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Safeguarding Endangered Built Heritage In Khyber Pakhtunkhwa – Pakistan: A Digital Restoration Approach

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Abstract:

The built environment is a product of both historical and contemporary civilizations, and it represents norms, values, architecture, the environment, and constructed heritage in the form of buildings that have been passed down through the ages. Cultural heritage is a part of our past that has been transformed, faded, or lost due to various internal or external causes. The goal of preserving and restoring the constructed legacy of the past for the benefit of the current and future generations is achieved through conservation, documentation, media, and various strategies. The main purpose of this study is to explore various means for getting the implicit knowledge from heritage available to be used effectively by the present generation and pass it to the future generations. There is an urgent need to preserve Khyber Pakhtunkhwa Province's built heritage due to challenges in the form of natural and man-made disasters that impact the built heritage in the area. Due to the pandemic (Covid-19), our built heritage has become inaccessible for people to visit. The current digital era of advancing technology provides an opportunity for protecting and restoring built heritage through digitalization, which is accessible to the public, including the community, organizations, students, professionals, and researchers. The research paper will focus on using various advanced technologies to create virtual and augment[1]ed reality in built heritage sites in Khyber Pakhtunkhwa, with the aim of protecting and restoring these buildings. The knowledge visualization theory basic concepts are utilized to streamline the various aspects of the digitalization of heritage. The presented conceptual framework can be used not only to document and propagate the traditional wisdom to be effectively utilized and made available for multidisciplinary scholars. This methodology will be used to create knowledge for other researchers and scholars for cross-examinations, conducting qualitative analysis as well as can be used. Research materials for further researchers were made available by knowledge reconstruction, which used visualization technology to turn embedded knowledge of architectural heritage into explicit knowledge.

Keywords: *Digitization, Safeguarding, Built Heritage, knowledge visualization, digital technologies.*

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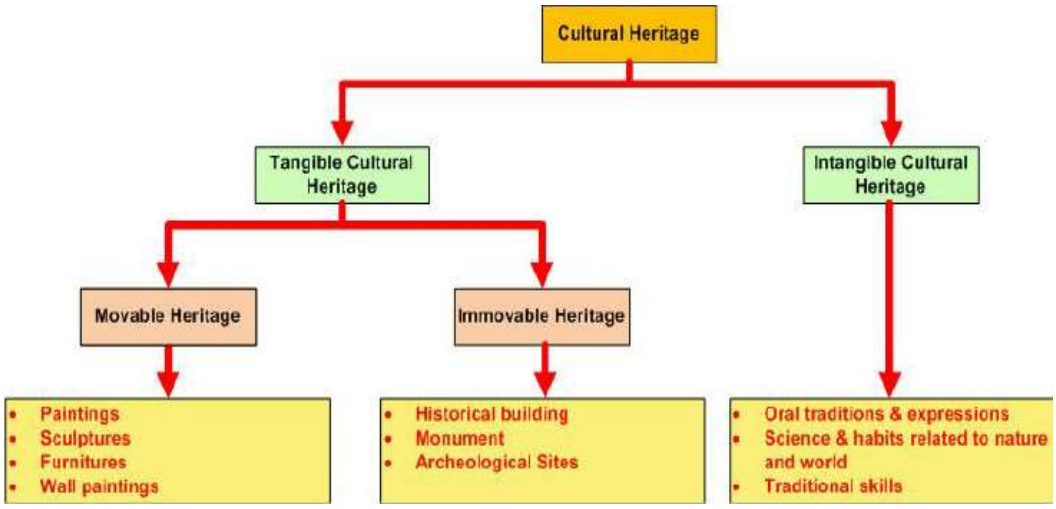
1. Introduction

Cultural inheritance is gradually becoming recognized and widely appreciated as a crucial component of the global social and economic environment. Furthermore, monetary reimbursements for cultural heritage have most usually been viewed through the prism of tourism growth. Nowadays, cultural heritage is viewed as a source of innovation capable of contributing to local and regional growth while also increasing employment at the local and regional levels. It is also regarded as a significant contribution to social cohesion in the sense of uniting different groups and younger generations while boosting their identity.

1.1. Cultural Heritage:

The constructed environment in which we live is a product of both historical and contemporary civilizations. Learning about the past through its architecture, environment, customs, and values—all of which are passed down from previous generations and are referred to as heritage. To keep our legacy safe and secure for the present and the future, we must conserve and restore the past through documentation, media, conservation, and all other means.



Without question, humanity's amazing wealth must be conserved for the benefit of everybody, particularly future generations. This preservation and related activities should be founded on international community-accepted values as well as scientific research and outcomes. These principles are crucial in the subject of cultural heritage conservation because they determine what, when, and how to protect. They play an essential role in both current practices and future aspirations. These actions are governed by international accords to which all civilized countries have agreed.

There are several examples of contemporary technology's major contribution to the conservation and preservation of cultural heritage, spanning all action stages, from archaeological research and prospection to recording, documenting, conservation, and dissemination. Photogrammetry, or image-based mensuration techniques, plays a particularly important role in this process. A great deal of effort has been made over the years, and we intend to include characteristic instances in the final version.

Historic sites are vulnerable to both natural and man-made disasters, including those caused by urbanization, development pressures, socioeconomic shifts, unsustainable tourism, resource depletion, and a variety of natural disasters including earthquakes, floods, changes in climate, winds, etc., as well as man-made conflicts. Disasters have a devastating effect on historic sites. The World Heritage Sites are exposed to many challenges and hazards on

a global scale. Examples of disasters, whether man-made or natural, are provided to illustrate how they affect cultural heritage.

The demolition of Bamiyan Buddha 2001

(Man-made disaster)

The Demolition of Bamiyan Buddha 2001
(Man-made disaster)

L'Aquila Earthquake Italy in 2009
(Natural disaster)

Earthquake in Turkey & Syria February 2023
(Natural disaster)

1.2. In Global Context:

Disasters are major threats to the survival of heritage, both architectural and natural, i.e. tangible and intangible (Bonazza, 2018 #38). All disasters, whether natural (floods, earthquakes, and volcanic explosions) or man-made (war, armed conflict, terrorist acts, and arson (fire), endanger the existence of heritage and people living nearby while causing irreplaceable physical and economic loss and loss of memory that coexists with the heritage (Khan, 2008 #37).

Natural and man-made catastrophic events can have an impact on World Heritage properties and heritage sites in general, endangering their integrity and possibly lowering their value. Due to their socioeconomic significance and cultural importance, these exceptional properties have significant adverse effects on local and national communities when they are lost or deteriorate.

Heritage is a source of a community's identity and a doorway to knowledge, skills, and lessons. For this reason, it is crucial to protect these sites and make sure that future generations can benefit from them. Heritage properties contribute to social cohesion and a sense of pride in the country and community.

1.3. In Local Context:

According to the PDNA (Post-Disaster Needs Assessment) study, 149 cultural sites in Pakistan, including some world heritage sites, were harmed by the recent floods in 2022. (Source: NDMA Floods, 2022). Numerous Buddhist heritage sites, including the Takht-i-Bhai (World Heritage Site), are in the Khyber Pakhtunkhwa (KP) Province. These sites are threatened by a variety of natural and man-made factors, such as earthquakes, floods, intense rains, vandalism, and illegal excavation. The recent flood and rainfall in Khyber Pakhtunkhwa Province have affected 16 Buddhist Heritage Sites, with an estimated damage cost of PKR 180 million. (Source: KP – DOAM).

2. How we can Protect Heritage:

Quickly growing Urbanization, mobility, and interaction are all part of development. We use technology to connect and to provide easy and good communication, and after COVID-19, our connection collapsed from one place to another, as well as our social connection, which is physically maintained, but thanks to the use of advanced technology, we are still digitally connected to survive, to work, and to keep connection with one another. Every era and country has a unique culture and heritage that reflects the culture, traditions, norms, and values that are important to us.

After COVID-19, most of these items will either disappear or deteriorate, but with the use of digital technology, we can preserve and restore them. As architects, the focus must be on preserving one of the most significant components of KP's cultural heritage—its architectural heritage—by utilizing technology to preserve and restore the architectural heritage that is in danger and cannot be visited. By doing so, people can view the preserved architectural heritage from the comfort of their homes or from other countries through virtual and augmented reality, which can boost KP tourism and turn the province into a source of economic growth.

The built environment is the product of various underlying layers of culture, history, technology, and traditions (Khel, 2022 #31). To maintain a strong link between the past, present, and future, it is necessary to preserve these sites, which have great value and significance for the neighborhood, the surrounding area, the economy, the architecture, and the culture. This can be achieved by using virtual and augmented reality to represent architectural heritage. For the people in this area, the global community, professionals, experts, and students, it is a standard and valuable.

The first step in protecting endangered cultural heritage is to identify it and make sure that everyone has access to it through a variety of accessible means, including local communities, organizations, professionals, students, researchers, and international communities.

3. Opportunities in the Contemporary Era:

In the modern digital age that we live in today, technology is being used and transformed at a very rapid pace to help people in their various countries, offices, and homes. Modern technology presents opportunities for people.

The "World Heritage Organization," UNESCO, is working to digitize cultural assets so that people can visit them using cutting-edge technology. The organization claims that 53.0 percent of people use the internet. Utilizing technology allows for the preservation and restoration of cultural heritage through digitalization, as well as the opportunity to visit inaccessible and vulnerable heritage sites.

Due to the COVID-19 Pandemic, most of our cultural heritage was put in danger, inaccessible to many, and lost. By employing virtual and augmented reality, we can use

advanced technology to preserve and restore it digitally and enable people to view and visit the Heritage at Risk.

UNESCO and other World Heritage Organizations are working on various cultural sites across the globe to enable people to visit them from the comfort of their own homes using cutting-edge technology. Following the COVID Crisis, most of the sites are accessible by car, and there is still the problem of international travel. Many people travel to various historical buildings, sites, landscapes, etc., but following the COVID-19 pandemic, most in-person visits have become more difficult. Moreover, in addition to the COVID-19 pandemic, other conflicts make it difficult to travel safely to any location in the world, depending on the local conditions.

Virtual and augmented reality technologies enable us to visit historical sites from the comfort of our homes and gain knowledge about them. Professionals, communities, and those wishing to visit the locations will all benefit from this method. The digital preservation and restoration of Pakistan's endangered cultural heritage, particularly in the province of Khyber Pakhtunkhwa, can lead to the creation of digital tourism.

4. Digital Cultural Heritage & Disaster Cycle Implication:

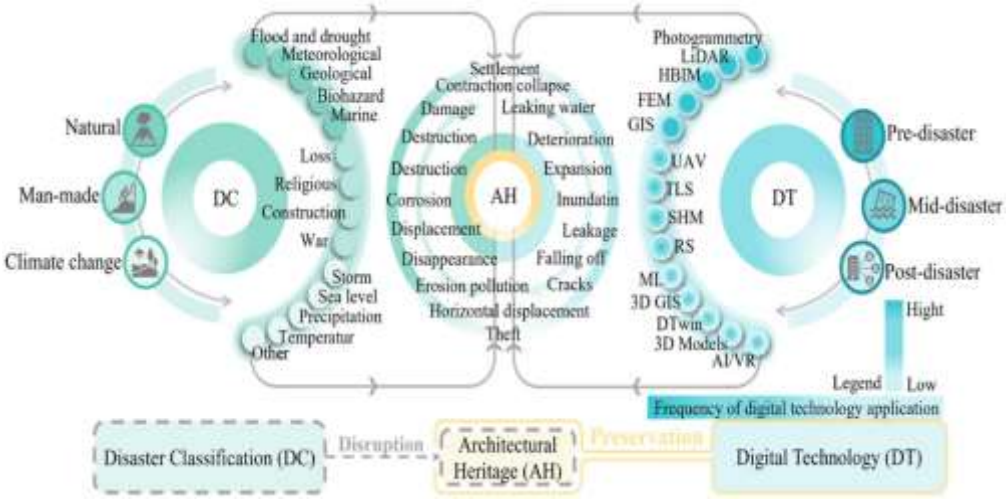
When determining digital methods of heritage within a historical context, the term "digital cultural heritage" is accepted as a standard terminology (Baucom, 2019 #36). The field of digital preservation of architectural heritage is incredibly multidisciplinary and covers a broad spectrum of areas. (Li, Du et al. 2023) state that environmental science, materials science, and geoscience are the main disciplines in this field.

In protecting architectural heritage from disasters, we need to apply the process keeping in view the three stages including the Pre-disaster, mid-disaster, and post-disaster stages. Pre-disaster measures can be classified as preventive maintenance, whereas corrective repair during disasters and restoration efforts after the disaster has occurred are required.

To prevent disasters from destroying architectural heritage, it is implied that: (1) apply methods and knowledge from the fields of earth science, material science, and environmental science to analyze the architectural heritage's location, structural features, and environmental impacts to create digital preservation plans that are appropriate; and (2) recognize the importance of information science in the digital preservation of architectural heritage and choose appropriate digital technology (DTech) based on the type and degree of damage in order to record, preserve, and use data that will lessen the likelihood of disasters and (3) To completely understand and communicate the varied values and meanings of architectural heritage, integrate knowledge from the humanities, engineering, history, archaeology, culture, architecture, and pertinent fields.

A study by Li, Du, et al. (2023) suggests a flow sheet diagram that classifies different disasters (causes) into three categories: natural, man-made, and climate change. The different impacts (effects) it has on the architectural heritage are then emphasized in the center. In the final stage of the diagram, the use of digital technologies is highlighted for efficient mitigation and management of cultural heritage in disaster cycles.

Figure 1: Flow sheet diagram from the study conducted by Li, Du, et al. (2023)



To address the three crucial avenues pertaining to heritage protection and technological involvement in this endeavor, a multidisciplinary approach is still required. The first is an accurate disaster prediction methodology; the second is an early warning system for heritage damage; and the third is an intelligent monitoring system that integrates human-machine interactions.

4.1. Heritage Protection using Advanced Visualization Technologies:

The location of the heritage, local vandalism, and destruction (threats resulting from ignorance and uneducated background), mafias, and a lack of funding for restoration efforts, preventive maintenance, and full restoration following various disasters present significant challenges for the various heritage in our local context in Khyber Pakhtunkhwa, Pakistan.

The built heritage's wisdom, principles, and significance are dependent on the natural world to endure and contend with a variety of factors over time. We can use the many state-of-the-art digital technologies to gather information from these settlements, and buildings, and its knowledge dissemination.

4.2. Specific case of Khyber Pakhtunkhwa regarding the Adoption of Current Technologies:

The built heritage of Khyber Pakhtunkhwa Province serves as a vital cultural resource for the next generation and as a bearer of our local identity. When people traveled through the valley on their way to and from the Indian subcontinent, it became a hub for the blending and assimilation of various racial and national groups, including Persians, Greeks, Mauryans, Scythians, Parthians, Kushans, White Huns, Turks, Hindu Shahis, and Muslims (De Nardi, 2017 #41). The architectural and cultural heritage is suffering from serious deterioration and could soon disappear due to several natural phenomena and the rapid socio-cultural development that is happening. Both man-made and naturally occurring intentional or inadvertent damages are included in the causes (Shah, 2022 #32). The swift advancement of digital technology, such as cloud computing, remote sensing, terrestrial laser scanning (TLS), and augmented/virtual reality, has made it possible to suggest an efficient future for heritage protection initiatives. By generating geometric and textual information about heritage sites, 3-dimensional scanning in conjunction with photogrammetry is opening new possibilities for their precise and adaptable protection (Zhang, 2022 #33).

5. Digitizing Cultural Heritage and Establishing a Traditional Wisdom Repository: Harvesting, Simplifying, and Distributing Knowledge for Upcoming Generations:

Visualizations, which depict abstract relationships, can reduce cognitive load, and speed up processing. For instance, they enable the expression of knowledge, its dissemination to others, and the acquisition of a comprehensive understanding of the subject matter. Visualizations help foster creativity because they offer methods for utilizing the creative potential of imagery, like the application of visual metaphors.

5.1. Knowledge Visualization Theory Application in Heritage Protection:

Knowledge visualization, according to Burkhard (Tergan, 2006 #30), can aid in the production of new knowledge. For example, groups using visualizations in workshops as well as individual students should be aware of this. There is a finite amount of time and capacity in a single person's working memory to store information.

In this study, the digital protection of cultural heritage is the focus. In selected geographical sections the built heritage sites are vulnerable to various disasters, some archaeological sites are excavated, partially excavated, and buried due to financial limitations. The artifacts excavated are transferred to the shelves of the nearby available museum displays. While the architectural features and the implicit knowledge are still not fully explored and available for future generations.

5.1.1.Knowledge Acquisition Stage:

This stage can be divided into two further substages: data collection and data processing (Ponciano, 2021 #34). The result of this stage will make the data acquisition possible for any selected Heritage site or building.

5.1.1.1. Data collection:

This phase of data collection generates unstructured data and permits the digitization of a cultural artifact. Various materials require different methods of collection; examples of contemporary techniques include three-dimensional (3D) remote sensing, airborne lidar, tilt photogrammetry, and aerospace remote sensing (Hatzopoulos, 2017 #39).

Building-related information can be broken down into categories such as building structure, architectural details, courtyard and surrounds, geographic setting, and so forth. Point clouds from the building's exterior and interior surfaces can be used to extract the geometric information of the building body. Architectural embellishments, including colorful paintings, intricate carvings, and plaques, were typically intricate and intricate in shape, despite their small size. Consequently, the scanning can be done using a handheld 3D scanner. UAV photogrammetry can be used to acquire the geometric and textural details of the courtyard and its surroundings. Satellite remote sensing images can be used to obtain information about the heritage site's 3D geographical environment, including topography, geomorphology, and vegetative cover.

5.1.1.2. Data Processing:

This phase of processing includes dividing, categorization, and analysis of unstructured data to produce structured data. Point clouds can be processed through various methods such as registering multisite original point clouds, extracting point cloud slices and contours, and removing background noise from nearby buildings and trees. For each image to be a high-definition, comprehensive image, it had to be processed using various techniques like color correction, distortion correction, stain removal, and image stitching. Accurate documentation of the architectural structures and dimensions can be achieved using CAD drawings and the building information model (BIM). The plans, elevations, and

sections of buildings were typically included in the CAD drawings that had to be created by measuring point clouds. Texture mapping in conjunction with 3D modeling can be used to create the 3D models. It is also necessary to store all digital data in the knowledge visualization base database.

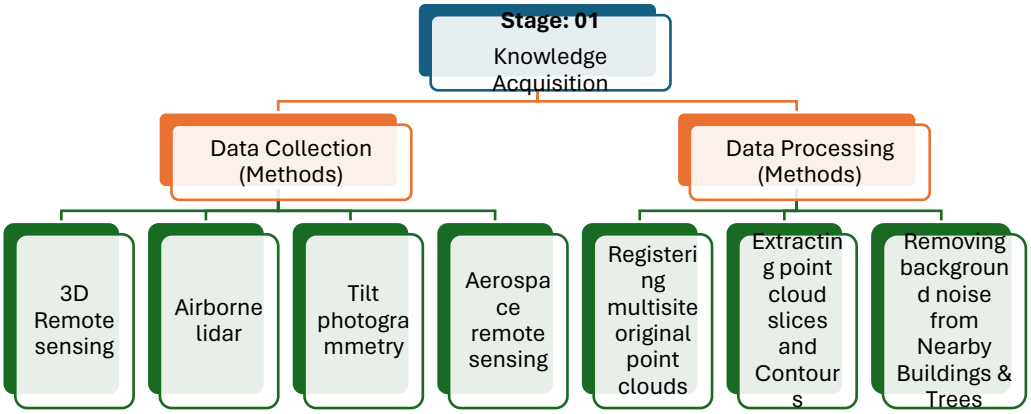


Figure 2: Knowledge Acquisition Stage

5.1.2.Knowledge Reconstruction Stage:

Knowledge extraction, absorption, and fusion were the primary processes that led to the formation of knowledge reconstruction.

5.1.2.1. Knowledge Extraction:

It was necessary to engage in knowledge reconstruction to translate the complex cultural heritage of architecture from the profound culture found inbuilt heritage into understandable knowledge.

5.1.2.2. Knowledge Absorption:

As a result, the knowledge of architectural heritage had to be reconstructed using the theoretical framework of knowledge transformation and a combination of the information obtained from the knowledge acquisition process and the attributes of architectural heritage.

5.1.2.3. Knowledge Fusion:

Using this approach, digital protection data such as point clouds, photos, CAD drawings, 3D models, and literature about the architectural legacy are represented by implicit understanding.

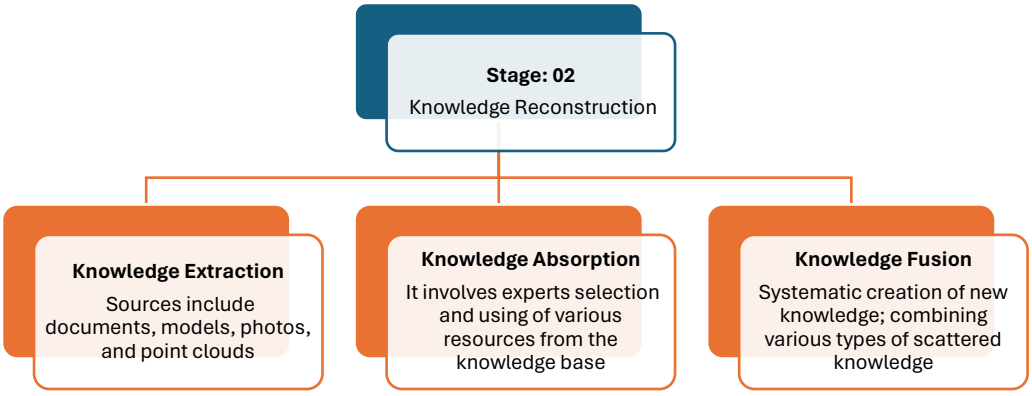


Figure 3: Knowledge Reconstruction

Nearly all the contents of architectural heritage were included in the information, but many were obscure and difficult for the public or scholars to understand. To be able to create a clear understanding that is easier to comprehend, we must reconstruct the knowledge of the architectural heritage mentioned above using visualization technologies like mind maps, concept maps, cognitive maps, and semantic grids.

The 3D model of the building included hidden information about the material; this allows one to reconstruct implicit as well as explicit knowledge, which are the ideas behind the size, shape, and craftsmanship of each building element. The unstated heritage knowledge that is concealed in the 3D model can be reconstituted into visible information using the technique. The knowledge can be expressed using words and charts, that are easier for researchers to use, and articulated in formal academic language. Moreover, the digital reconstruction data had to be preserved in the architectural heritage knowledge visualization material database.

5.1.3.Innovation of Knowledge:

Knowledge Innovation: By utilizing visualization technologies like knowledge graphs, VR/AR, and animations, knowledge dissemination can be used to spread the understanding of architectural heritage. The general populace can be exposed to the architectural cultural heritage through viewing, hearing, touching, etc., which enables them to appreciate the appealing qualities of the architectural heritage more effectively and methodically.

5.1.3.1. Identification of Topics:

To explain architectural heritage knowledge, it is necessary to first identify user groups and consider factors such as user characteristics, mental capacity, acceptance level, and ability to accept knowledge. The choice of visualization techniques, such as animation and VR/AR, is crucial as well. Lastly, choose a design topic, like user interaction with augmented reality.

5.1.3.2. Development and Production

To convey the deeply ingrained culture, it was necessary to realize the topics using visualization technologies, such as knowledge graphs, digital displays, and cultural creativity. There were graphics, photos, VR/AR, animations, and more on the digital displays. A more specialized type of virtual environment that gives the user a sense of presence is called virtual reality. Another way to think about presence is the user's sense of

"immersion" in the virtual world (Liritzis, 2015 #35). Different production and design methods consisted of a result of these display methods. User Interface design, VR/AR interactive design, post-effect production, material and lighting production, overall design, and more can all be used to showcase VR/AR design. Both online and offline dissemination is possible. It was also necessary to store the innovative works in the knowledge visualization results database.

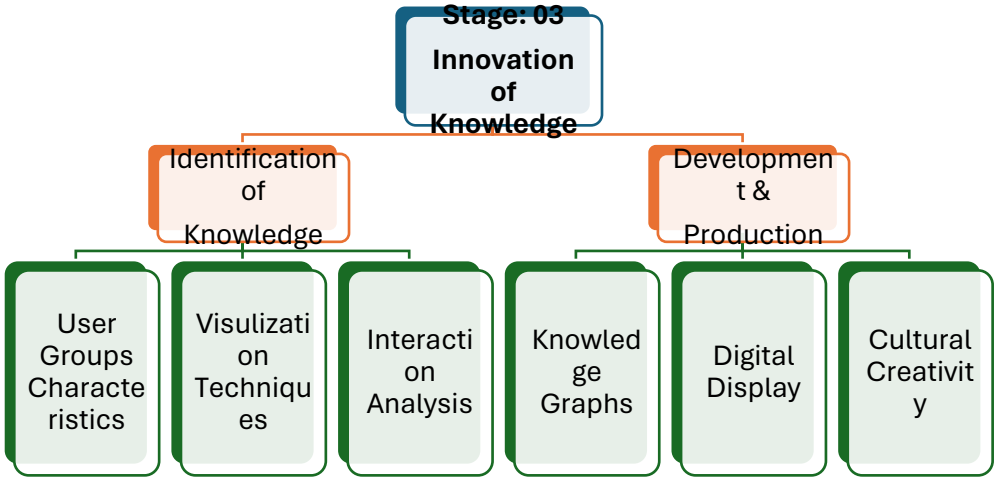


Figure 4: Innovation of knowledge Stage

5.1.4.Management of Knowledge:

To handle and make use of the multi-source diverse information produced throughout this entire process, knowledge management is crucial. There will be an abundance of information about architectural heritage that is scattered widely. As a result, immense amounts of data will be produced by digital protection and utilization, which may be challenging to handle and use efficiently. Scientific techniques will be needed for this to precisely arrange it into a strong management structure.

The digital protection and digital utilization subsystems make up the two divisions of the system as shown in Fig. Digital protection is required for managing the managers' and professionals' knowledge visualization base database. The databases for researchers and the public that contain knowledge visualization results and material can be used to manage digital utilization.

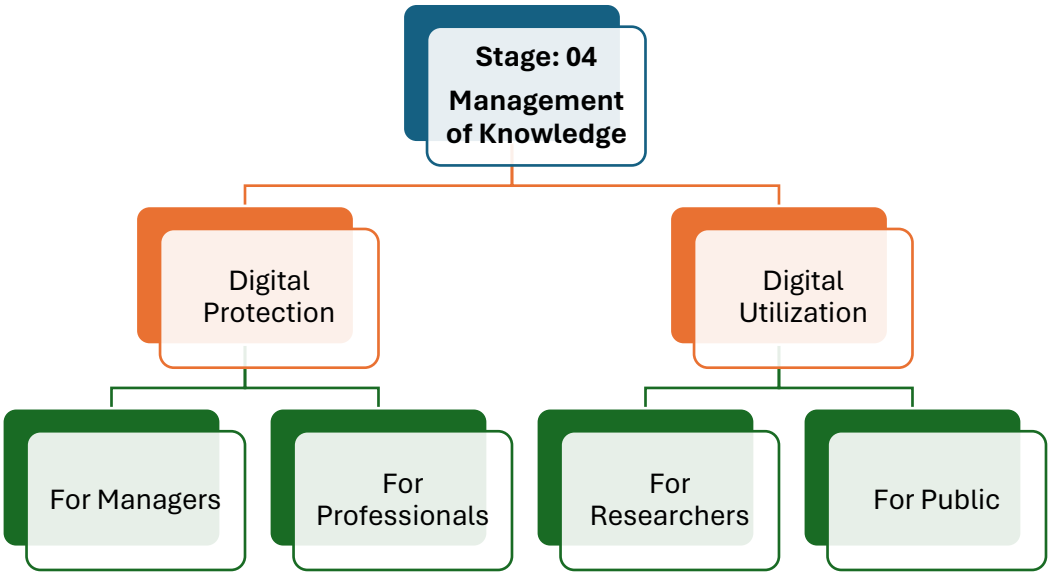


Figure 5: Management of Knowledge

5.1.5.Discussion:

The framework for knowledge visualization theory presented above will serve as the foundation for the creation of the various databases. These databases are organized according to different stages to store data and apply applications. Every piece of information will be stored in a knowledge visualization database during the first stage, which is referred to as the Knowledge Acquisition stage. Both the processed data following the unstructured data sorting procedure and the original data collected from the site had to be fed to the database. CAD drawings, geographic information, photos, 3D databases, and literature databases are a few examples of this type of data. Knowledge Visualization Material Database is the second database. It will include the information produced following the Knowledge Reconstruction phase. The data may consist of the building's spatial data, structural data, data about the elements, data about decoration, and data about human history. The databases in this section will all need to be categorized according to building elements like floors, walls, doors, windows, and roofs.

After the innovation of the knowledge stage is finished, a knowledge visualization result database will be formed. A database of graphs, animations, videos, VR/AR, cultural creation, and digital humanities can all fall under this category. Several databases and datasets will be combined into these databases at once.

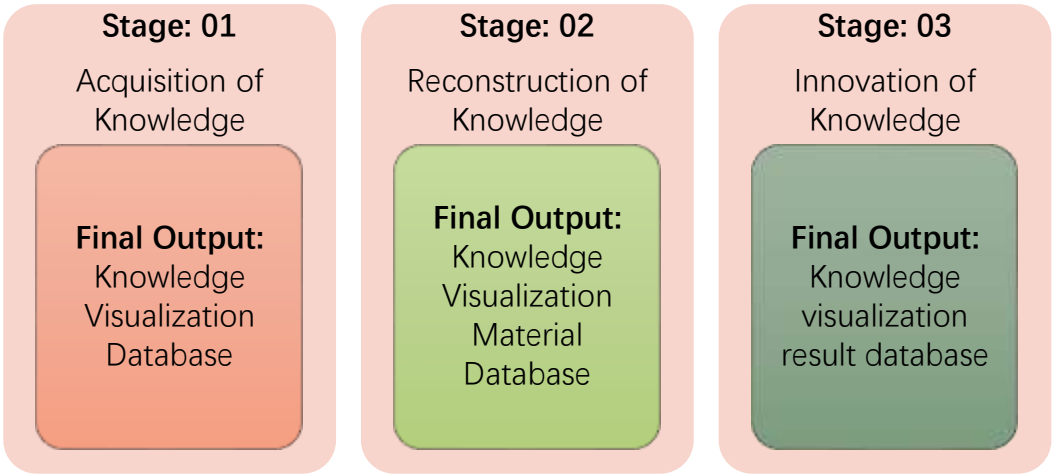


Figure 6: Summary of Database Created

The most crucial basis for preventive protection and building preservation is knowledge acquisition-based digital protection. The use of digital technology creates a bridge between individuals from various academic backgrounds (Akram & Abdelrady, 2023; Abdelrady & Akram, 2022). since there are currently significant obstacles separating architectural research and digital protection. On the one hand, a significant quantity of data related to digital protection has been idle (Ramzan et al., 2023). Nonetheless, a dearth of primary data causes architectural research to be shelved. Following knowledge reconstruction, different kinds of professional knowledge related to buildings can be categorized and expressed. For example, bucket arches of every building can be found in a database, making it easy for researchers to gather information and carry out in-depth studies.

This approach still needs to be improved, yet. To strengthen this endeavor and invest more in it, more experts and cutting-edge techniques are required. For instance, more research using interdisciplinary experts and methodologies is required to fully examine the cultural connotation.

6. Conclusions & Recommendations:

In developing nations like Pakistan, particularly in Khyber Pakhtunkhwa, the built heritage is not fully explored, preserved, and marketed on the global map of knowledge. It is still untranslated and of great significance. Only a small number of sites have been excavated, documented, and preserved (limited components). Even after undergoing preservation efforts, some people are still unable to fully share their knowledge with scholars, the public, and tourists. Today, it is imperative that we work methodically to preserve these cultural treasures and make them known to researchers and the public alike.

We learned from this entire process that, to begin working on the development of mitigation strategies and the prediction of disasters, we must first develop a variety of technologies and their applications across several carefully chosen sites as pilot projects. To effectively mitigate the risk of disaster, we must base our plans on state-of-the-art technologies in this interdisciplinary field. It was necessary to establish an international collaboration and launch capacity-building initiatives with our local experts.

Secondly, to make the knowledge database accessible on sites, we must implement such strategies. These databases ought to function as an open repository for professionals, specialists, tourists, and the public alike. These are the area's cultural assets, and it is necessary to delve deeply and make the implicit knowledge found in these objects, structures, and locations explicit. This information needed to be applied and shared

globally. Experts from across the globe would grab the chance to research and analyze it, and we could showcase our rich cultural characteristics.

Journal articles, survey reports, books, and other traditional technological mediums are currently being used by professionals and researchers to document and disseminate knowledge for this valuable work. However, we must investigate the numerous novel trends that researchers around the world are currently observing. We must create a fully functional database of every Heritage site, object, and structure that presents its implicit knowledge in the most straightforward and comprehensible way possible. It is possible to access these databases for a range of industries and use innovation to preserve, promote, and raise public awareness.

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