

Maintenance and Restoration of Traditional Wells in M'zab Valley

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Abstract:

Traditional wells in desert areas and especially in M'zab region are of great importance due to their vital role in providing water to the population and revitalizing agricultural lands with a unique and sophisticated irrigation system, facilitated by traditional religious and customary systems. Their maintenance and restoration ensure their continuity and preservation of these strategic and important structures, as well as our human heritage and values, so that the message reaches future generations, God willing.

Regardless of the different perspectives on how to maintain and restore them, it is certainly not just a matter of repairing architectural elements, but rather a process with its own local roots and traditions. It must be carried out based on extensive experience and complete knowledge of the nature and characteristics of different types of archaeological buildings. Otherwise, maintenance and restoration efforts will lose their purpose, considering that traditional wells in the M'zab Valley are not merely material entities but intellectual and artistic components of a rich civilization.

Keywords: M'zab Valley; Traditional wells; Water; Maintenance; Restoration.

Introduction

Water is considered an important and fundamental element of the establishment of civilizations and human settlements. Starting from prehistoric humans who settled and formed the first communities near springs and waterways, which were the direct cause of their transformation from a life of mobility and hunting to stability, agriculture, and domestication of animals." In the dawn of history, other civilizations emerged near rivers, perhaps the most important of which were the civilization of Mesopotamia in Iraq and the civilization of the Nile Valley in Egypt. From here we see how humans always strive to provide this vital element, in accordance with His saying: "And We made from water every living thing. Will they not believe?". If we don't say that most of the upcoming wars will occur mainly due to the conflict over vital water sources.

Humans have used various methods and numerous means to obtain water, where these methods varied according to the diversity of the environment and the region in which humans reside. If we take the desert region as a sample of the regions that represent a large percentage of the aridity, and usually do not have surface water, and do not contain rivers, the existence of humans in this region drives them to provide the element of water in various ways to ensure their survival. One of the ways to obtain water was to dig wells to exploit groundwater close to the surface. Therefore, we wanted to study this type of water structures, which are widespread in desert areas in general, including Algeria, which has many oases in the south that contain a significant number of wells that have formed a basic resource to ensure human survival. One of these areas is the M'zab valley, which is administratively affiliated with the Ghardaia province and contains a significant number of these wells, which are the secret to human survival and the continuity of civilization.

The desired goals of this study do not exceed an attempt to restore the reputation of these water structures that have reached a state of deterioration that requires urgent intervention to save what remains of them through maintenance and restoration before it is too late. Additionally, these structures represent a living memory of this area that must be valued and preserved through rehabilitation.

The problem here lies in the role of maintenance and restoration in restoring the traditional wells in M'zab valley from a technical and artistic perspective. This is to preserve and protect its authentic character without losing its vital role that continues to this day.

Firstly: Descriptive and technical study of traditional wells in the valley M'zab:

Near every qaser lies an oasis of palm groves, divided into gardens, forming an independent architectural and urban model. The narrow streets formed by the brick walls of the gardens serve as seasonal channels for measured outlets, allowing only the specific amount of water for each garden. If there is another garden behind the garden, it receives its share of water from the channel through a small hole that penetrates the shared wall.

The oasis contains several traditional irrigation facilities for storing rainwater seepage in the ground, in dams, as well as draining and distributing it accurately and wisely within the gardens, thanks to wells, underground channels, and water channels (Protection and Development Office of valley M'zab. 2008: 08).

1-The traditional irrigation system in valley M'zab:

Due to the scarcity of water, everyone was chased to the point of determining a building area and expanding the network of ksour, and establishing three systems for water supply (Protection and Development Office of valley M'zab. 2008: 08). The first thing they did was to surround all the highlands and plateaus with a network of canals, all of which flow into tanks created for this purpose. The amount of precipitation in the area imposes this - once or twice a year. The second system is to regulate the flow of the flowing valley, which is also subject to the process of rainfall, as the flow of the valley may be three times in one season, and then it may return to dryness for a period that exceeds three years or more (Ben Zakri, H. 2015: 18).

This system depends on the principle of total and optimal exploitation of rainwater. Different barriers were placed on the highlands of the valley before reaching the dam to reduce the intensity of its flow, confine and direct it according to the size of the flood and the needs of the orchards.

At first, the natural stream of the valley takes its course, if the water is abundant, to later reach two canal diversions directed towards a sand hill. Tunnels are dug underneath them, leading to orchards. These sand hills also work to deposit fertile soil, and the excess is automatically directed to the various dams that form a plain for settling water that is excess to immediate use, thereby nourishing the groundwater layers. Then, the water overflows into the natural course of the valley, where small dams follow to reduce its speed, deposit fertile soil, irrigate the orchards adjacent to the valley, and receive accumulated water at the entrance of the underground tunnels, for which a special system is put in place. These tunnels, in turn, are covered with flat stones built with interlocking, and their sector decreases and their shape changes from the beginning to the end to record a decrease in the speed of the flowing water. Along these tunnels, there are ventilation openings that allow air to escape under the pressure of the rushing floodwaters, thus avoiding the breakage of these channels. When they emerge from the tunnel, they are directed towards the orchards by a complex system of openings and canals.

This system has been designed on the basis of gradual slowing down of drainage speed whenever the water penetrates deeper into the orchards, and on the basis of the needs of each orchard in terms of the number of its palm trees and the area of its land, without any human intervention, so this system operates autonomously. The quantities of water and their distribution methods have been determined over the centuries and recorded in documents known as laws and agreements. The guardians of the river oversee their implementation and monitor the smooth operation of these facilities, and avoid the damage that may occur when the valley flows for a long time. They close the openings of the irrigation channels and divert the excess towards the natural course of the valley. This system is based on the principle of optimal utilization of rainwater and equal distribution, and it ensures the storage of water in the ground, which is later utilized and extracted when needed through traditional wells.

2-The concept of wells in the M'zab valley:

The well is referred to by several different names in the Amazigh dialect, its name among the Mouzabites is the word "Tirist", and there is another term which is "Ighersan" and its singular form is "Ighers",

and its meaning is a deep well and it can be derived from the word "Arsan" in Berber which has the same meaning, and Al-Bakri referred to this name when mentioning the wells spread in Morocco where he said: "They are many wells built with the wood of the Araar...and called in Berber Arsan..." (Abou Ebaid, B. n.d : 72).

There is a term called 'Al-Khatara', which refers to a well in the M'zab area, where this name was mentioned in a document containing the agreement of the Supreme Council of M'zab valley in the year 1247 AH / 1832 AD regarding the exploitation of wells (Haej Sied, Y. 2003: 42). which stated: 'The Council of M'zab valley agreed, both the students and the common people... whoever has a white land with a Khatara and wants to plant it...' (Moullias, D. 1927: 191). In the western regions of Morocco, Al-Khatara refers to the machine used as a means of extracting water from the well. As for the name given to the well, it varies from one well to another. There are some wells attributed to the person who dug them (Daniel Moullias, 1927: 191), such as the Balalou well located near the qaser Ghardaia market, and there are wells attributed to the street or the place in which they are located, such as the Baba Salah well, the Rahba well located in the center of qaser, and the Mosque well located in the mosque.

These historical structures are of great importance in the ksour of M'zab valley, as they were important buildings in the qaser, providing the qaser facilities and residents with water for various purposes. They also introduce us to the way this vital element was exploited, and the role of these structures in reviving agriculture in the region and the traditional irrigation method, highlighting a distinctive architectural style built with these wells.

3- Traditional wells in valley M'zab:

One of the most important features of wells in different regions is the external shape of the well, represented by the structure designed to carry the tools for extracting water from the well, and the internal shape that starts from the usually round or cylindrical nozzle, as well as the square and rectangular shapes that were common among the Romans in ancient times, and the infrastructure that is often paved with stones or lined with wood.

Based on this, we divided the architectural shape of the traditional well in the M'zab valley region into two main sections based on the design of its structure, which are the upper structure that represents the external shape, and the infrastructure that represents the internal shape that is below the well. Due to the impossibility of reaching this part of the well due to the high level of groundwater in it, it can only be accessed during dry periods.



Photo 01: Traditional wells in the M'zab valley by OPVM.

3-1-The Upper Structure:

Generally, it is found protected by a small stone wall behind and a stone slab in the mouth of the well, containing lists on which the well supplies are fixed, which are advanced by the basin, as the external shape of the well differs in terms of architectural elements, and its accessories increase and decrease depending on the functions of the well.



Photo 02: Superstructure of a traditional well in the M'zab Valley.



Photo 03: Infrastructure of a traditional well in the M'zab Valley.

3-2- The infrastructure of the well:

It is a circular or cylindrical hole preserved by a stone wall in most cases, containing water at the bottom that varies in taste depending on the location of the well.

4-Types of traditional wells in M'zab valley:

There are several criteria for dividing wells, including shape, function, and type of water. Therefore, we can divide wells in the M'zab valley region into two main types:

4-1- Public wells:

These wells are spread across various neighborhoods, especially in ancient ksour. Most of them were established as a waqf (endowment) for the benefit of people. They are used for washing and various purposes except for drinking because most of them contain salty water. However, wells that contain fresh drinking water are found outside the ksour, especially along the valley course. They contain a rope, a pulley, and a small jug for water storage.

4-2- The Animal Irrigation Wells:

This type of wells is spread inside the gardens and oases of the M'zab Valley and is used for watering green areas. The irrigation process used to be done in a traditional way as follows:

Water is drawn from the well in the M'zab Valley using animals such as camels, donkeys or mules. The animal pulls the bucket using two ropes that pass through two pulleys along a sloping path to ease the

pulling effort. When the bucket is emptied into the basin, the animal returns towards the well to repeat the process (Doudou, M. 2015: 91), The farmer accompanies the animal back and forth to urge it to walk and assist in the pulling, and to unload the load (bucket) at the appropriate time. The bucket is a large leather jug with a capacity ranging from twenty to thirty liters, and the displacement rate is twice per minute (Ibn Umaira, M. 2005: 108).

4-3- Warwar Wells:

These are special wells in that their springs never dry up even during times of drought, and this is due to the strength of their source.

4-4- Wells that receive runoff water:

In addition to their function in irrigation, they receive excess runoff water from the orchard irrigation (during the water distribution process) in order to store it and feed the groundwater layer. This water descends through drains located at the bottom of the upper part of the well from the rear.

4-5 Ajam wells:

These are wells designated for irrigating high areas within the orchard, where it is not possible to irrigate these areas with the ordinary wells located in the low land of the orchard in the traditional way. The inhabitants of M'zab Valley have established different dams and tributaries of varying importance and function, to reserve and direct water, give the soil enough time to absorb water and supply the aquifer that supplies the wells. These dams have multiplied to the point where we find that in every qaser of the M'zab Valley network, there is a group of dams, whether at the level of M'zab Valley or at the level of the hills and valleys present in each qaser (Chakhab, M. 2006: 41).

5-The traditional well building materials and techniques in M'zab Valley:

The relationship between the geographical environment and the architectural buildings produced by humans is a close relationship, reflected in the materials available to them in their surroundings and how they use them. In this field, human ability and intelligence in

making the best use of these materials available around them are evident. This close relationship between humans and their natural environment was most evident in the M'zab region, where all buildings were constructed using raw materials available in their area, and the homogeneity between these structures and the natural environment surrounding them was apparent, making them seem as if they were a natural product rather than a human-made one.

5-1-The traditional materials used in the construction of wells in M'zab Valley are:

A- Limestone:

It is widely available in the region, where it is cut into suitable sizes for use without being polished. Limestone tiles are also used as a barrier in the mouth of the well and the front of the basin, and to tile the floors of the basins.

B- Gypsum (Timchemt):

It is a type of gypsum that is available in large quantities in the M'zab Valley region. It is characterized by its reddish color, and is used as a mortar and bonding material (Protection and Development Office of valley M'zab. 2014: 07).

C- Lime:

Lime is obtained by burning limestone rocks at a temperature of up to 900°C. After burning, we obtain live lime, in the form of (CaO), which is then mixed with water to turn it into slaked lime. This slaked lime is then added to the sand of the valley, mixed, left to ferment, and then used as a mortar in construction.

D- Sand of valleys:

It is sand that accumulates at the level of valleys, with circular grains mixed with gravel, with a diameter of about 1.5 cm. This sand is used after isolating the gravel from it to make lime mortar, and the quality of the sand is controlled by the absence of clay material.

E- Wood:

The main source of this material is the palm tree, and palm wood is not used in architectural structures except after its death, then it is cut into trunks and used in the well in the form of beams, and the pulley is made from it. (Protection and Development Office of valley M'zab. 2014: 08).

5-2- Traditional well-building techniques in M'zab Valley:**A- Infrastructure building:**

This technique involves stone paving. It is used in building the inner wall of the well's infrastructure, where the stones are laid on top of each other without using any bonding mortar.

B- Upper part building:

This technique involves mixing and building two opposing walls:

- Mixing technique:

This is a technique imposed by the stone material used for direct building, as it exists in nature without any refinement, and the builder must choose the appropriate stones with the designated location, then fill the gaps with gypsum or lime mortar.

- Building two opposing walls:

The well margin or the outer wall is built using a special technique, which is building two opposing walls and filling the gap between them with gypsum mortar mixed with gravel, and sometimes with clay and gravel.

Second: Maintenance and restoration of traditional wells in M'zab Valley:

These historical facilities are of great importance in the ksour of M'zab Valley, as they were important buildings in the qaser, as they supply the qaser facilities and residents with water for various purposes. We learn about how this vital element was utilized and the role of these facilities in reviving agriculture in the region and the traditional irrigation method. They also highlight a distinctive architectural style built into these wells. In order to maintain their great importance and to fulfill

their mission and purpose for future generations, it is necessary to preserve what remains of them and protect them from various damaging factors. If they are deteriorating or in a state of continuous damage, they should be restored to their original condition or as close to it as possible. By preservation, we mean the methods and mechanisms that must be followed to prolong the life of these facilities to remain a witness to the passage of time. To understand the mechanisms and methods that must be applied in maintenance and restoration, it is important to understand the factors and manifestations of their damage.

1-Factors and manifestations of damage to traditional wells in M'zab Valley:

Historical wells and other major historical structures in the M'zab Valley region are affected by a set of factors that can be divided into:

1-1- Factors and manifestations of human damage to traditional wells in M'zab Valley:

Human factors are considered the most influential, and their effects can be seen in the following:

A- Abandoning the use of traditional wells:

This poses a significant risk to these structures, as it leads to the erosion of the building over time on the one hand, and on the other hand, it leads to the pollution of the groundwater due to the lack of renewal of its water through repeated use.

B- Urban expansion at the expense of historical structures:

The phenomenon of urban expansion is the biggest threat at present, which threatens historical landmarks and archaeological sites and destroys their treasures, due to the rapid development of this expansion on the one hand and the lack of attention to those remains.

C- Acts of demolition and sabotage:

As a result of lack of monitoring and ignorance of the historical value of such facilities, it has become easy for individuals to demolish wells they own for personal gain.

D- Throwing trash:

Due to the indifference of some individuals, lack of awareness and education among young people, and the failure to prohibit such behaviors, especially in unused wells that have become dumping sites for waste and debris.

E- Using some wells for sewage disposal:

Some people resort to directing the sewage channel from their home into the well, in the absence of an effective drainage system. This behavior also leads to pollution of the aquifer, which contributes to abandoning the use of these wells.

F - Random restoration of wells:

This means restoration carried out by people with little experience and skill or who are not guided by the opinion of specialists and skilled people in restoration, which leads to distortion of the face and shape of the well, and thus makes it lose many of its original elements.

G- Vibrations:

As a result of the use of heavy-weight drilling machines and means of transportation in projects adjacent to historical ksour and oases, which causes the floors to vibrate, and thus vibrations in their structures, which causes cracks and fissures on buildings and wells, in addition to recently supplying the wells with pumps that cause vibrations whose effect is visible Over time.

1-2- Natural factors and manifestations of damage to traditional wells in the M'zab Valley:**A- Water affects wells in three ways, namely:**

- Floods:

They destroy all the architectural structures in front of them, and the wells that are most affected by these floods, especially those located in the valley stream, most of which were removed due to them, and among the most famous of these floods in the region: the 1820 AD flood, Flood

in 1848 AD, Flood in 1901 AD, Flood in 1991 AD, and Flood in 2008 AD (Dubief, J. 1953: 274).

- Flood water that pours into the wells receiving water:

it causes the internal wall to be washed away, thus demolishing the infrastructure for this type of well, especially if the spaces in the internal wall are not filled well.

- The phenomenon of the water level rising and falling inside the wells:

By repeating this process, it leads to the washing away of stones that are not well paved, and thus part of the infrastructure is destroyed.

B- Heat:

Heat causes damage to organic materials, as its high temperature contributes to the drying of the wood that forms the wells, such as beams, and thus cracks and breaks. It also affects inorganic materials, and as temperatures rise and differ between night and day, it causes cracking of stones and mortar, due to physical action. It results from the freezing of water droplets or frost in the cracks of stone.

C- Humidity:

The rise in temperature underground leads to an increase in the rate of evaporation of groundwater located at the bottom of the well, which results in the condensation of water vapor as the vapor rises to the top as a result of the decrease in surface temperature, especially in the winter. Condensation of water vapor helps fungi grow, especially if the relative humidity is greater than 70%. These fungi are usually dark in color (mostly black) distorting the surface of the stone forming the inner wall of the well.

D- Wind:

The effect of wind is represented by the factor of wind erosion, as strong winds loaded with grains of sand encourage the plastering layers formed from lime mortar, especially in the upper parts of the well. Strong winds may lead to the demolition of the well's legs and wooden beams, especially if they are in fragile condition.

E- Palm roots:

The palm tree is known to plant its roots deep in the ground, in search of water and salts, and due to the presence of palm trees often in the vicinity of wells in the M'zab Valley, these roots negatively affect the infrastructure of the well, as they penetrate between the stones and penetrate them, causing... As they shift, they lose their cohesion and cohesion with each other, and these stones collapse over time.

2- Stages of maintenance and restoration of traditional wells in the M'zab Valley:

After understanding the materials and techniques used in constructing traditional wells in the M'zab Valley, as well as their various types, and identifying the key factors causing damage and deterioration, we will focus on establishing guidelines for their maintenance and restoration. These guidelines include the following:

2-1 - National and international legal protection:

Familiarity with international and national conventions, laws, and executive decrees is crucial for effectively managing the restoration and preservation of water distribution facilities in the M'zab Valley. This knowledge will also help prevent any potential mistakes that could harm the historical sites.

2-2- Examination and Diagnosis:

Before starting any work to protect the wells, it is necessary to have an initial idea about the condition of the structure based on its historical aspect and to conduct field observation and inspection of the extent of damage, its location, nature, and measurements. Accordingly, the building is classified according to the degree of deterioration damage.

This requires experts to conduct a detailed field survey of all structural elements and facilities attached to the archaeological site and investigate all types of damage to the archaeological site.

It is necessary to record and document all aspects of damage by preparing a detailed file that allows for the identification and determination of all losses incurred to the fixed structures and building materials (such as fractures, cracks, deterioration, etc.), taking into

account accurately locating them on the plans, elevations (manual, topographic, and photogrammetric), and detailed drawings.

These manifestations and damages are classified taking into account the conservation status and the degree of damage, such as severe damage that requires urgent intervention and then moderate damage.

A report is prepared that accurately identifies the causes and factors of damage and deterioration of the protected real estate, with a clear explanation of the mechanisms of damage and determination of the degree of deterioration, mentioning the expected and suitable solutions for its restoration and reclamation, and avoiding these causes and factors as much as possible.

In order to achieve a true understanding of the conservation status of the wells, a technical card has been allocated to them, mainly aimed at gathering information about the building, determining the main structural elements, their construction materials, their conservation status, dimensions, conclusions, and proposed works. These data are collected through the inspection of the building and are considered essential elements used in all stages of the restoration process.

2-3- Restoration Works:

These are the necessary interventions that cannot be dispensed with in the restoration of structural elements of wells, and sometimes complement the reinforcement works, with the aim of preserving the heritage site.

A- Treatment of Stone Deterioration:

This process affects the wall stones that make up the upper part of the wells, which have been damaged by chemical factors such as salt crystallization and plant growth, or by physical factors such as pressure. However, the treatment of stones in archaeological buildings has evolved significantly due to technological advancements and the discovery of hydrogels that can resist damage, although these methods are not without flaws (Doudou, M. 2015: 196).

The process of treating fragile stones in the structures of traditional wells in M'zab valley depends on their examination and subjecting them

to tests related to the physical resistance of the unit that makes up the archaeological wall. This examination leads to intervention to treat the deterioration using two methods:

-Strengthening the constituent stones of the monument:

It focuses on the original stones that make up the wall of the archaeological monument, which are still in a stable condition. All factors of deterioration are removed, the perimeter of the stones is strengthened, gaps are filled, and connections are restored to ensure the cohesion of the stones in the future.

-Replacing severely deteriorated stones:

This process is carried out on fragile and severely deteriorated stones that pose a threat to the archaeological monument. The process of replacing the deteriorated stones is done as follows:

-Reinforcing the archaeological wall to prevent it from being affected by the removal and replacement of the deteriorated stones.

-Removing the deteriorated stones one by one, individually. Each deteriorated stone is removed and replaced before moving on to the next one.

-Ensuring that the stones have the same characteristics as the stones that make up the archaeological wall.

-Cleaning the empty space (from which the stones were removed) from dust and impurities.

-Lightly spraying water to ensure the cohesion of the mortar between the old and new stones.

-Placing lime mortar in the empty space, then placing the new stones and filling the gaps with mortar, and smoothing it against the wall.

B- Retouching cladding:

The process of treating the cladding depends on inspecting the wall cladding and assessing its stability and resistance to damage, with the treatment of deteriorated cladding done in two stages:

- Removing the deteriorated cladding:

This includes cladding affected by the upward movement of water, which is usually swollen or completely detached from the wall, or fragile cladding.

- Applying new cladding:

After removing the deteriorated cladding, the walls are cleaned from the remnants of the old cladding and any impurities and dust it may leave behind. Then, the walls are cladded again using the same mortar used in the cladding process (lime or clay), taking into account the direct or indirect effects of damage on it.

2-4- Reinforcement:

It is all the interventions on parts and elements of the archaeological structure, aimed at stopping their deterioration and ensuring their greater cohesion. Also, the term "reinforcement" can refer to all temporary and situational actions and interventions on archaeological monuments until appropriate solutions for their restoration are found. Proposed reinforcement operations can be classified according to their methods and means into two categories:

-Reinforcement without the use of construction materials:

This reinforcement is temporary until a final solution is found. It can also complement the final reinforcement and restoration process, taking care not to damage the archaeological structure and its essential components during and after the reinforcement process.

- Reinforcement using building materials:

These are all interventions in which building materials such as mortar and stones are used as primary means in reinforcement operations. They should be used in reinforcement and strengthening operations, using materials that have been previously tested, as stipulated by international agreements in this field. In this case, it is preferable to use local lime due to its suitability for restoration and reconditioning works (Doudou, M. 2015: 196).

A- Strengthening the infrastructure:

Reinforcement is done by replacing the crumbling stones from the inner wall of the well and strengthening the joints with cement mortar. This is to ensure the safety and cohesion of the wall, in order to secure the lives of those involved in various restoration works inside the well.

B- Reconstruction of the superstructure:

Wherein the upper part of the well is rebuilt with stones and dual mortar (lime and cement) and restored to its original shape. The wooden beams and pulley are also repaired and rebuilt, and all the parts attached to the well, such as basins and camel alleys, are restored and reconstructed.

2-5- Preventive Maintenance:

For every intervention on archaeological sites, each has its own condition. As for the preventive maintenance of traditional wells in valley M'zab, it requires the following:

A- Cleaning:

This involves removing all stones, dirt, and debris from the bottom of the well, as well as removing excess water from the well using large pumps. This is done to facilitate intervention on the structure.

B- Monitoring:

Monitoring is an essential result of the awareness of the importance of traditional wells in valley M'zab. This process requires simplicity in execution, but is important in its impact, controlling natural and human factors of damage. It also requires specialized survey cycles to prevent the reoccurrence of damaging factors.

The monitoring process is a type of guarding the site and preventing intentional and unintentional human violations that target traditional wells in valley M'zab. This process requires reactivating the Guardians of the Dam Authority to give these facilities a kind of historical credibility that contributed to their emergence and development into the current form.

C- Awareness:

Most of the damages that affect archaeological sites are directly related to human factors, as a result of unawareness of the value of these sites and the values they hold related to individual personality, societal history, and ancestral genius.

Raising awareness of the civil society about the value of archaeological sites in general and the traditional wells in valley M'zab specifically, does not only prevent them from causing harm, but also makes them eager to preserve them and report damages resulting from other factors, as they are closer to them than anyone else. This can be achieved through holding lectures, seminars, exhibitions, and field visits that serve the purpose of raising awareness and bringing them closer to these sites. In addition, the media in all its forms can play a role in the same context. It is also advisable to reach an agreement with government and private entities responsible for implementing development projects to address the risks threatening architectural heritage in the area where those entities operate due to the implementation of their projects.

Thirdly: A model for the maintenance and restoration of traditional wells in valley M'zab:

1- Study on the maintenance and restoration of Bayyizi well in Ghardaia Qaser:

1-1- Description of the well's condition:

- This well is located in the Bayyizi neighborhood, Ghardaia oasis.
- It is located at a height of 10 meters above the riverbed.
- It is covered with a wooden door.
- The superstructure and infrastructure of the well have deteriorated.

1-2- Works carried out under the supervision of the Office for the Protection and Development of valley M'zab:

- Cleaning the well from debris and dirt from inside the well.
- Reinforcing the internal connecting wall.

-Rebuilding the collapsed parts of the connecting wall using local building materials.

-Restoring the infrastructure of the well, which was in a moderate state of preservation?

-Reconstructing the superstructure of the well in the traditional manner, using local building materials, which were significantly damaged.

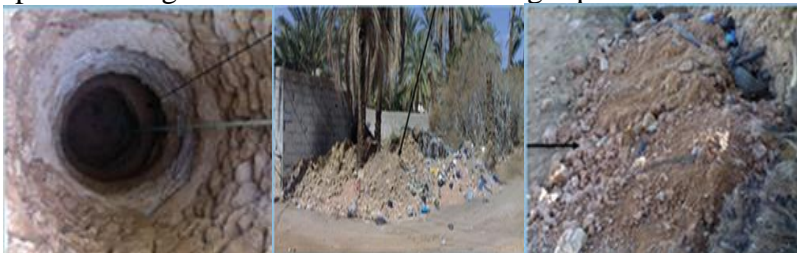
-Conducting preventive maintenance on the superstructure and infrastructure of the well (Protection and Development Office of valley M'zab. 2014: 26).



Photo 04: Deterioration of the superstructure and infrastructure of the Boujebouj well in the Qaser Ghardaia oasis.

1-3-Maintenance and restoration stages for the traditional well in valley M'zab (Boujebouj Well):

The maintenance and restoration process of Boujebouj Well, located in the qaser Ghardaia Oasis, which was supervised by the office of Protection and Development of valley M'zab, was carried out in three specified stages as shown in the following report:



The first Phase: The well cleaning process of the Boujebouj well in Qaser Ghardaia.



Phase Two: Preparing the raw materials to strengthen the infrastructure of the Boujebouj well in Qaser Ghardaia (stones, moisture-resistant mortar).



The Third Phase: Restoration of the superstructure of the Boujebouj well in Qaser Ghardaia.

Conclusion:

Traditional wells have great importance in the ksour of valley M'zab, as they were important and vital facilities in the region and in all desert areas. This is because they supply the qaser facilities and residents with water for various purposes, and they have a role in reviving agriculture through traditional irrigation and watering systems. This highlighted a

distinct architectural pattern in the construction of these wells. Maintaining and renovating them ensures this vital nerve of life, which is water, and guarantees the preservation of our human heritage and its values, so that the message can be passed on to future generations, God willing.

- Solutions and recommendations for the maintenance and restoration of traditional wells in valley M'zab:

To mitigate these risks, it is necessary to carry out works that provide protective measures and rescue operations for these historical wells that are threatened by the dangers we previously mentioned, caused by human and natural factors.

One of the most important tasks is to address the natural hazards, especially the danger of floods and valleys. These hazards are sometimes difficult to avoid, especially since some of these wells are located along the course of the valley. Therefore, measures must be taken to at least reduce their damage. Some of these measures include increasing the building's resistance, repairing weak points and cracks that allow floodwaters to seep into the structure of the building, such as walls and foundations. There are several methods to treat such cases in stone buildings, such as sealing gaps and openings and repairing cracks using cementitious liquid suitable for such situations, as well as replacing old mortar with suitable mortar or other materials.

As for facing the dangers resulting from human behavior such as intentional destruction, urban expansion, and construction of buildings, the matter can be easy if determination and awareness of the importance of cultural heritage are available, then the treatment becomes easier.

Regarding the exclusion of dangers arising from the intentional demolition and destruction of historical structures of all kinds by the owners of these buildings, whether by demolishing them or adding something modern to them due to personal interest or ignorance of the importance of their possessions to national heritage, and for this, the citizen must be educated and made aware of the importance of cultural heritage because it is history and identity. At the same time, intensify monitoring effectively in order to exclude any destruction and attack on heritage.

It is advisable to reach an agreement with the government and private entities responsible for implementing development projects to address the threats facing the architectural heritage in that area resulting from the implementation of their projects, as most Arab countries are developing countries and constantly evolving, and therefore there are large projects under implementation or already implemented.

Regardless of the different perspectives on how to maintain and renovate historical and heritage buildings (traditional wells in valley M'zab), restoration operations are not merely repairing damaged architectural elements, but rather have their own principles and traditions. They must be carried out based on extensive experience and a comprehensive understanding of the nature and characteristics of different types of heritage buildings. Otherwise, restoration operations will lose their purpose, and incorrect restoration has lost rare artifacts and important archaeological elements. Therefore, restoration operations must be adapted and diversified according to the type and characteristics of the case requiring restoration, including its material, shape, appearance, and artistic features, considering that historical or heritage buildings are not just physical entities but also carry intellectual and artistic cultural content.

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