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Ecological restoration of historical monuments (With a Focus on the Restoration of Chogha Zanbil)

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Abstract

Architecture has always been an art wherein one can observe the traces of human desires, goals, and behavioral patterns throughout history. Iran, a land of ancient heritage, is rich in architectural elements, historical spaces, and monuments, which not only hold a powerful presence in the realm of Iranian culture but also serve as a means to revive and expand historical and cultural connections with the past. This research employs a descriptive-analytical approach alongside field observations to address the subject of restoring historical monuments and its significance and necessity for preserving the historical fabric of Iranian architecture. The approach taken in this study is ecological restoration. We aim to illustrate not only the architectural characteristics and features of the unique earthen structure of Chogha Zanbil but also to assess the countless possibilities offered by this ecological method of preserving and maintaining historical structures. The findings indicate that the ecological restoration of the Chogha Zanbil ziggurat, on one hand, preserves the historical-cultural and religious authenticity of the site, and on the other hand, reflects the cultural relationship between the architectural space of the ziggurat and the surrounding environmental elements of these historical monuments.

Keywords: Restoration; Conservation; Historical Fabric; Ecology; Choghaznbil Ziggurat

1. Introduction

Restoration, as one of humanity's vital activities, consistently reflects mankind's endeavor to preserve order and to rebuild and care for the original state and its continuity throughout history. It serves as an action to prevent disordered and chaotic changes in the environment. Therefore, restoration can be defined as an activity that incorporates various elements, such as human, cultural, natural, and social environments. It represents a purposeful approach to preserving historical buildings and artworks of the past. A significant outcome of restoration is the continuous harmony with the environment and the internal elements that constitute it. It can be argued that the restoration of historical artifacts is one of the most economically viable concerns and a wise and valuable challenge among all the latest and most modern environmental management strategies (France, 2007). In the restoration of cultural and historical artifacts, one should not solely rely on ecological needs—that is, the coordination of the structure with its environment and nature—but also consider the cultural and historical characteristics of the structures, reviving their symbols and artistic and cultural elements in a modern and contemporary manner; similarly, the results of an experimental program that evaluated the seismic behavior of steel frames with hollow-core wall panels under reversed cyclic loading indicate that innovative

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structural elements can enhance both the resilience and historical integrity of buildings in earthquake-prone areas (Monfaredi et al., 2021). Essentially, the restoration of historical-cultural landscapes seeks to understand the present through tracing the past and, as much as possible, to create a connection between the past and the present (Spiran, 2016).

Artistic restoration is a continuous process that cannot be confined to a specific and fixed timeframe. Restoration can be approached in two ways: first, through repair, and second, through maintenance. Repair involves a set of interventions aimed at improving the physical condition of urban spaces. However, repair can sometimes occur intermittently and continuously over time as a result of various actions. In contrast, maintenance encompasses a broader perspective beyond mere repair. Maintenance takes into account the need to keep the work up-to-date and essentially involves a series of interventions aimed at enhancing the condition of historical and urban spaces while contemporizing them. In this regard, restoration can be summarized in terms of rehabilitation, modernization, and reconstruction (Habibiand Maqsoodi, 2022).

In the present study, efforts have been made to investigate the restoration methods of the Chogha Zanbil Ziggurat. The Chogha Zanbil Ziggurat is a product of the ancient Elamite civilization, located 40 kilometers southeast of Shush. This temple was designed and constructed at the order of King Untash-Napirisha. The site of this historic structure was in the city of Dur-Untash, intended to comprise 22 temples, although only thirteen were completed. Chogha Zanbil represents the ingenuity, thought, and distinct religious approach of the Elamites regarding the relationship between humans, God, and the universe. Primarily, Chogha Zanbil is a temple for worship and prayer. However, it should not be forgotten that in ancient times, prayer was not merely a religious act aimed at pleasing God; rather, it was the unique Elamite way of expressing their relationship with the Divine. Therefore, the Chogha Zanbil temple must be regarded as an expression of Elamite art and culture. The Ziggurat of Chogha Zanbil was plundered and destroyed during the reign of the last Elamite king, Huban-hal-tash III, amid the war with Ashurbanipal. In Dur-Untash, there is no longer any sign of prosperity, growth, or the emergence of new civilizations, and this city, along with its monumental structure, has been forgotten. Thus, the central question of the present research is: What is the most important feature of the ecological restoration of the historical site of Chogha Zanbil? Undoubtedly, the most significant characteristic of restoring a site like Chogha Zanbil involves understanding the materials and construction techniques of the structure, paying attention to the form and composition of the work, and ultimately representing the Elamites' comprehension of the architectural space (Nazarian, 2015). Without grasping this aspect, it becomes impossible to identify the religious and social functions of this building in ancient times.

2. Background and Research Methodology

In the field of historical preservation, numerous articles and theses have been written and compiled. However, regarding the Ziggurat of Choghakznbil, although some research has been conducted, it is not substantial in terms of quantity and quality. Therefore, we will refer to some resources that are thematically closer to the present research:

Mohammadi-Moradi et al. (2019) emphasize that the concept of preservation and restoration has historically represented a general mindset in Iran and is not limited to specific fields. The authors endeavored to elucidate the necessity of restoration as a factor in maintaining a cultural relationship with history and the past. Majidi Khameneh (2005), attempted to examine all architectural and environmental features of Choghakznbil based on the understanding of Elamite civilization. According to the author, this ziggurat dates back to the 13th century BCE, which is the period of flourishing for Elamite civilization.

This research employs survey, documentary, and analytical methods to analyze data. As a result, the present study is classified as applied in terms of topic and analytical in terms of framework, following descriptive-analytical methods. In this research, efforts are made to investigate the ecological restoration of this historical site based on qualitative methodologies, analysis of library documents, and historical examination of the Ziggurat of Choghakznbil while demarcating the boundaries of the context according to historical data. The data collection tools in this study involve note-taking and observation. The method of data analysis in this research is also qualitative.

2.1. Historical Context of Monuments

According to the Amid Dictionary, the term “monuments” is defined as “buildings, structures, the plural of building” (Amid, 2002). Essentially, monuments refer to buildings and historical structures that belong to a particular culture. In ancient Iran, we encounter countless historical monuments, each serving distinct functions. Architecture enters a new phase during the Achaemenid period, where the art of architecture and construction is influenced by neighboring culture. This evolution reflects a sociological redefinition of the concept of neighborhood, as residents began to perceive

their spaces not merely as physical locations but as interconnected communities shaped by collective identities and shared experiences (Ghorashi et al., 2015). Furthermore, the emergence of various subcultures during this time contributed to the creation of new social issues, challenging existing norms and fostering a dynamic dialogue that influenced architectural styles and urban planning (Ghorashi et al., 2024; Bevilacqua et al., 2023). The finest examples of architecture from this period can be observed in Persepolis and several other monuments in Fars and Shush.

In the Islamic period, a substantial number of historical monuments from the Seljuk, Timurid, Safavid, and Qajar eras also exist. Architecturally, the historical monuments from the Seljuk era hold significant importance. Generally, historical buildings are divided into religious and non-religious categories. One of the most important religious buildings from this era is the Jameh Mosque of Isfahan, which showcases the power and elegance of Seljuk architecture in its best form (Poup, 2009: 106).

On the other hand, the historical context invariably preserves the identity and memories of the past, fostering a dynamic and vibrant relationship between people and these architectural elements. Fundamentally, the historical context consists of any form of constructed space where comprehensive progress and the ongoing, deliberate evolution of human thought can be observed from a past era. The endeavor to preserve and restore historical contexts is a product of the modern world. Historically, it was in the late nineteenth century that a movement emerged emphasizing the protection, restoration, and continuous care of monuments and historical artifacts. Later, in the twentieth century, the preservation of historical contexts took on new dimensions, primarily focusing on the conservation of individual structures and the maintenance of landscapes and urban spaces between buildings. During this period, the first urban restoration plans and projects were developed (Khalidian, 2014: 105).

Restoration of historical artifacts can be categorized into three main approaches: museum-oriented restoration, cellular restoration, and systemic restoration. Among the most significant approaches to renewing and revitalizing historical monuments are museum-oriented and systemic restoration. Many archaeological centers worldwide are currently being renewed using a systemic approach. This is because in the systemic approach, a monument is not merely seen as a historical structure but is understood and renewed in a contemporary context. In fact, these monuments are revitalized with respect to their existing roles within urban spaces

This is because in the systemic approach, a monument is not merely seen as a historical structure but is understood and renewed in a contemporary context. In fact, these monuments are revitalized with respect to their existing roles within urban spaces (Chan and Lee, 2008), emphasizing the renewal of hidden urban spaces and stressing the importance of neighborhood in effectively managing city and urban development (Beyki et al., 2016).

2.2. Ecological Restoration of Historical-Cultural Landscapes

When referring to ecological restoration, it entails an approach wherein the inherent features of a historical site are preserved, and the surrounding environment of the site is revitalized without human intervention. In today's world, the destruction and degradation of ecosystems are of major concern, especially in rapidly developing areas (Skeveland, 2003). For instance, the construction of roads, extractive industries, mining operations, and the establishment of refineries and large factories are all factors contributing to the alteration of the landscape. Some of these activities create new forms, but it is rare for such developments to have appropriate site locations or to establish connections between the landscape and ecosystem processes (Bell, 2015; Solaimanian et al., 2022). Essentially, ecological changes in land, rivers, lakes, oceans, and even deserts can be traced directly to human intervention, highlighting the urgent need for fundamental thinking when applying ecological restoration strategies (Apfelbaum and Thomas, 2008). The management of municipal solid waste in Iran exemplifies this pressing issue, as ineffective waste treatment exacerbates ecosystem degradation and contributes to greenhouse gas emissions, underscoring the necessity for innovative, sustainable solutions that integrate environmental considerations into urban planning and waste management practices (Rouhi et al., 2024).

Architects of historical buildings, when engaged in the ecological restoration of any historical or natural area, base their work on ecological findings and information, which they consider integral elements of the collective memory of that location (ASLA, 2008). In their designs, they pay attention to what the collective memory holds regarding the environment and nature. The primary goal of ecological studies in the restoration of any historical site is to uncover the existing order between the historical site and its surrounding environment. Restoration should align with this purpose, fostering new relationships between historical structures and their surroundings, particularly the region's ecosystem, thereby contributing to increased order and facilitating the evolution of the environment (McHarg, 2007). Historical-cultural landscapes can be divided into four categories:

- Historic Sites: Landscapes categorized under this group gain significance due to their association with important historical events or notable figures. They may include religious buildings, residential gardens, rural landscapes, tombs, and cemeteries.
- Historic Designed Landscape: These landscapes are intentionally designed by a landscape architect, traditional gardener, or architect. They may reflect a particular movement or event in environmental design or represent a significant development in the theory and execution of landscape architecture.
- Historic Vernacular Landscapes: These landscapes have evolved through human activity and work, showcasing the daily interactions of the people. Functionality and usage play a crucial role in historic vernacular landscapes, which can include a farm or a collection of properties, such as agricultural, rural, industrial landscapes, and estates.
- Ethnographical Landscape: Landscapes that encompass a diversity of cultural and natural resources recognized by people as heritage (cultural) resources. Contemporary settlements, sacred religious sites, monumental geological structures, and small communities of plants, animals, and even lands and places of indigenous ceremonies also fall under this category of cultural landscapes (Benson, 2000)

One of the most important actions in the field of ecological preservation of historical sites is the renovation and restoration of old and historical buildings. Renovation refers to the renewal of historical structures and spaces through actions or processes that eliminate signs of decay, destruction, and stagnation of these buildings. Renovation is synonymous with rejuvenation and rebuilding. Thus, it can be said that renovation is the act of restoring life to a structure and space, reviving it while emphasizing the preservation of the original structure and historical context. Therefore, the renovation of historical buildings is essentially the adaptation and updating of the architectural and spatial organization of these structures based on our current understanding of history and related developments (Shomai and Pourahmad, 2017: 21). Moreover, the integration of modern construction techniques, such as precast hollow-core wall panels, can enhance the structural integrity and seismic resilience of these renovated buildings while maintaining their historical value (Monfaredi et al., 2022).

2.3. Chogha Zanbil Ziggurat

Many structures from the pre-Islamic and early Islamic periods were built using mud bricks, among which the most significant is the Chogha Zanbil ziggurat located in Khuzestan, Iran. This mud-brick structure dates back to approximately 1250 BCE. Chogha Zanbil is situated about 45 kilometers southeast of the city of Shush in Khuzestan province. This remarkable site has a history of 3200 years and is associated with the Elamite civilization of ancient Iran. The structure represents a multi-tiered architectural design that was constructed by the ancient Elamites around 1250 BCE, primarily used as a temple for the worship of deities. It was commissioned by Untash-Napirisha for the worship of a god named Inshushinak (Ghirshman, 2017).

The term "ziggurat," derived from the meaning "to ascend to the sky," was referred to as "zagrat" in Elamite (Amieh, 2017). This entirely mud-brick structure measures approximately 105 meters by 105 meters and stands 52 meters high, making it the largest among the remaining ziggurats in several countries around the world. The sacred area of the Chogha Zanbil ziggurat encompasses three small and large temples, and in the past, it was connected to the surrounding areas through seven gateways. Today, this site is registered as a UNESCO World Heritage site (Majidi Khameh, 2005).

The construction of this temple occurred in two phases, resulting in a five-tiered ziggurat. Currently, only three tiers of Chogha Zanbil remain, reaching a height of 25 meters, compared to its original height of 53 meters (Vandenberg, 2012: 70). Ziggurats were originally temples that typically reached seven tiers, with spiral paths constructed around the structure. These spiral paths were designed for access to the upper levels. Ziggurats similar to that of Chogha Zanbil can also be found in the civilizations of Sumer, Babylon, and Akkad; however, Chogha Zanbil holds historical significance as the most important structure. Each side of the temple measures 100 meters, and its angles are aligned with the four cardinal directions, all constructed with unbaked bricks. In the middle of each wall, there is a door that opens to a large central courtyard (Amieh, 2017: 53). This central courtyard, akin to a sacred square, was built somewhat lower than the main structure. Most archaeologists estimate that this courtyard likely served as the venue for religious ceremonies, where offerings and gifts were presented outdoors (Soltanzadeh, 2024).

3. Results and discussion

Natural and cultural heritage in any country is a clear manifestation that includes both natural sites and artificial historical and cultural environments. It encompasses a range of landscapes, historical places, archaeological sites, constructed buildings, collections, and biodiversity, reflecting humanity's efforts from the past to the present in terms of culture, knowledge, and various aspects of life. This heritage serves as a dynamic document and a suitable tool for

recording changes and progress. The immovable heritage accumulated from the past and history is considered a valuable reminder and a foundation for development in the present and future within any region or society. Therefore, the preservation and restoration of these historical and cultural landscapes hold fundamental value (ICOMOS, International Charter for Cultural Tourism, 1999).

Historical and cultural landscapes reflect the evolution of human communities and the inhabitants of a given area over time. This evolution is influenced, on one hand, by the physical conditions and the situations and opportunities that the natural environment provides for humanity, and on the other hand, by the social structure, economic factors, and cultural norms, both external and internal. Historical and cultural landscapes represent a geographical area that encompasses cultural and natural resources intertwined with historical events, individuals, and narratives. These landscapes can range from thousands of hectares to small farms. Historical-cultural landscapes express the visual and spatial relationships of humans with their environment. For instance, agricultural lands, public parks, university campuses, cemeteries, scenic highways, and even industrial sites can fall within this category. It can be said that historical-cultural landscapes are a blend of art and environmental context, narrating cultures and histories and reflecting local identities (Benson, 2000).

The process of preserving historical and cultural landscapes consists of four stages. The first stage is the protection of these landscapes. Conservation refers to maintaining the site or preserving the current condition of a heritage resource from destruction or alteration (Nezhad et al., 2021). In other words, it involves actions taken to prevent decay and enhance the longevity of the site. The second stage is preservation. The aim of preservation is to carry out practical actions to maintain the site in its existing condition. In Latin, this term denotes preventive and protective actions. In practice, preservation involves identifying and mitigating the factors of decay and degradation (caused by water, wastewater (Jafarzadeh et al., 2023), chemicals, insects, rodents, pests, plants, and microorganisms) to prevent their escalation. The third stage is restoration. In the past, restoration had many meanings. The commonly accepted definition refers to the act of returning the lost form and appearance of an object. The goal of restoration is to maintain the integrity of a historical, cultural, or religious artifact. The fourth stage is reconstruction. Reconstruction means rebuilding. This term can refer to work executed using either old or modern materials (or both) with the aim of recreating the destroyed elements of a historical-cultural monument. Reconstruction must be based on accurate documentary evidence and archaeological findings, rather than mere speculation (Fielden, 2023).

Table 1 Measure for the Protection of Historical-Cultural Landscapes

Reservation	This process includes the initial measurements and monitoring necessary to preserve the historical site, primarily focusing on the conservation and maintenance of materials and their current condition rather than replacement or the use of new constructions. In this approach, nothing is added; however, the modernization of mechanical and electrical systems is carried out in a very limited manner.
Rehabilitation	Creating conditions for the utilization of a historical site occurs through restoration, modification, and addition. However, these interventions should be limited to the extent that the characteristics indicating the site's historical significance are not compromised.
Restoration	The act or process of describing the form, characteristics, and identity of a location corresponds precisely to the historical period in which it existed. This process involves the removal of elements from other periods and the reconstruction of features that have been lost over the course of restoration. The possibility of modernizing and utilizing mechanical and electrical systems to make the structure functional is not prohibited.
Reconstruction	The act or process of constructing new buildings, forms, and landscape elements, with the aim of resembling a specific period in time and space that has previously existed.

Now, considering these four stages shown in Table 1, we can study the ecological restoration characteristics of the Chogha Zanbil ziggurat. It is essential to remember that the first stage in the restoration process of a historical site is defining the design site. A precise and clear definition of the characteristics and deficiencies of the design site appears to be the first step in initiating the design of historical landscapes and structures. Typically, the failure of historical landscape design projects in addressing issues is not only related to the designer's capabilities but also to the insufficient information in accurately defining the deficiencies and problems of the site (Motloch, 2000). The next topic is understanding the relationship between nature and culture in the creation of historical and natural landscapes. Many of the historical and natural sites in our country reflect their true meaning through this understanding and connection.

In fact, by recognizing that each culture's approach fundamentally relates to its perception of nature and the natural world, we can comprehend the wonders of architecture and the atmosphere present in historical structures.

In the early decades of the 20th century, the city of Dur-Untash was identified through aerial photographs taken to study the oil basins of the region. Simultaneous protection of a large part of this site was carried out between 1951 and 1962 by the French archaeologist Roman Ghirshman. Since then, up until 1998, various efforts have been made towards the preservation and restoration of the structures of this historical site, particularly the Ziggurat of Chogha Zanbil. During these years, the Cultural Heritage Organization of Khuzestan Province, specifically in the city of Shush, has been responsible for the protection of this historical ensemble and has undertaken various activities to maintain this historical monument. However, due to the vastness and significance of the complex, there is still a need for a deeper examination and greater effort in this regard.

Restoring an important site such as the Ziggurat of Chogha Zanbil requires precision, ample time, and skill in carrying out four stages of preserving a historical-cultural artifact. The Ziggurat of Chogha Zanbil has undergone several restoration efforts in contemporary times. One of the most significant actions regarding the restoration of this site dates back to the early 1980s, when under the supervision of engineer Heydari, the first and second levels of the ziggurat and the surrounding worship area were restored and rebuilt. One of the major issues in the ecological restoration of artifacts like the Ziggurat of Chogha Zanbil is the material of the construction, which is mud brick. Over time, this material has either deteriorated or eroded, making the restoration of some of the adobe bricks of this immense structure extremely important. Many of the bricks in this monument bear inscriptions in cuneiform, and the integration of these clay pieces requires not only architectural understanding and skill but also linguistic comprehension.

Unfortunately, in recent decades, several restorations of this grand monument have taken place without re-evaluating the inscriptions engraved on those bricks. Furthermore, in earlier years when the Ziggurat of Chogha Zanbil lacked security, many valuable bricks from the structure were stolen, or they deteriorated due to the region's harsh winds, rains, and scorching sun. Nevertheless, significant efforts have been made in contemporary times to restore this site. In what follows, we will enumerate some of the architectural features of this structure, discuss the methods used in its restoration, and emphasize the necessity of considering ecological factors in the restoration of the Ziggurat of Chogha Zanbil (Figure 1).

Figure 1 Ziggurat of Chogha Zanbil

In any case, the functions of the Choghazanbil restoration project can be categorized into three areas: research, cultural-educational activities, and emergency protections – civil services.

The first and most important action for implementing conservation measures for a historic landscape is defining and determining its boundaries. Every entity, including a historical site, has a boundary that is primarily essential for its survival; it serves as both a protective barrier and a means of engagement. The boundary acts as a protective barrier by preserving the integrity and existence of the site while clarifying the extent of its interaction with other entities. Conversely, it serves as a means of engagement by deriving its significance from its relationship with the surrounding environment. The boundary is an area determined by the legal regulations for preserving the site through its connection to the environment, as established by the custodian of the historical site.

The physical appearance of the boundary of a historical site consists of precisely defined areas that are marked on a map. The number and extent of these areas depend on the characteristics of the site and its surroundings and are determined after conducting the following assessments:

- The condition of the site in terms of aesthetic, historical, and cultural features.
- The surrounding environment of the site and its development concerning archaeological, historical, architectural, technical, and economic characteristics.
- An examination of the broader environment regarding urban and regional infrastructure, livelihoods, and the significance of the site in the local economy and way of life.
- The bidirectional visual connection between the site and its environment.
- Historical pathways and the layout of land in the vicinity of the site.
- An assessment of potential actual and potential damage to the historical site and its relationship with both the artificial and natural environment.

Following these assessments, the areas that meet the criteria for the protection of the historical site are determined, among which those with similar criteria are identified (Habibi and Maqsoodi, 2022).

To gain a more precise understanding of the status of a historical site, whether in the past or present, it is essential to study not only the site itself but also its natural, cultural-social, and historical characteristics over time. This comprehensive approach allows for the development of fundamental strategies for the future. What is certain—and historical evidence confirms this—is that the natural situation of the region has significantly changed, and the ancient site of Chogha Zanbil did not resemble its current state in the past. This site is located in the gently sloping floodplain of the Dez River, which has altered its course many times over time due to meandering phenomena.

On the other hand, the continuous and persistent presence of humans and the intensified pressure on water, soil, and plant and animal resources have led to changes in the region's natural characteristics and a significant decrease in its biodiversity. As a result, today only small patches of the once extensive forests, which covered a large part of Khuzestan and extended into Iraq and Syria, remain along the banks of the Dez and Karkheh rivers. Studying the trends in natural changes enables predictions about future conditions. For example, by knowing the rate at which the meander of the Dez River is advancing towards the third enclosure of the ziggurat, one can estimate the approximate time frame for the direct destructive impact of this shift on the third enclosure. Furthermore, the damage caused by natural erosion factors, such as wind erosion and the impact of raindrops on the ziggurat's structure, is notable. The role of burrowing animals and plant roots in undermining the stability of the Chogha Zanbil ziggurat is also evident.

In the process of ecological restoration of the Chogha Zanbil ziggurat, attention to two vital elements—the vegetation of the Chogha Zanbil site and its wildlife—is crucial. Historical evidence shows that the ancient site of Chogha Zanbil, located in the Dez region, includes a specific type of tropical and semi-tropical forest that embraces the permanent Dez River. These forests are, in fact, remnants of the vast woodlands that once thrived in the region.

Today, due to human intervention and extensive exploitation of the surrounding environment of the Chogha Zanbil Ziggurat, only small patches of forest remain visible along the banks of the Dez River (Figure 2). In recent years, agricultural development year-round along the river has been the primary factor in the loss of pastures in this region. Furthermore, the influx of sheep and goat herds into the area has led to a significant degradation around the Chogha Zanbil Ziggurat, closely aligned with agricultural expansion and the establishment of villages. Currently, the area is characterized by weak rangeland coverage, accompanied by isolated shrubs of Sereem, Bangaleh, Sabirk, and Kouhark. Therefore, an ecological restoration approach, through the examination and identification of environmental challenges and issues surrounding the Chogha Zanbil site, should aim to revive and rebuild the region's natural fabric. The goal of ecological restoration is not solely about the structural and physical aspects of the buildings; rather, structures such as the Chogha Zanbil Ziggurat emerge from the interaction between humans and their surrounding environment. Hence, ecological restoration endeavors to return environmental conditions as closely as possible to their original state.

Figure 2 Vegetation Surrounding the Ziggurat of Chogha Zanbil

Additionally, despite the presence of environmental threats and the exacerbation of phenomena such as often unbalanced and unsustainable economic and social development, the area's wildlife exhibits remarkable diversity and serves as a vital ecological complement to the natural environment of the site; however, the increasing urbanization and associated risks—such as rising income inequality and concentrated knowledge complexity—further challenge the resilience of both local communities and ecosystems (Bevilacqua & Sohrabi, 2020), necessitating that city authorities address the challenges of each community achieving a green transition with more targeted programs based on its needs, while cities, public authorities, and private organizations respond to climate change with various green policies and strategies to enhance community resilience (Sohrabi et al., 2022; Talebzadeh et al., 2024).

In the 2000s, in order to maintain security measures for the structure, a semi-high iron fence was erected around the Ziggurat. Furthermore, to promote historical tourism, both the Ziggurat and its expansive courtyard were illuminated. Although both actions are deemed necessary from economic and social perspectives, they fundamentally contradict the essence and spirit of the monument due to their lack of harmony with the structure and its surrounding environment. The issue here is not merely the removal of these security and decorative elements, but rather the disregard for the principles of an ecological restoration. In an ecological restoration, the entirety of the structure is primarily defined as a connecting element with its environment. The fencing around the Ziggurat is so obtrusive that it suggests the designers had no understanding of the Ziggurat of Chogha Zanbil and the necessity for every man-made element to harmonize with this site. The lighting of the structure is executed in such a clumsy and unprofessional manner that during the day, the projectors installed on the ancient bricks of Chogha Zanbil leave any history enthusiast or admirer of ancient artifacts in awe.

On the other hand, various methods have been proposed for the restoration and conservation of earthen structures such as the Ziggurat of Chogha Zanbil. The best approach in this context is one that respects the local conditions necessary for the preservation of the historical site. Worldwide, there are numerous examples of the restoration, construction, and rebuilding of earthen structures. For instance, studies and projects have been conducted in Uganda (Craterre Editions, 2005), Scotland (Little and Morton, 2001), Australia (Moor and Heathcote, 2002), and Peru (Blondet, Torrelva, & Villa Garcia, 2002).

The restoration of earthen structures can be performed using both traditional and modern methods. In both approaches, it is acknowledged by experts that the most significant weaknesses of adobe (the material used in these structures) are its low resistance to rain and rising moisture, surface shrinkage, wind and storm effects, and biogenic factors (Kian-Nejad, 2023). The reinforcement of adobe buildings, such as Chogha Zanbil, takes place in three areas: structural modification, the building's framework, and the enhancement of adobe strength. Structural modifications involve improving the quality of materials used, increasing the resistance of wall connections at corners, lightening the structure (a continual concern for the restorers of the Ziggurat of Chogha Zanbil), firmly anchoring the building's support to the ground, and strengthening the overall framework. (Jahānābādīān, 2005) It is important to note that in adobe structures like Chogha Zanbil, walls play a vital role. Therefore, in reinforcing the building's structure, concentrated loads on the walls or any part of them are minimized. The wall construction of Chogha Zanbil, much like the original structure, must be simple and involve few breaks. To mechanically increase the strength of adobe, the soil particles must be compacted more densely by applying pressure and compression without the use of stabilizers, resulting in a block with medium

and suitable density. In the physical method, the movement of adobe is strengthened by increasing the suitable neutral stabilizer and creating a restrictive network (Kian-Nejad, 2005).

In terms of architecture, the Ziggurat of Chogha Zanbil possesses a unique design that is distinctly different from other ziggurats found in Mesopotamia. For instance, the structure of the Chogha Zanbil ziggurat features independent bases that elevate each level of the building above the ground, creating separation between them. Each level is nested within the one above it, thereby preventing the possibility of settlement in the center of the structure. One of the notable visual characteristics of the building is the use of forms such as arches and vaults. The doors of the temple were made of wood and adorned with frosted glass in black and white (Soltanzadeh, 2024).

Therefore, in the restoration of this site, it is essential to carefully consider the placement of the levels, the method employed for the use of adobe bricks, and the preservation of the structural forms. Moreover, the bricks used in this construction were fired to ensure the building's strength and durability. One of the reasons for the preservation of these bricks despite centuries of climatic changes is the method of firing the adobe bricks. As a result, in restorations undertaken on this ziggurat, the bricks utilized are often those salvaged from the original structure or made from the local soil, crafted in a traditional manner. The use of remaining materials and components from the original site during restoration reflects an ecological approach to the preservation of historical monuments (Figure 3).

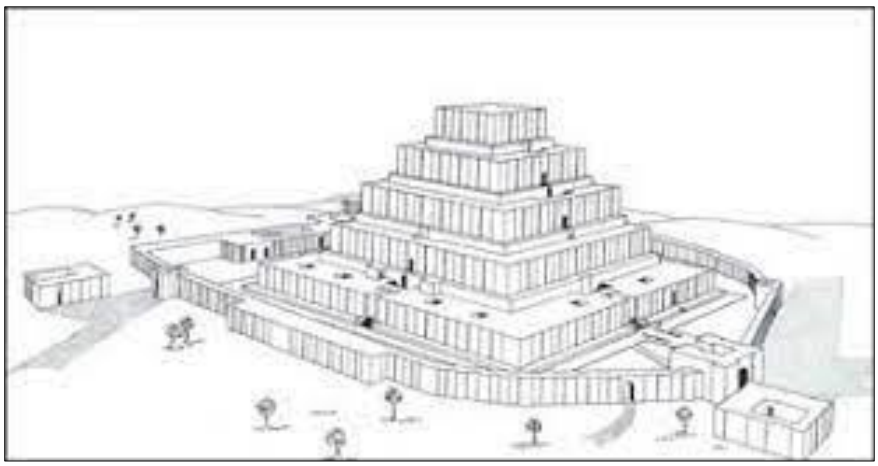

Figure 3 The complete view of the Chogha Zanbil Ziggurat

Historical artifacts cannot be altered, nor can the atmosphere and environment of the structure be changed at will. In the restoration of historical monuments, it is essential to use the original and historical methods as much as possible when selecting materials and maintaining the form and structure of the building. The walls and many of the coverings of the Chogha Zanbil structure were made with raw bricks, while the walls of the lower levels were constructed with fired bricks. This method of using both raw and fired bricks is quite clever, as it provides the structure with sufficient resistance against natural elements such as wind, rain, and sunlight (Prada, 2024).

4. Conclusion

The present research has been conducted based on a central question: What is the most important feature of the ecological restoration of the historical site of Chogha Zanbil? The research hypothesis indicates that any ecological restoration must take into account four principles—protection, revitalization, restoration, and reconstruction of historical structures—while considering the historical-cultural landscape of the site. Without adhering to these dimensions, we will not only be unable to comprehend the architectural and environmental elements of the site but also witness the loss of its historical connection to the past and its revival in the contemporary era. The consequence of such an oversight is the disconnection and inability to recognize the cultural, artistic, and historical characteristics of the site. Therefore, a successful ecological restoration must, on one hand, respect the four principles of historical landscapes, and on the other hand, strive to reflect the historical fabric of the site in accordance with its geographical and historical information, adopting a primarily site-oriented approach. In fact, an effective ecological restoration is one that preserves and highlights historical elements within a site while reflecting its historical fabric through its architectural form and internal space.

The Ziggurat of Chogha Zanbil, as one of the country's historical structures, has not been restored and revitalized in a principled manner for many years. In recent decades, the foundation, as well as the first and second layers and the brick façade of the structure, have been restored. Additionally, the sacrificial altar of the ziggurat has also undergone restoration; however, there remains a long way to go concerning the ecological restoration of this site. Recent restorations have shown lesser attention to the ecological characteristics of the region. In this regard, the focus has solely been on the physical structure of the buildings, resulting in insufficient consideration of ecological elements such as the interactions between the natural environment and the structure, vegetation, wildlife, and so forth.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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