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# Multi-Temporal Geospatial Analysis of Unplanned Urban Encroachment on Ancient Landscapes: A Case of the Thamuskani Site ( ALGERIA )

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**Abstract**: Preserving historical sites amidst urbanization is a significant global concern, especially as urban growth intersects with ancient landscapes. Algeria's burgeoning urbanization and rich cultural heritage pose a unique challenge in this regard. This essay delves into the impact of urban encroachment on the Thamuscani archaeological site (Kharbat Zambia) from 1975 to the present. It employs modern geographic technologies such as satellite imagery, GIS, and historical data to examine how ancient sites have been displaced by extensive urban expansion. Through spectral analysis techniques such as NDBI and NDVI, NDVI minus NDBI and other pencil-source data, along with supervised classification and fieldwork, the study accurately gauges the extent of urbanization and its repercussions on archaeological landscapes. The results reveal a dramatic increase in the built-up area within the archaeological site, from 0.5 hectares in 1975 to 50 hectares in 2023, with projections indicating further expansion to over 25 hectares by mid-century. These results confirm the urgent need to quickly protect the Algerian cultural heritage, which is part of the World Heritage, in the face of rapid urbanization, especially in the absence of adequate monitoring and preservation tools.
**Key words**: Historical geography; Archaeological site; urban hazards; geospatial tools.

**Conflict of Interests:** The authors declare no conflict of interest.

**Ethical Statement:** We, the authors of the manuscript. We affirm that this research is the result of our own endeavors, and we have adhered to fundamental ethical principles throughout the research process.

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**Introduction**

According to the World Council on Monuments and Sites (ICOMOS), archaeological heritage is defined as "the part of our material heritage for which the methods of archaeology provide the basic knowledge. It encompasses all traces of human existence and concerns places where all human activities have been carried out, abandoned structures and remains of all kinds, on the surface, underground or underwater, as well as the material associated with them" (ICOMOS, 2011).

This definition categorizes archaeological heritage based on its location, whether it is on the surface, underground, or underwater. In turn, archaeological heritage encompasses all material traces of humanity that require protection and enhancement to allow researchers to study and interpret them for future generations. The European Convention also emphasizes this need, stating that archaeological heritage includes "the remains, objects, or any other traces of human beings, constituting a testimony of eras and civilizations of which the main or one of the main sources of scientific information is ensured by excavations or discoveries" (Council of Europe, 1969; Inoudjal I, Mekiri K 2015).

Furthermore, the Convention Concerning the Protection of the World Cultural and Natural Heritage, established in Paris in November 1972, defines archaeological sites as "works of man, or the combined works of man and nature" and areas that include archaeological sites of outstanding universal value from a historical, aesthetic, ethnological, or anthropological perspective. This definition falls within a broader scope that defines the cultural heritage of monuments, ensembles, and sites (UNESCO, 2001).

According to Algerian Law 98-04, archaeological sites are defined as areas, whether built or not, that serve no active function and bear witness to the actions of humans or the combined actions of humans and nature. These sites include the subsoil and hold historical, archaeological, religious, artistic, scientific, ethnological, or anthropological value (Article 28, Law 98-04).

Algeria boasts a rich and exceptional cultural heritage with significant historical and symbolic importance, reflecting the influence of numerous civilizations throughout history. This heritage comprises a priceless variety of architectural, urban, and archaeological wonders (S. Khelifa-Rouaissia ; H. Boulkroune, 2017). The National Center for Archaeological Research has identified over 15,200 sites across the country (<https://www.elwatan.com/edition/culture/celebration-du-mois-du-patrimoine-4000-sites-archeologiques-recenses-08-05-2021>). Among these, 7,640 sites are included in the archaeological atlas created by Stephen Gsell (aps.dz), encompassing structures, architectural ensembles, built sites, monuments, and more.

However, many of these sites require restoration and proper protection due to deterioration caused by natural hazards, such as earthquakes, landslides, precipitation, flooding, muddy run-off, and erosion. Additionally, anthropogenic actions, urban decay, and the construction of infrastructure have also contributed to the damage of this invaluable cultural heritage. The threat of deterioration is often exacerbated by large-scale development projects.

Urban centers, such as Mila, Tebessa, Tazoult (Kerboua, 2019), and Thamuscani (Kharbat Zambia), serve as examples where the encroachment of concrete and urbanization has led to the degradation of this precious heritage. The Algerian authorities and communities need to recognize the significance of their cultural heritage and take proactive measures to safeguard and preserve it for future generations.

Maintaining cultural heritage in the face of urban expansion can be effectively achieved through the strategic utilization of geospatial systems, as per Anne Moreau (2022). These systems offer an array of tools and techniques that can be leveraged to evaluate and mitigate the threats posed to archaeological sites by urban development, as per Inoudjal Imene and Mekiri Kamelia (2016). By integrating diverse datasets, such as archaeological site locations, land use, and environmental factors, geospatial systems enable analysts to pinpoint areas where urban growth endangers cultural heritage, as per Ramach Youcef (2022).

High-resolution satellite imagery facilitates detecting changes in land use over time, identifying encroachment on archaeological sites, and assessing potential risks to cultural heritage, as per Rayne

Louise et al. (2020). Geographic Information System (GIS) modeling allows for the simulation of various urban expansion scenarios, aiding in risk assessment by considering factors such as population growth and conservation policies, as per Plata Rocha et al. (2011).
This quantitative risk assessment facilitates prioritizing conservation efforts and informing land use decisions, as per Rayne Louise et al. (2020). Additionally, geospatial tools engage communities through visualizations and maps, fostering awareness and involvement in heritage conservation initiatives. Ongoing monitoring with remote sensing technologies enables authorities to detect unauthorized construction near archaeological sites and take timely enforcement actions, while geospatial analyses provide evidence for policy development, recommending measures such as buffer zones to integrate heritage conservation into urban planning, as per Ahris Yaakup et al. (2002).
So, geospatial systems empower stakeholders to adopt a proactive approach to heritage conservation and ensure sustainable coexistence between cultural heritage and urban development.

**Study area:**
Khirbet Zambia has been referred to by various names in academic discussions and archaeological texts. One such name, Thamuscani, appears in archaeological inscriptions (directorate, 2019). In the Peutinger Table, it is noted that Thamascani does not seem to be a Latin name but may be rooted in the local Amazigh language, as it begins with the letter "TH."
The challenge of identifying Thamascani persists due to the inscription's discovery near Thamuscani (Belimour, Al-Anaser, Al-Hamadia). Many scholars propose that Kharbat Zambia corresponds to Thamuscani, as argued by researchers Gezal and Robert A. Robert A. supports this hypothesis based on the distance between Khirbet Zambia, Al-Hammadia, and Ras El Oued (Robert A, 1923).

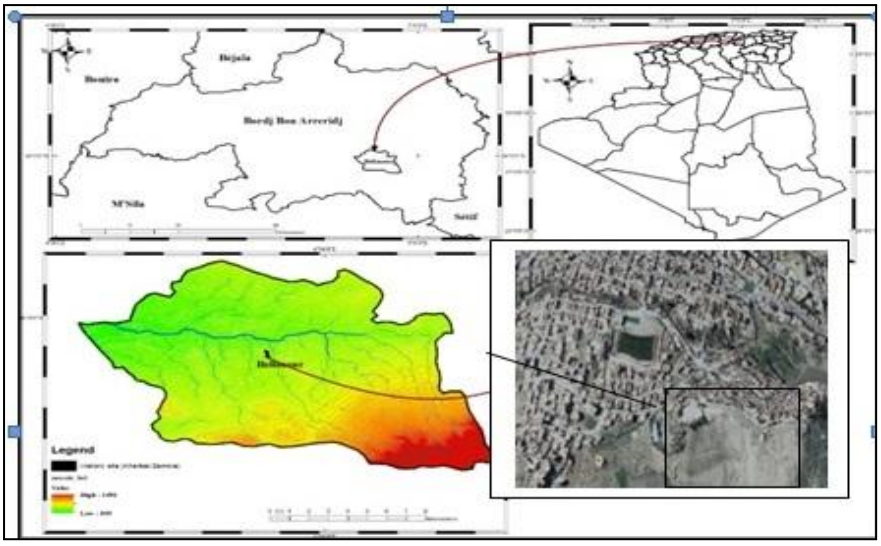



*Fig.1: Study area, treated in Q GIS App*

Kharbat Zambia is situated on the eastern bank of the Wadi al-Qaeda and is located to the north of the Serez (Belimour) region. Identified as point (N) F16 (347) on the gazelle map, it is confined within the coordinates (35.59,1366N- 04.52,1197 E). Located in the foothills of the Hodna Mountains, a part of the southeastern landscape, it is bordered by the Mazaytah Mountains to the east and west. Its elevation ranges from 1000 meters, with slopes varying between 12.5 to 25 degrees, featuring malleable limestone formations. The area also includes the Maadid Mountains (Fig:01-02).

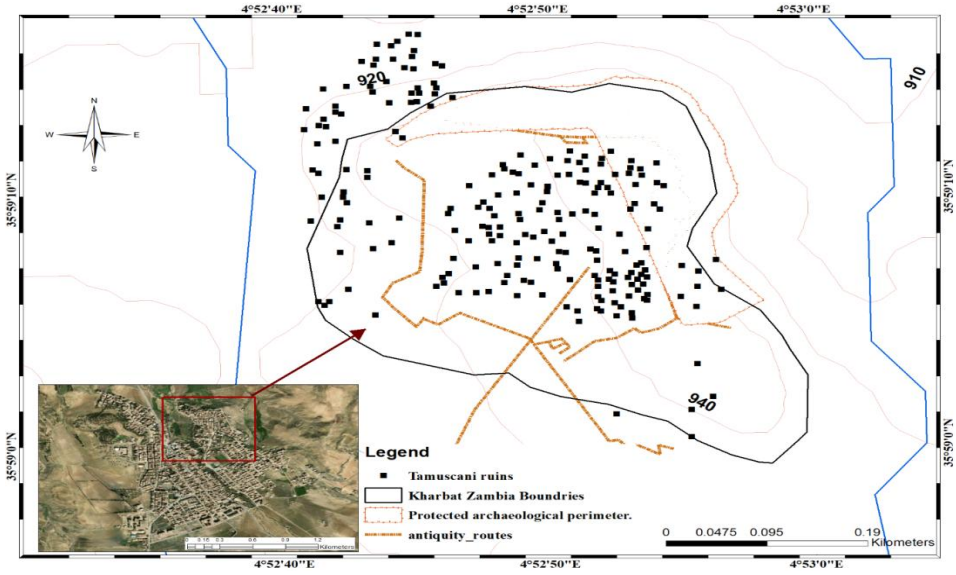



*Fig.2: Thamuscani through Achille Robert in the late 19th century (Robert A 1905)*

The site, which is a state-owned property, is listed in the Registry of Approvals under No. 01, Article No. 88, and comes under the purview of the Directorate of Culture. Following a deliberation and examination conducted by the Municipal People's Council of Belimour, in accordance with Article 93, Paragraph 1, No. 90/08 dated 07/04/1990, it was designated as an inventory. This decision was further reaffirmed by Resolution No. 1177, which was passed on September 25, 2014, by the Directorate of Culture (2019).

The archaeological site of Kharbat Zambia has played host to a wide range of historical periods, thereby underscoring its historical significance. The site traces its origins back to the prehistoric era, during which Silex tools, notably Silex gris (Robert, 1912), and a Libyan inscription, which was discovered by Achille Robert in the late 19th century, were unearthed. The Libyan inscription, which features Libyan characters, was analyzed by Charbonneau (A) 1860 and was assigned the number 841 (Ramache, 2019; Habari, 2018).

The area, as per the field observations, may have been home to rural Roman-era dwellings. The well-regarded researcher, Paul A. Fevrier, has suggested that during the reign of Philip the Arab in the 3rd century AD, Khirbet Zambia served as a municipality (Fevrier, 1996)

The archaeological findings from the Roman era include three inscriptions from the reign of Gordian III, as documented by Muhammad Ism. These inscriptions, which were noted by Carcopino, mention Castellum Table, Vanarzanens Castellum, and Castellum Limelense (Carcopino, 1915).

Additional evidence indicates that Khirbet Zambia was fortified during the reign of Gordian III, possibly for defensive purposes, and may have existed during Alexander's reign, as suggested by Fevrier (Fevrier, 1996).Researcher Dados Theodosos Kuthila highlights that the rise of municipalities in the early 3rd century AD led to the decline of fortified towns, with Khirbet Zambia, also known as Limelivens, transitioning into a municipality akin to neighboring settlements such as Mons (M'hantel 1996).Fevrier suggests that it officially became a municipality during Philip the Arab's rule. An archaeological inscription discovered at the site pertains to repairs made to the aqueduct (Fevrier, 1996).

**Methodology**

The methodology used in drafting this paper comprises the integration of historical data gathered from a diverse range of historical and archaeological sources (Figure 03), alongside the utilization of plans published by governmental entities. However, the core of the study primarily depends on a substantial compilation of satellite imagery that spans an extensive timeframe, surpassing the archive's capacity for referencing.

In order to guarantee the utmost accuracy and dependability of the data obtained through remote sensing, we conducted fieldwork to rectify certain spectral readings that were captured by the satellite imagery. The instruments and techniques employed in this research paper are detailed below.

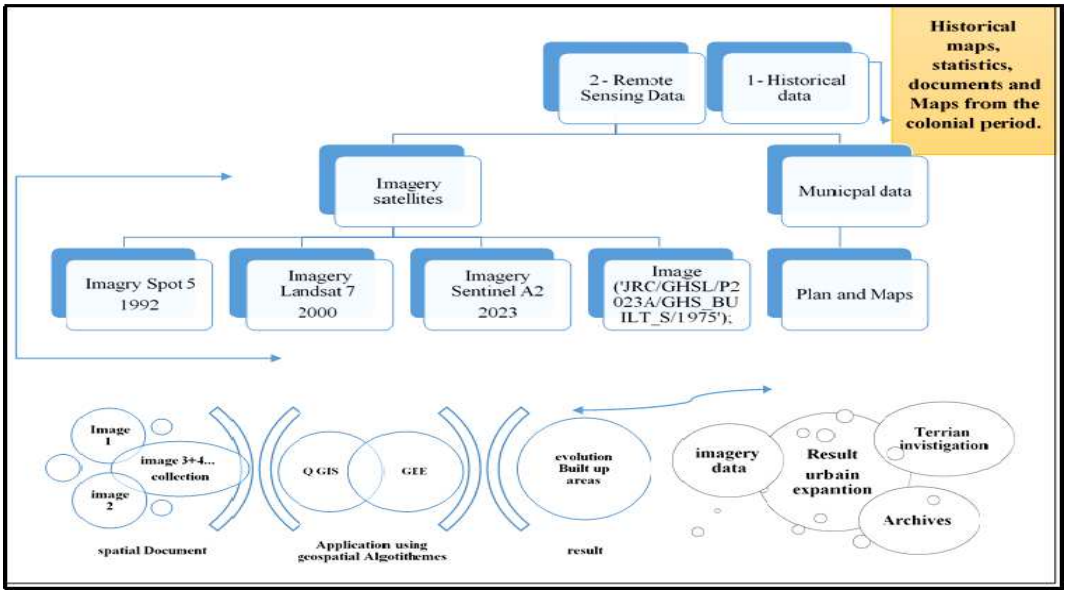



*Fig. 3: Methodology Adopted*

**Selection of data and methodology adopted historical and administrative documents**

This research focused on verifying historical data and geographic details related to Kharbat Zambia (Thamuscani) by examining reputable historical sources in the fields of historical and archaeological studies in North Africa. These sources include:

The city plan authored by Achille Robert, as documented in: Robert A, Antiquity of the mixed commune of Maadid, Geographic overview, page 73.

Cagnt (R), "The Roman Army of Africa and the Military Occupation,"

Gsell (st), "Archaeological Atlas of Algeria,"

Peutinger's Table "Salama P," Government of the Algerian cartographic service, 1949.

Simultaneously, plans and maps from various relevant entities and departments were consulted, such:

The archaeological site report and Lift plan for Kharbat Zambia (Thamuscani) authored by expert “Saidani Kamal”, dated October 10, 2015, commissioned by the Directorate of Culture of the Bordj Bou Arreridj wilaya (Fig 06)

The topographic elevation plan, crafted by Engineer ‘’Hakas Abdel Aziz’’ on April 18, 2010, at a scale of 1/5000, tailored for the site under scrutiny, commissioned by the Land Survey Directorate in the Bordj Bou Arreridj wilaya (Fig 07)

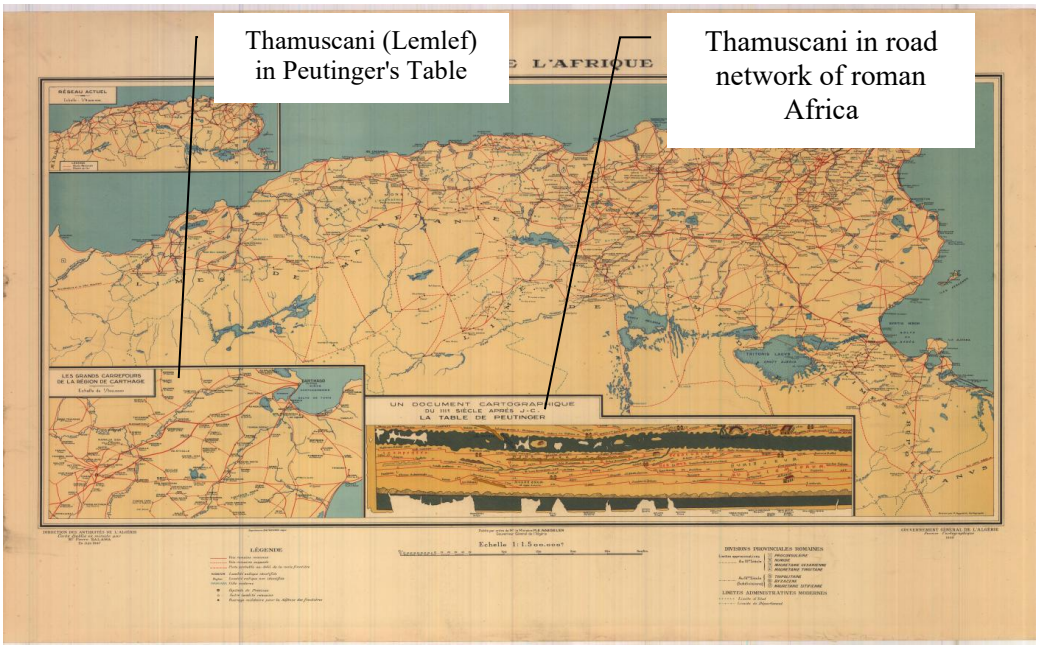



*Fig 04: Thamuscani Site in Peutinger table: a cartographic document from the 3rd century (Salama P 1949)*

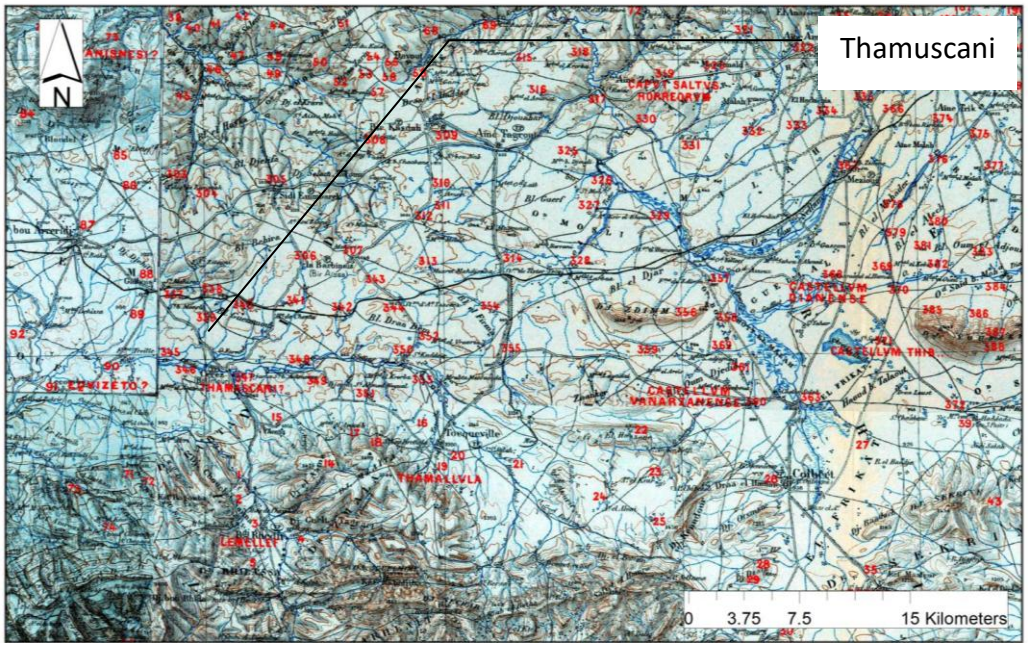



*Fig 05 : Thamuscani in "Archaeological Atlas of Algeria (Gsell st. 1912)*

The methodology employed in this study involved a thorough review of extensive historical records to assess the significance of the archaeological city of Thamuscani. This process involved scrutinizing historical data and working with geographic information systems to understand its location, urban layout, and other pertinent details.

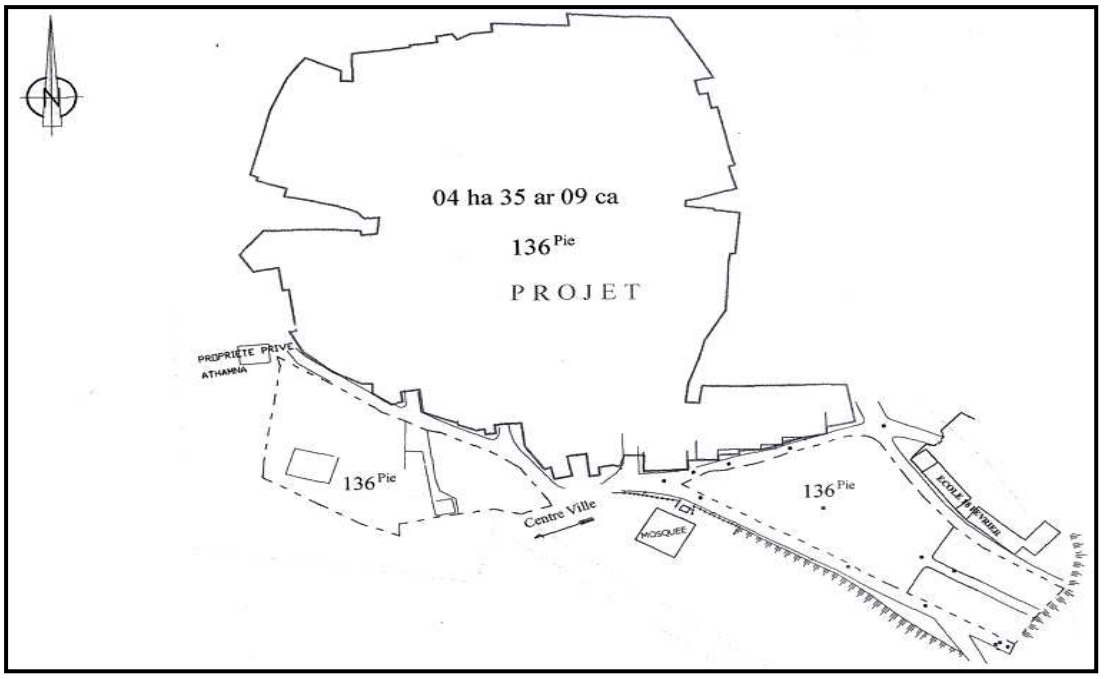



*Fig 06: plan: topographic survey, project: regularization site March 19 (kharbet zambia)*

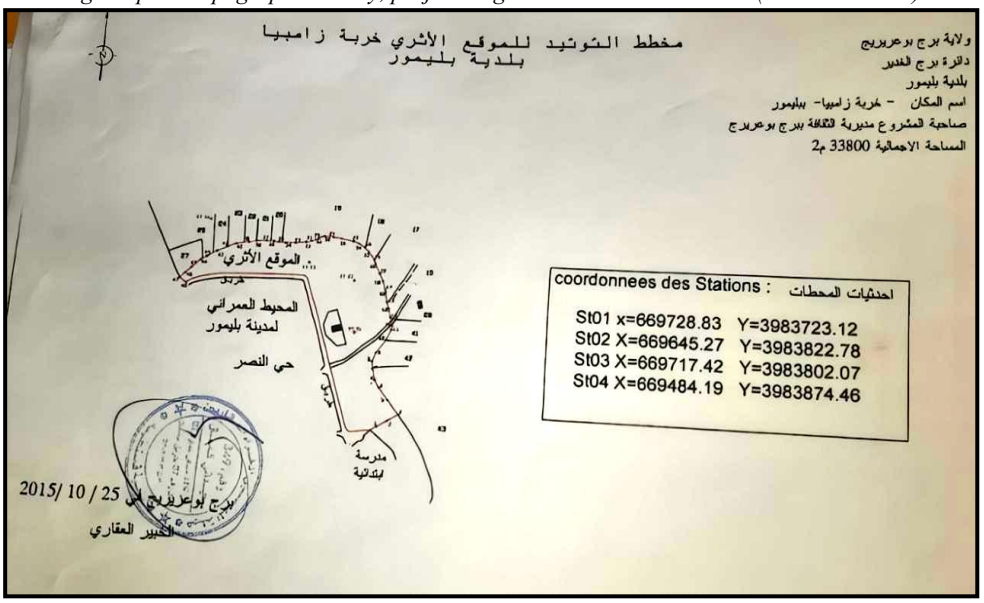



*Fig 07: Lift plan for Kharbat Zambia (Thamuscani)*

The study began with data input from the survey phase, leading to the creation of a database and subsequent digitization based on the necessary visual variables for cartographic representation. The aim was to extract geometric data for the site, drawing from both historical records and urban plans provided by governmental bodies at the state level.

**Satellite imagery data and maps**

The investigation of the urban evolution of Kharbat Zambia and its impact on the archaeological city of Thamuscani necessitated the acquisition of a comprehensive array of satellite images with diverse spectral and spatial coverage. This was deemed essential due to the inadequacy of open-source satellite imagery available, which failed to provide high-resolution and extensive coverage of the relatively small area under investigation. The following characteristics describe the attributes of the images utilized to enrich this research paper:

The Global Human Settlement Layer (GHSL) was used, which offers global spatial information, evidence-based analysis, and insights into human presence on Earth. GHSL employs advanced spatial

data processing technologies to automatically analyze and extract information from vast and diverse geospatial datasets, including global fine-scale satellite imagery, census data, and crowdsourced or volunteer geospatial information sources.GHS-BUILT-S R2023A is a raster dataset that showcases the built-up surfaces in a specific area. It was created using Sentinel-2 data from 2018 and Landsat data from 1975 to 2030. (European Commission, HSL Data Package 2023) The data was analyzed using Google Earth Engine (GEE), which is a platform that allows users to run large-scale algorithms and conduct research without charge. (Velástegui Montoya et al. 2023) GEE was designed to promote research, support global solutions to big data problems, and provide free access to its services. (Amani, Meisam, 2020).The required data was accessed using the following algorithm: (https://developers.google.com/earth-engine/datasets/catalog/JRC_GHSL_P2023A_GHS_POP) using the following code: Image SRTM (The Shuttle Radar Topography Mission): n36_e004_1arc_v3 covering the study area were downloaded from the website 'https://earthexplorer.usgs.gov/ with following feature: For the first time, this SRTM image presents a near-global digital elevation model (DEM) of high resolution, characterized by homogeneous quality and free accessibility. (Yang, Liping et al., 2011).The Shuttle Radar Topography Mission (SRTM) was a significant milestone in the creation of the first near-global dataset of land elevations. Part of the Space Shuttle Endeavour's STS-99 mission, it gathered topographic data covering around 80% of Earth's land surfaces (<https://www.earthdata.nasa.gov/sensors/srtm>).

This data enabled the production of accurate maps for our sites: "Thamuscani and Kharbat Zambia." In this research, we included the "spot 02 image" from 1992, labeled as S2_055-278-0_1992-07-24-10-35-01_HRV-2_P_DT_TT.

Additionally, we obtained multiple Landsat images captured in October 2000 (LE07_L2SP_194035_20000110_20200918_02_T1_SR_B3.), December 1990, and February 1995 (LT05_L2SP_194035_19950205_20200912_02_T1) using various sensors such as MSS, TM, ETM+, and OLI. These images were sourced from the U.S. Geological Survey website ([https://earthexplorer.usgs.gov/](https://earthexplorer.usgs.gov/)) and employed to compute the NDBI index and monitor urban expansion between 1990 and 2000.

While the Multi Sentinel-1-2 imagery captured in February 2015 and February 2023 with VV-Descending polarization were employed to detect flooded areas between 2015 and 2023, the ArcMap software and the Google Earth Engine platform (<https://code.earthengine.google.com/>) were also utilized to compute the NDBI index and monitor urban expansion during the same time frame.

The methodology employed in processing satellite images involves the calculation of the Normalized Difference Built-up Index (NDBI), which is a remote sensing index utilized to identify and analyze built-up or urban areas within satellite imagery. It quantifies the degree of urbanization within a specific area by measuring the variation in reflectance between the near infrared (NIR) and shortwave infrared (SWIR) bands. The NDBI is typically calculated using the formula:

$$NDBI = \frac{SWIR - NIR}{SWIR + NIR}$$ (Xu, Rudong et all. 2018 )

**Where**:

-NIR represents the reflectance in the near-infrared band.

-SWIR represents the reflectance in the shortwave infrared band.

-NDBI values typically range from -1 to 1, where:

In the context of Spot 02, it is important to highlight that while the Near Infrared (NIR) band can be substituted with the green band, the accuracy of the result may suffer. To achieve accurate outcomes, it is essential to use the genuine NIR band. However, we can proceed with the standard NDBI calculation. In light of the absence of a Shortwave Infrared (SWIR) band, we can resort to an approximation. In this instance, we can utilize the Red band (0.61-0.68 μm), which is relatively closer to SWIR when compared to the other available bands.

Our findings align with those from the spectral analysis, as well as the on-site guided or supervised classification and interviews with prominent individuals who possess a deep understanding of the city's urban history.

-Values close to 1 indicate a high probability of built-up areas.

-Values close to -1 suggest the absence of built-up areas, such as water bodies or vegetation.

-Values around 0 indicate areas with little or no urbanization.

The fundamental concept behind NDBI is based on the observation that artificial structures, including buildings, roads, and concrete surfaces, typically exhibit high reflectance in the near-infrared (NIR) band and low reflectance in the shortwave infrared (SWIR) band, due to their unique composition and arrangement. On the other hand, natural features, such as vegetation and soil, generally display lower NIR reflectance and higher SWIR reflectance. By calculating the normalized difference between these bands, NDBI effectively increases the distinction between developed and non-developed regions, thereby serving as a useful technique for urban mapping and surveillance.

However, we have used NDVIndex behind NDBI to determine vegetation cover, the formula for NDVI is:

$$NDVI = \frac{NIR-RED}{NIR+RED}$$ (Meera Gandhi, G et al. 2015)

-NIR represents the reflectance in the near-infrared band.

-Red is the reflectance in the red Band.

The normalized difference vegetation index (NDVI) ranges from 1 to -1, with lower values close to -1 indicating sparse or stressed vegetation. By subtracting the normalized difference built-up index (NDBI) from the NDVI value, a new index is obtained that represents the front-print built-up area. This method was introduced by Shah et al. in 2003 and further elaborated by Shah et al. in 2022. A negative value result signifies that the built-up area is dominant over the vegetation. To gain a deeper understanding of these findings, it is recommended to combine the supervised classification with fieldwork and interviews with knowledgeable individuals about the region.

The exponentiation of urbanized land area: Based on the result of imagery satellite interpretation, we have applied this equation for predict the future built-up area in the study region:
https://esdac.jrc.ec.europa.eu/public_path/shared_folder/projects/DIS4ME/indicator_descriptions/population_growth_rate.htm)

- B_A = Built_up area rate.
- B2 = Ending Built_up surface.
- P1 = starting Built_up surface.
- T = time interval (in years) between the starting and ending stages.
- Ln = natural logarithm

**Expansion estimation for built-up areas:**

(https://www3.nd.edu/~apilking/Calculus2Resources/Lecture%205/NotesL5.pdf),
(https://miniwebtool.com/exponential-growth-calculator/)

**B(t):** This represents the built-up surface at a time

**T:** It's the dependent variable, meaning its value depends on the value of t.

**C:** This is the initial value of B(t) when t=0. It's also called the initial condition or the constant of integration.

**e:** This is the base of the natural logarithm, approximately equal to 2.71828
2.71828. It's an irrational constant that appears frequently in mathematics.

**k:** This is the growth (or decay) rate. It determines how quickly the quantity B(t) changes over time.

**If:** k>0, the quantity grows exponentially. If k<0, the quantity decays exponentially.

**t:** This represents time. It's the independent variable, meaning it's the variable we're interested in observing or manipulating.

## Results

### Geospatial identification of the ancient site “kharbat zambia –thamuscani-“

The precise location of the archaeological site in Kharbat, Zambia, was established through satellite imagery from the Shuttle Radar Topography Mission (SRTM). Additionally, historical data, including maps, plans, and open-source geographic information systems, were employed in this research. Various research institutions, commissioned by the Directorate of Culture of the wilaya of Bordj Bou Arreridj or the municipality of Belimour, also conducted fieldwork, which yielded the aforementioned results.

### The spatial extent and boundaries of the site

The archaeological site is situated in the Zambia neighborhood, within an area known as "Al-Shafer," surrounded by Wadi Zeddika. Positioned on a plateau at an altitude of 850 meters, the site encompasses a rectangular parcel of land enclosed by a wall. The site spans 14 hectares, confirmed through geometric and geographic information systems analyses (approximately 13.711155 ha, Fig. 02-08-09). Its boundaries extend north and east into cultivated areas, south to the municipal stadium, and west and southwest into existing buildings. This is consistent with an elevation plan conducted by a certified real estate expert on October 25, 2015, which delineates the consolidation of the archaeological site of Kharbat Zambia in the municipality of Belimour (Fig. 06-07).

Based on an approximate survey conducted through archaeological analysis and the spatial distribution of archaeological discoveries, the site's boundaries extend to residential houses on the western side. However, evidence indicating the southern border was not found, except for the presence of Maharas, reportedly brought from M'zaita (a mountain situated between the municipality of Bordj Ghedir and Ras El Oued). To the east, the site is clearly delimited by agricultural lands, while to the south, it extends towards the municipal stadium, identified as a Roman site (Habar 2019). Through Achille Robert's map (Fig. 02) and field inspection, it is evident that the antiquities are concentrated in abundance on the western and southwestern sides, covering approximately 8.30 hectares. However, the protected archaeological perimeter designated by the Directorate of Culture, according to Resolution 1177 dated September 25, 2014, is only estimated at approximately 3.43082 ha (Fig. 8).

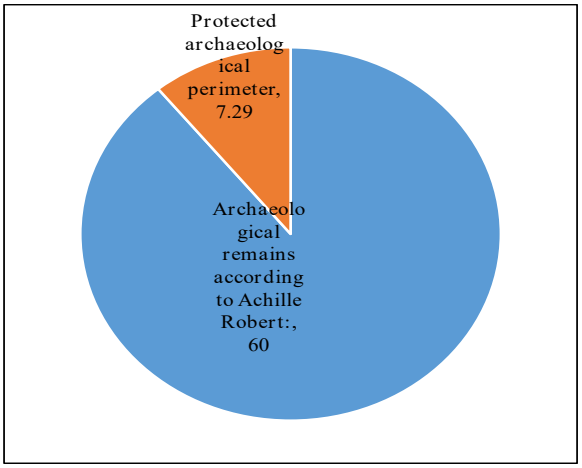



*Fig08 : the rate of archeological remains and the protected area*

Using Geographic Information Systems (GIS) and integrating different layers, such as neighborhood delineations, French colonial-era archaeological findings, and the designated protected area, the analysis concludes that the archaeological area significantly surpasses the boundaries of the Kharbat Zambia neighborhood, particularly to the north and northwest (Fig. 09-10).

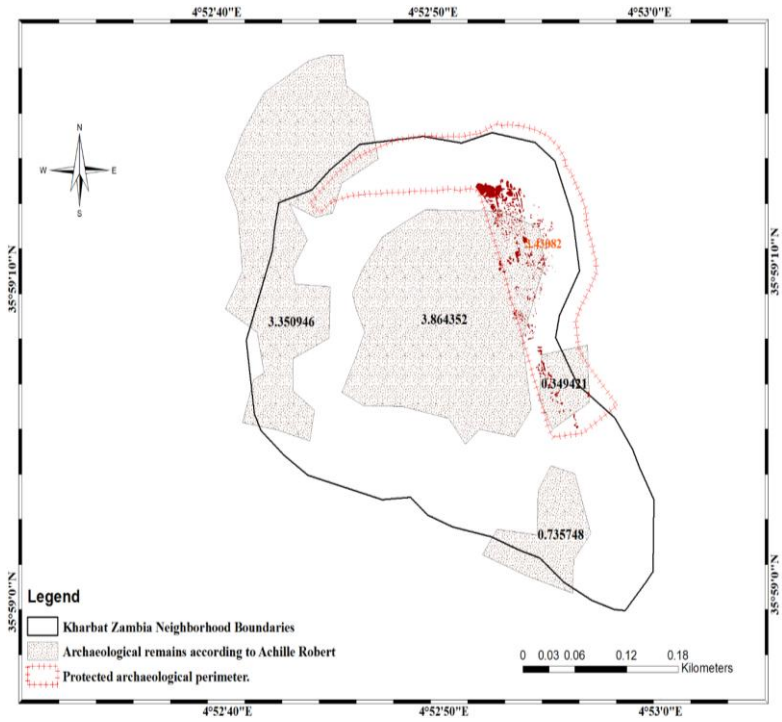



*Fig 09: Kharbat Zambia, Archaeological remains (Robert 1905)*

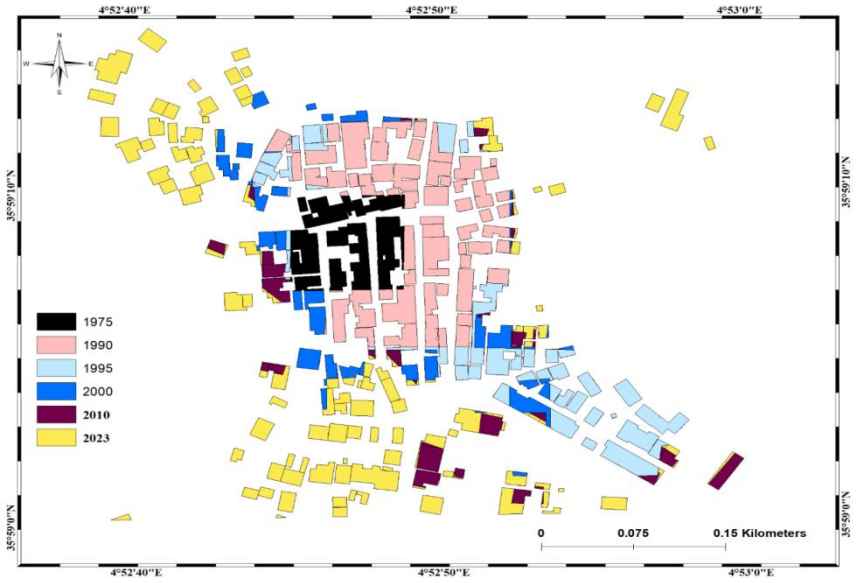



*Fig10 : Kharbat Zambia; Urban expansion from 1975 to 2023 treated in GEE and Q Gis*

As of September 25, 2014, the protected area comprises only a small portion of the original city's ruins, amounting to no more than 3 hectares out of the 8 hectares that existed during the French colonial era.

## Discussion

### The Archaeological Site's Extinction in Favor of Careless Urban Growth

The dataset "JRC/GHSL/P2023A/GHS_BUILT_S/1975 for 2023" reveals that urban expansion is encroaching upon the archaeological site of "Kharbat Zambia - Thamuscani-". By incorporating spectral data from Landsat 5, 7, and 8 satellites, Spot 2, and Sentinel A2, and applying spectral equations such as NDBI and NDVI, along with calculating the spectral difference between them, it is evident that urban expansion in the Kharbat Zambia region has grown exponentially.

In 1975, the built-up area was approximately 0.50 hectares, increasing to 1.75 hectares by 1990, with

an annual growth rate of approximately 0.8 hectares. This rapid expansion starkly contrasts with the relatively small size of the ancient city.

Applying the prediction equation, the built-up area was estimated at 8.35 hectares by 2005 and 27 hectares by 2015. The highest rates of reconstruction occurred between 1975 and 1995, a period characterized by uncontrolled expansion due to a lack of urban growth regulation and oversight. The indices derived from the NDBI and NDVI-NDBI confirm this trend (Fig. 11-12).

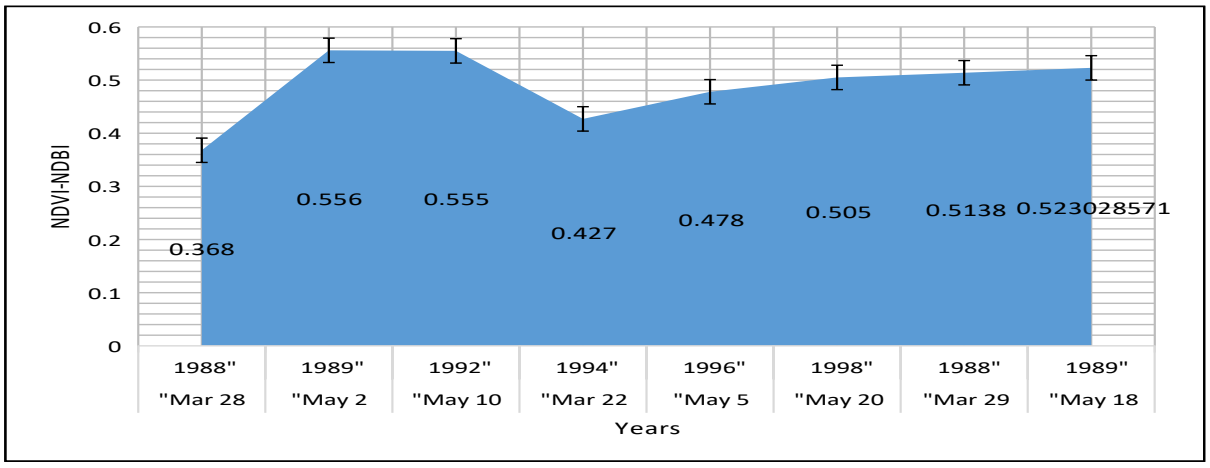



*Fig 11: Built up area index (NDVI-NDBI) in Khrbat Zambia from 1988 to 2009 within GEE*

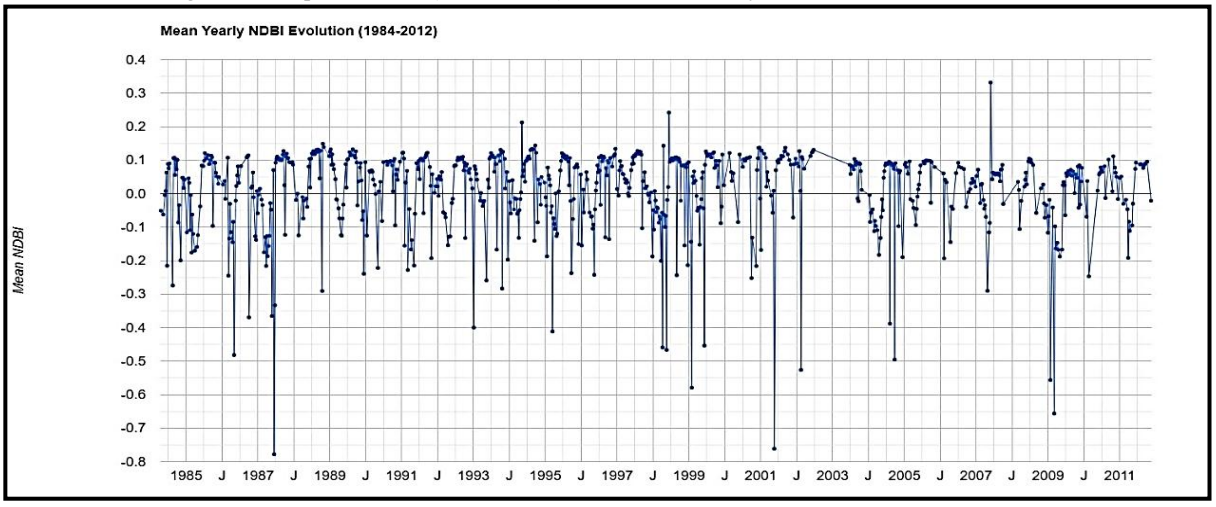



*Fig 12: NDBI index from 1985 to 2011 through Landsat 05-07 within GEE*

However, as Table (01-02) demonstrates, the region's building growth rates diverge from projections.

*Table (01) Built-up area prediction from 1975 to 2025*

| years | 2025 | 2015 | 2005 | 1995 | 1985 | 1975 |
|---|---|---|---|---|---|---|
| **Built-up prediction Ha** | 92.27088305 | 27.76850245 | 8.353174922 | 2.6542 | 1.1514 | 0.499144 |

**Source: calculated through Expansion estimation formula**
**Ha: hectare**

As shown in Table (02), before 2000, the reconstruction coefficient displayed a positive trend, reaching its highest value between 1990 and 1995. This upward trend can be attributed to the security challenges Algeria faced during this period, which hindered governmental supervision of rehabilitation efforts. However, a significant decrease in the coefficient was observed between 2000 and 2010, likely due to the implementation of stricter security measures that limited random reconstruction activities.

| *Table (02) Built-up area coefficient (Ha) from 1975 to 2025* | | | | | |
|---|---|---|---|---|---|
| **Time series** | **2010-2023** | **2000-2010** | **1995-2000** | **1990-1995** | **1975-1990** |
| **Evolution coefficient(Ha)** | 0.044467527 | -0.007333127 | 0.03286061 | 0.117557333 | 0.054793019 |
| **Source: calculated through Expansion estimation formula**<br>**Ha: hectare** | | | | | |

However, beginning in 2010 and continuing through 2023, the reconstruction process regained momentum. This resurgence was particularly noticeable following 2014-2015, when the state implemented stricter land occupation and protection plans for the archaeological area, allowing reconstruction outside the protected perimeter.Analysis of satellite images and GIS data enabled continuous monitoring of the archaeological site and urbanization from 1975 to 2023. According to the Scholl map, which estimated the total archaeological area at approximately 8,300,467 hectares, the site has been significantly reduced compared to its state during the French colonial period.

As depicted in Maps (Fig. 13-14), urbanization began encroaching on the archaeological site in 1975. By that time, the built-up area had expanded to approximately 0.356 hectares. By 1990, the affected area had reached 1.369 hectares, representing a difference of almost 0.218 hectares from the original site. By 2000, the built-up area increased to 1.737 hectares, although structural collapse between 2000 and 2010 reduced the urban area to 1.527 hectares. However, by 2023, the area expanded again to 2.339 hectares, meaning 20% of the archaeological site is now covered by buildings, 20% is protected, and the remainder lies beneath rubble such as roads and green spaces. Additionally, antiquities have been stolen and relocated to other areas.These findings underscore the urgent need for stricter protection measures and active intervention to preserve Algeria's archaeological heritage from uncontrolled urbanization.

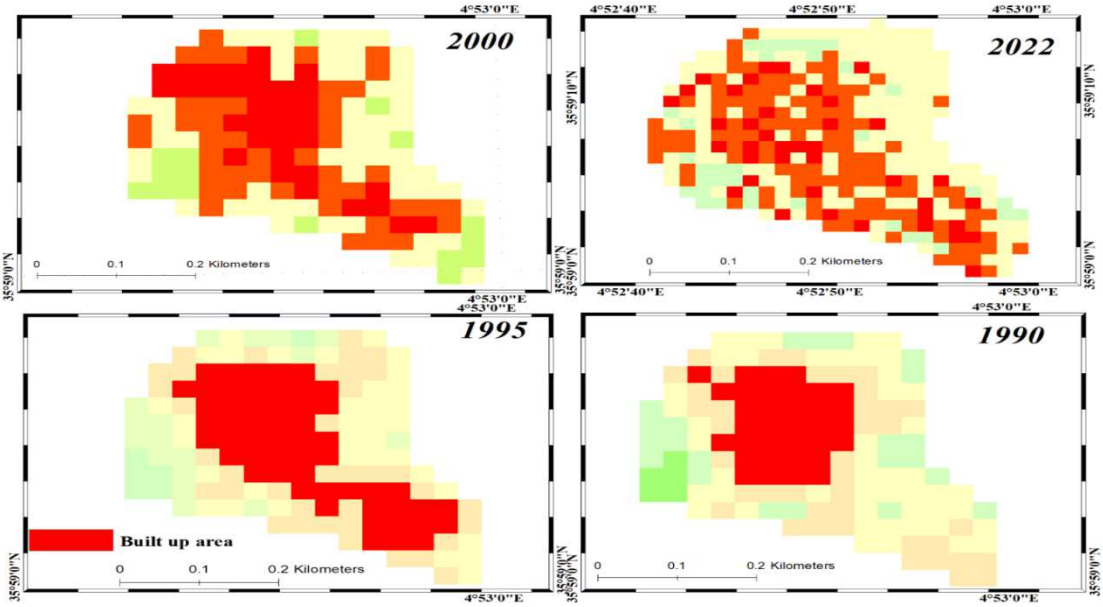



*Fig 13: Built up area 1990 to 2023 through Landsat 05-07 - sentinel A2 analysis within GEE and Q Gis*

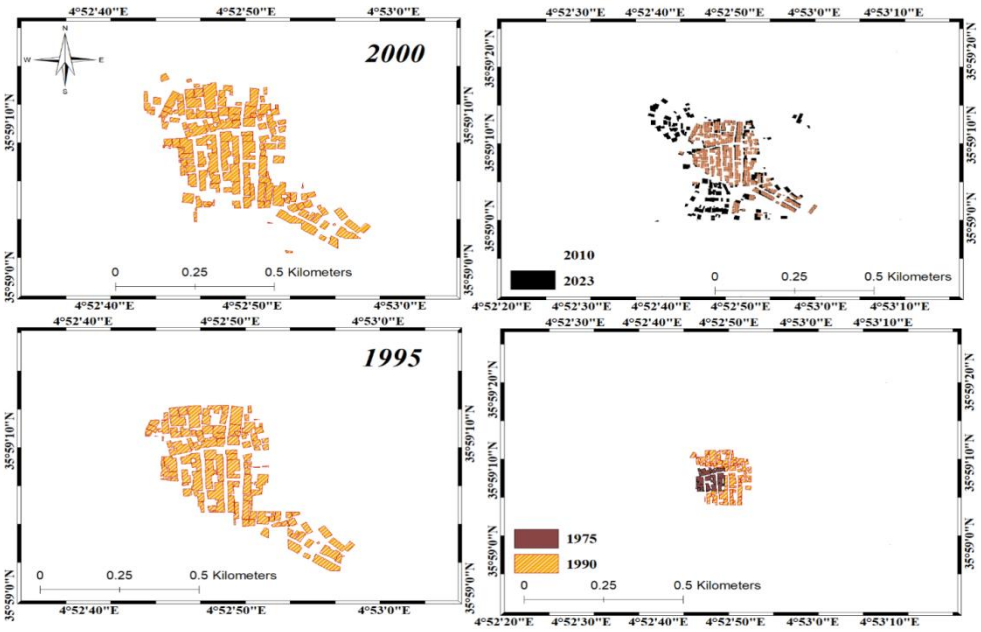



*Fig14: archaeological site's extinction in favour of careless urban growth.Through Landsat 05-07 - sentinel A2, GHSL analysis within GEE and Q Gis*

**Conclusion**

This study aimed to address a crucial issue in historical geography by employing contemporary geographic methods to reconstruct the characteristics of a historical site. Specifically, the research scrutinized the Kharbat Zambia (Thamuscani) archaeological site in Algeria in great detail, thereby elucidating the difficulties and requirements associated with safeguarding global cultural heritage in the face of urban expansion. By integrating historical research, satellite imagery analysis, and geographic information systems (GIS) approaches, this study has shed light on the intricate dynamics that shape the fate of archaeological sites in the context of urbanization.

To comprehend the importance of preserving archaeological heritage, it is essential to consult the glossary of terms provided by reputable organizations such as UNESCO and the World Council on Monuments and Sites. Algeria, which boasts over 15,200 sites as part of its impressive cultural legacy, serves as a vivid illustration of the diverse civilizations that have shaped the country throughout its history. However, natural disasters and human activities pose significant threats to cultural heritage, necessitating proactive measures to ensure its preservation for future generations.

The alarming rate of urban encroachment on the archaeological site at Kharbat, Zambia has been starkly revealed by the meticulous examination of historical records and satellite imagery. As a result, sizeable portions of the historic city have vanished due to the region's exponential urban growth between 1975 and 2023.

Algeria's cultural heritage is under significant threat due to uncontrolled growth, which has been accompanied by a lack of urban planning and regulatory control. This study emphasizes the pressing need for prompt action by Algerian authorities and communities to prioritize the preservation and conservation of cultural heritage.The archaeological sites that are not under state monitoring or preservation are particularly vulnerable to urban development. However, by utilizing geospatial systems, such as geographic information systems and satellite image analysis, it is possible to monitor, evaluate, and mitigate these risks. This allows stakeholders to make informed decisions and allocate resources wisely, ultimately striking a balance between development needs and heritage conservation.

Ultimately, preserving the cultural heritage of the world and Algeria, in particular, is not only a matter of historical care, but also a moral duty to honor the heritage of past civilizations and ensure the enrichment of future generations. It is a crucial aspect of historical geography research. By adopting

proactive measures and utilizing advanced geographical technologies, Algeria, as well as other countries, can create a sustainable development plan that is in harmony with its rich cultural fabric, ensuring that the echoes of history continue to resonate for centuries to come.

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