it became necessary to sample lusterware tiles from the National Museum of Iran's collection for technical studies. Given limited non-destructive methods and the uniqueness of samples, the museum's scientific committee approved micro-destructive sampling from non-distinctive areas. In 2024, sampling clay seals from Hastijan Cave, due to their fragility and small size (<2 cm), was restricted to fragmented remains to avoid damaging motifs. In all cases, ethical considerations, precise documentation, and minimal intervention ensured a balance between scientific objectives and artefact preservation.

Based on the above case studies, the challenges of sampling historical artefacts in Iran can be categorised as follows:

- **Technical and Methodological Challenges:** Limitations in non-destructive methods, reliance on micro-destructive sampling, and considerations regarding sample size and volume.
- **Ethical and Conservation Challenges:** Justifying any damage to artefacts, balancing research needs with artefact integrity, selecting appropriate sampling locations, taking responsibility for cultural heritage, and collective decision-making involving conservationists, archaeologists, and museum curators to minimise harm.
- **Management and Decision-Making Challenges:** Establishing specialised committees, obtaining approval from scientific bodies (e.g., the Conservation Institute's research committee), and coordinating with custodians of historical sites and museums.
- **Documentation Challenges:** Keeping detailed records of sampling stages, locations, and scientific justifications for future reference.
- **Artefact-Specific Challenges:** The uniqueness of artefacts, their material fragility, and potential changes in chemical or physical properties.
- **Technological and Laboratory Challenges:** Limited access to advanced non-destructive methods and the need for minute samples that, even with current technologies, may not be sampled with high precision.

Thus, sampling historical artefacts in Iran faces multidimensional challenges that require:

- Interdisciplinary collaboration among conservators, archaeologists, and chemists;

- Development of non-destructive or low-impact methods;
- Formulation of transparent ethical protocols to balance research objectives with conservation efforts;
- Enhancement of laboratory infrastructure to reduce reliance on destructive sampling.

These challenges underscore the complexity and responsibility of sampling historical artefacts in Iran, which can only be effectively managed through a systematic approach grounded in conservation principles (Table. 3).

prioritisation of low-impact methods serve as protective mechanisms that enhance transparency and accountability. These approaches align with international standards, such as ICOM’s Ethical Sampling Guidelines (2019), which advocate stakeholder engagement and risk assessment before sampling. However, Iran’s sociocultural context introduces unique considerations, particularly when IT comes to sampling human remains or sacred artefacts, necessitating ethical adaptations to accommodate cultural sensitivities. Scientific outcomes—such as the

**Table. 3:** Systematic Analysis of Challenges in Sampling Historical Artefacts in Iran and Proposed Solutions

| Challenges Classification      | Concrete Examples from Iranian Experiences   | Proposed Solutions   |
|--------------------------------|--|--|
| Technical and Methodological   | Uncertainty of XRF Results in Tiles of the Shrine of Abdul Azim<br>-Need for Micro-Sampling of Zarinfam Pottery                                | -Development of Advanced Non-Destructive Methods<br>-Use of Micro-Sampling with Minimal Damage                 |
| Ethical and Conservation       | -Conflict between Research and Maintaining the Integrity of the Artefact (Clay Seals)<br>-Selection of Sampling Locations from Destroyed Areas | Formation of Research Ethics Committees<br>- Sampling Only from Less Important or Damaged Areas                |
| Management and Decision-Making | -Need for Research Committee Approval (Qajar Tiles)<br>- Documentation of Sampling Steps   | -Development of Standard Protocols<br>- Accurate Recording of Processes with Images and Scientific Reports     |
| Nature of the works            | - The uniqueness of Zarinfam tiles<br>- The fragility of the glaze and body of the pottery   | Prioritising non-contact methods<br>- Using alternative samples (such as crushed remains of seals)             |
| - Technology and facilities    | Limitations of non-destructive devices in Iran<br>- The need for very small samples (1mm <sup>2</sup> )  | - Investment in laboratory equipment<br>- Cooperation with international centres to access modern technologies |

**Discussion and Analysis of Research Findings**

Integrating scientific sampling within ethical frameworks is an inherently complex process that requires balancing competing priorities. As observed in the case studies, real-world scenarios often involve tensions between preserving rare cultural artefacts and the need to generate meaningful scientific knowledge. This tension underscores the importance of ethical decision-making models that transcend abstract principles and are tailored to specific contextual conditions. For example, applying micro-destructive methods on damaged sections of tiles—deemed technically necessary and conducted under institutional oversight,demonstrates the feasibility of ethical sampling even in constrained circumstances. The establishment of review committees, documentation of informed consent, and

identification of metallic nanoparticle technology in Ilkhanid tiles,highlight invaluable insights that precise and ethically conducted sampling can yield. These findings affirm that sampling, when executed within a thoughtful ethical-scientific framework, not only contributes to conservation science but also offers a deeper understanding of the craftsmanship and technological sophistication of past civilisations.(Figure.5)

**Comparative Analysis of Ethical-Scientific Challenges in Sampling: Iran vs. International Standards**

This comparison highlights a systematic gap between current practices in Iran and international standards, analysed across four key domains as follows:

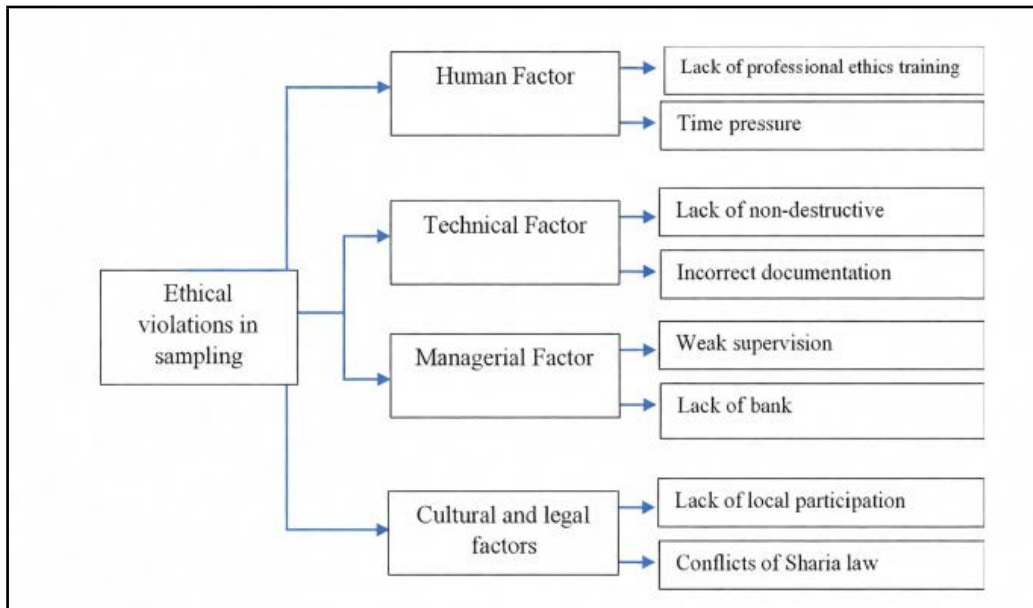


Figure 5: Ethical violations in sampling.

A. Structural-Legal Gap: Iran lacks a unified legal framework for ethical sampling, while international standards (e.g., ICOM and UNESCO) provide a clear hierarchy from principles to operational guidelines. A notable example is the absence of mandatory consent from local communities in Iran, which contradicts Article 4 of the ICOM Code. This can lead to conflicts in field projects.

B. Technological Gap: Iran’s reliance on imported equipment (e.g.,  $\mu$ -XRF) and the impact of sanctions have pushed the country toward traditional destructive methods. In contrast, international standards prioritise non-destructive approaches as fundamental principles. Paradoxically, Iran has capabilities for certain local technologies (e.g., sterile micronano-needles) that could be effectively leveraged by adapting international protocols (e.g., BS EN 16085).

C. Knowledge Management Gap: The use of non-digital documentation systems in Iran results in redundant sampling and resource wastage. Conversely, the CIDOC-CRM standard enables global sample tracking. Additionally, the lack of professional ethics training in universities contributes to unintentional violations of principles like "minimum intervention."

D. Cultural-Social Gap: Sharia-related conflicts, especially concerning the sampling of human remains, pose a unique challenge in Iran. While international standards (e.g., the Venice Charter) emphasise the importance of respecting cultural values, they lack operational mechanisms to address these conflicts. A key finding is the absence of mediation mechanisms between scientific and religious institutions, which delay project implementation (Figure.6, Table. 4).

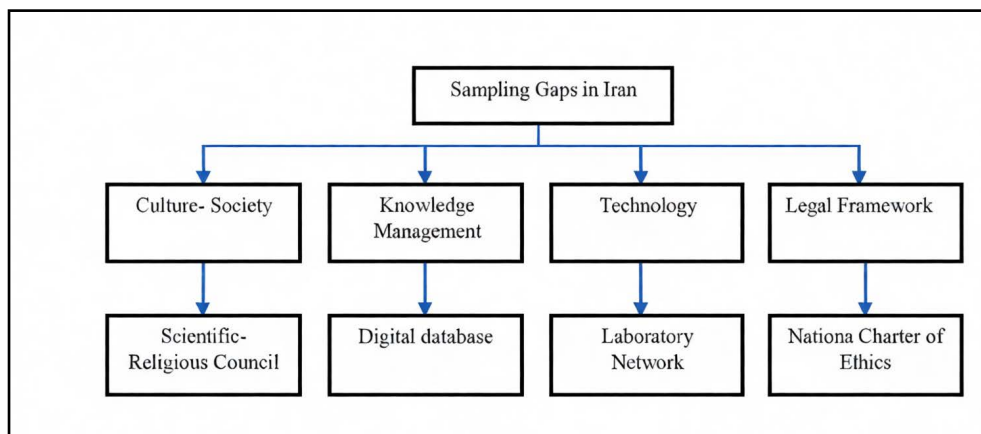


Figure 6: Strategy for Reducing and Eliminating Gaps.

**Table 4:** Systematic Comparison of Ethical-Scientific Sampling Challenges in Iran and International Standards

| Component                      | Iran (implementation obstacles)  | International documents   | Gap/Challenge   | References                           |
|--------------------------------|--|---|---|--------------------------------------|
| Laws and regulations           | - Lack of a binding national document for ethical sampling   | International documents (ICOM, UNESCO, ICON)  | Incompatibility of domestic laws with global standards      | (ICOM 2021; UNESCO 1970)             |
| Technology and equipment       | - Lack of advanced non-destructive devices (such as $\mu$ -XRF) in museums in deprived areas           | - ICOM Code of Ethics (2021) and UNESCO Convention (1970) as a global framework   | Dependence on imported equipment and sanctions              | (Quye and Strlič 2019; ICON 2019)    |
| Stakeholders and participation | - Lack of requirement for local communities to participate in the decision-making process              | - Emphasis on the use of non-destructive or minimally destructive methods (ICON Guidelines, 2019)   | Resistance of local institutions due to a lack of awareness | (ICOM, 2021; UNESCO, 2003)           |
| Training and empowerment       | - Lack of a course unit on "ethics of sampling" in restoration and archaeology                         | - Requirement of informed consent of stakeholders (Article 4 of the ICOM Code of Ethics) and participation of indigenous communities (UNESCO, 2003) | Knowledge gap between domestic and global experts           | (ICON 2021)                          |
| Sample bank                    | - Lack of an integrated network for storing and sharing samples  | - Mandatory training courses for professionals (e.g., ICON certificates)  | Waste of resources due to repeated sampling                 | (BSI 2012; British Museum 2015-2016) |
| Risk assessment                | - Lack of use of quantitative risk assessment matrices in projects                                     | - Existence of reference sample banks (e.g., British Museum with BS EN 16085:2012 protocol)   | Citizen decisions without scientific support                | (ICOM-CC, n.d)                       |
| Documentation                  | - Manual and unsystematic documentation (lack of use of a national database)                           | - Requirement of multidimensional risk assessment (technical, ethical, legal) before sampling (ICOM-CC Guidelines)                                  | Deficiencies in tracking samples and publishing results     | (Velios 2021)                        |
| Human remains                  | - Conflict between religious regulations and scientific standards (such as DNA sampling)               | - Use of digital systems (e.g., CIDOC-CRM) for tracking samples   | Religious restrictions on advanced analysis                 | (ICOMOS 1964)                        |
| Financial resources            | - Insufficient budget allocation for less destructive methods (preferring cheaper destructive methods) | - Compliance with global protocols (e.g., Venice Charter 1964) with emphasis on respect for human dignity   | Financial pressure to comply with standards                 | (World Monuments Fund 2025)          |
| Monitoring and inspection      | - Partial monitoring and lack of an independent supervisory body                                       | - Project financing based on ethical priorities (such as WMF international funds)   | Lack of transparency in reporting                           | (UNESCO 2021)                        |

The existing gaps represent not only challenges but also opportunities for local innovation. For instance, the model proposed in this study, by integrating Sharia ethics, domestic technologies, and adapted global standards, can serve as a model for countries with similar conditions. This analysis indicates that half of the obstacles (e.g., documentation and training) can be addressed through administrative reforms, while the remaining barriers require in-depth interdisciplinary research. Here, a localised sampling model tailored to Iran's capabilities and conditions is presented. It combines cutting-edge science, local ethics, and smart management to address Iran's unique challenges in sampling historical artefacts. It is designed based on the principles and conceptual framework outlined in the previous section (Table. 5).

## Conclusion

Sampling historical-cultural artefacts is a complex and sensitive process that requires balancing the demands of scientific research with the preservation of heritage authenticity. This study demonstrates that the success of this process hinges on integrating three dimensions: 1) technical (employing minimally invasive and precise methods), 2) ethical (upholding stakeholders' rights and cultural values), and 3) managerial (organising sample repositories and documentation). Neglecting any of these dimensions can lead to physical damage to cultural heritage, introduce scientific inaccuracies, and undermine public trust in the expert community as representatives handling their cultural heritage. Responsible sampling should be regarded as a "conditional scientific privilege," not an absolute right—

*Table. 5: Proposed Localised Model for Scientific and Ethical Sampling of Historical Artefacts in Iran*

| Principle  | Key components   | Adapting to Iranian conditions  |
|------------|--|---|
| Scientific | - Minimally destructive methods with high precision  | Prioritising domestic technologies (such as portable XRF devices made in Iran)                    |
| Ethical    | Respect for the rights of stakeholders (local communities, religious institutions, future generations) | Forming "tripartite committees" (experts, clerics, local representatives) for sensitive artefacts |
| Management | National sample bank with standard conditions  | Creating a network of provincial museums as storage nodes   |
| Adaptive   | Flexibility based on the type of artefact and available facilities                                     | Sampling human remains only with the approval of religious authorities and medical scientists     |
| Indigenous | Integration of traditional conservation knowledge with modern methods                                  | Using traditional, less destructive methods (such as sterile clay for packaging metal samples)    |

### Penalties for Violations

- Suspension of offenders from sampling for a specified period.
- Obligation to return unauthorised samples to their original location.

### Advantages of the Model Compared to Global Standards

- Resolution of Sharia conflicts: Integration of religious institutions in decision-making processes for sensitive artefacts (e.g., human remains).
- Reduced reliance on imported equipment: Utilisation of technologies compatible with sanctions.
- Financial sustainability: Sampling costs reduced by up to 40% (through localised methods).

a privilege legitimised by strong scientific justification, adherence to minimum intervention, assurance of heritage sustainability, and stakeholder participation. Within Iran's cultural context, it is crucial to respect local values (e.g., respect for human remains or sacred sites) alongside global standards in ethical sampling considerations. By raising the issue of ethics in sampling cultural and historical artefacts, this article highlights the need to develop unified national guidelines, establish standardised sample repositories, and provide professional ethics training as a component of responsible sampling. It emphasises that the stakeholders of historical artefacts

are diverse, including the scientific community, local communities, future generations, and sometimes religious groups. Therefore, the sampling process must be designed based on the active participation of these stakeholders. To enhance ethical sampling within the framework of professional ethics in Iran's heritage sciences, the following recommendations are proposed across various domains:

#### 1. Governance and Oversight

- Establish specialised ethics committees within cultural heritage institutions to evaluate projects.
- Require ethical approval prior to sampling.
- Develop a standardised national sample bank with detailed documentation to prevent redundant sampling.
- Form hybrid oversight structures, such as "regional ethics committees," comprising technical experts, representatives of local communities, and religious institutions (for specific artefacts).

#### 2. Policy-Making and Infrastructure Development

- Develop a national ethical sampling document that emphasises minimally invasive standards and transparency.
- Enhance infrastructure by creating reference sample repositories across provinces and a national database to record collected samples, thus preventing redundant experiments.
- Localise the BS EN 16085 standard by incorporating Sharia considerations and addressing equipment limitations.

#### 3. Education, Empowerment, and Innovation

- Incorporate professional ethics courses in relevant disciplines (conservation, archaeology, and archaeometry).
- Conduct practical workshops to train professionals in non-destructive sampling methods.
- Publicise research results to local communities while respecting the cultural and religious rights of artefacts.
- Allocate research credits to projects that utilise the national sample bank to prevent redundant sampling.

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