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# The Impact of Climate Changes on Sustainability of Archaeological Sites at Luxor

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## Keywords

Climate change
Archaeological sites
Sustainability

## Abstract

Climate change significantly impacts the sustainability of archaeological sites, such as rising sea levels, which negatively affect ecosystems and human communities and may lead to the submergence of some monuments. Scientists, researchers, and governments are collaborating to study the effects of climate change, assess its impacts, and develop adaptation and mitigation measures. This study aims to analyze the impact of climate change on the sustainability of archaeological sites in Luxor. To achieve this, the research employed a descriptive-analytical approach, developing and distributing a questionnaire to a random sample of 162 faculty members from tourism and hotel management colleges and archaeology colleges, experts from the Ministry of Tourism and Antiquities in several governorates across Egypt, and staff working at archaeological sites in Luxor Governorate. The results of the instruments were analyzed using descriptive statistics, factor analysis, reliability analysis, coefficient analysis, and Pearson correlation analysis, supported by SPSS 25.0. The research findings demonstrate and underscore the urgent need to adopt sustainable conservation practices, including improving site drainage, conducting regular environmental monitoring, using climate-resistant conservation materials, and implementing awareness programs for local staff and visitors. The research recommended developing a long-term strategy to monitor and manage the effects of temperature fluctuations, humidity, flooding, and wind erosion on the sands of the archaeological site in Luxor. It also recommended installing advanced environmental monitoring systems to track local climate changes around major archaeological sites, such as the Karnak and Luxor temples and the Valley of the Kings.

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# 1. Introduction

The tourism industry is a crucial economic sector, accounting for around 25% of the gross domestic product of many countries (Al-Romeedy,2024).Tourist destinations are affected by climate change in multiple ways, including changes in temperature, rainfall, wind, storms, and rising sea levels. Research indicates that climate change is increasingly affecting tourism, and its impact is growing overtime (Barnett, 2020).
Anthropogenic climate change, driven by the increase in CO2 to more than 410 ppm in 2020, has resulted in unprecedented rates of environmental change (Ashtari, 2020). As such, changes to the environment and environmental systems influence and impact heritage and its associated values The tourism industry is actively working to assess the impact of climate change on tourist destinations and devise plans to adapt to and mitigate its effects. These plans include promoting sustainability in tourism by developing environmentally, socially, and economically sustainable tourism practices, adopting clean energy technologies and renewable resources in the tourism industry, and collaborating with local communities to improve the environmental, cultural, and social management of tourist destinations (Edgell, 2019).

### Problem of the Study

Luxor, one of the world's richest open-air museums, is home to numerous archaeological sites that reflect the grandeur of ancient Egyptian civilization. However, these invaluable heritage sites are increasingly threatened by the effects of climate change, including rising temperatures, fluctuating humidity levels, increased rainfall, flooding from the Nile, and sandstorms. Such environmental changes accelerate the deterioration of monuments, wall paintings, and building materials, posing serious challenges to their preservation and sustainability.
Despite the growing global concern about climate impacts on cultural heritage, there is a lack of comprehensive assessment and strategic planning focused specifically on how climate change affects Luxor's archaeological sites. This gap hinders the development of effective adaptation and conservation strategies that ensure the long-term protection and sustainability of these irreplaceable cultural assets. Therefore, this study addresses the critical question of how climate change influences the sustainability of archaeological sites in Luxor and what measures can be implemented to mitigate its negative effects.

### Study Aim and objectives

The aim of this study is to analyze the impact of climate change on the sustainability of archaeological sites in Luxor, focusing on how changing climatic factors—such as rising temperatures, increased humidity, floods, and sandstorms—affect the physical integrity, conservation, and management of these sites. The study also aims to develop sustainable strategies and adaptive management approaches to protect Luxor's archaeological heritage from current and future climate-related threats. The main aim is divided to sub objectives as follows:

1. **To identify** the major climatic changes occurring in Luxor and their potential effects on archaeological sites.
2. **To assess** the degree of vulnerability of key archaeological sites in Luxor to climate-related hazards such as erosion, flooding, and thermal stress.
3. **To examine** the current conservation and management practices implemented by heritage authorities in response to climate change impacts.

4. **To evaluate** the level of awareness and preparedness among stakeholders involved in heritage preservation and tourism management.
5. **To propose** sustainable adaptation and mitigation strategies to enhance the resilience and long-term sustainability of Luxor's archaeological sites under changing climatic conditions

## 2. Literature Review

**Climate changes**

Egypt is highly vulnerable to climate change, with a projected increase in heat waves, dust storms, and extreme weather events. Stronger warming has been documented over the past 30 years, with average annual temperatures increasing by 0.53°C (United Nation International Children's Emergency Fund, Uncif, 2025).

Per decade literature review present definition of climate change ,its causes ,The Impact of Climate Change on Archeological Sites in Luxor and the efforts made by the Egyptian government to reduce the negative effect of climate change

### 2.1 Definition of Climate Change

Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas. (NASA, 2023).

### 2.2Causes of Climate Change

The natural and human causes of climate change in Egypt:

#### 2.1.1. Natural Causes:

Desertification: Egypt is predominantly covered by desert, and desertification is a natural process that occurs due to arid conditions and wind erosion. It can lead to changes in local climate patterns and contribute to the overall warming of the region. Nile River Flood: The Nile River flood has a major impact on the climate in Egypt through its contribution to increasing the moisture content in the soil and air, which positively affects the local climate, and also contributes to the redistribution of heat. When the flood occurs, the atmosphere is significantly cooled as a result of the evaporation of excess water. This contributes to reducing high temperatures and improving climatic conditions in the areas surrounding the Nile, (Environmental protection agency, 2023).

#### 2.1.2. Human Causes:

Greenhouse Gas Emissions: Egypt's greenhouse gas emissions primarily come from the burning of fossil fuels for energy production, industrial activities, and transportation. These emissions contribute to global warming and climate change. Deforestation: The clearing of forests and vegetation in Egypt for agriculture, urbanization, and infrastructure development reduces the capacity of the land to absorb carbon dioxide ($CO_2$) through photosynthesis. This leads to higher $CO_2$ levels in the atmosphere, contributing to climate change. Fakana (2020).

Urbanization and Land Use Changes: The rapid urbanization and expansion of cities in Egypt result in the conversion of natural landscapes into concrete jungles. This alters the local climate by reducing vegetation cover, increasing the urban heat island effect, and disrupting natural airflow patterns. Agriculture and Irrigation: Agricultural practices, such as irrigation techniques and water management, can affect local climate conditions Overuse or inefficient use of water resources can lead to changes in soil moisture levels and local humidity, influencing the microclimate. (Epa, 2023).

### 2.2 Environmental climatic drivers

**Temperature Rise**: Temperatures, especially during the summer months, have been rising at an average annual rate of 0.1°C per decade between 1901 and 2013, and at an accelerating rate of 0.53°C per decade over the past 30 years.( Osman,2023).

**Water Scarcity:** This has been exacerbated by climate change, population growth, and unsustainable consumption patterns, with the country rapidly approaching the critical threshold of absolute water scarcity (500 cubic meters per capita).(Tahrir Institute for middle east policy,2021).

**Drought and Land Degradation**: The risk of drought and land degradation is increasing due to erratic rainfall and rising temperatures, impacting agricultural productivity and food security.(Yossif, 2019).

**Sea Level Rise and Coastal Flooding**: Rising sea levels, land subsidence, and coastal erosion threaten coastal cities, including Alexandria, and agricultural areas in the Nile Delta.(environmental protection agency,2025).

**Extreme Weather Events**: An increase in the frequency and intensity of extreme weather events, such as heat waves, flash floods, and storms, which can damage infrastructure, impact agriculture, and affect human health.(World meteorological organisation,2022).

**Rainfall Variability**: A decrease in rainfall and changes in rainfall patterns, with no some areas experiencing more frequent and intense flash floods, while others face prolonged periods of drought ( Meteorological office,2025).

### 2.3 The impact on tourism, use and sustainability

Tourist destinations are significantly impacted by climate change, which causes changes in temperature, natural landscapes, rainfall, biodiversity, and natural resources. These changes can affect the appeal of tourist destinations and their ability to attract visitors (Weiskopf et al., 2022).

For instance, rising temperatures and changing climate patterns can have a negative effect on winter tourism, particularly in mountainous regions where snow and ice are essential for attracting tourists. As a result, tourism in these areas may be significantly impacted. Similarly, climate change can disrupt rainfall patterns during peak tourism seasons in certain regions, affecting agriculture, water resources, forests, and ultimately, the tourism industry (Steiger et al., 2022; Kilungu et al., 2019).

It should be noted that certain tourist regions may be susceptible to natural disasters resulting from climate change, such as floods, hurricanes, droughts, and forest fires, which can cause substantial material losses and disrupt tourism in these areas. The tourism industry is one of the most vulnerable industries to the effects of climate change, as it heavily depends on natural resources, natural landscapes, and climate to attract visitors and promote environmental, economic, and social sustainability (Dogru et al., 2019).

For instance, water scarcity in arid areas can jeopardize the sustainability of tourist destinations, as the industry relies on water for various activities such as swimming, diving, water sports, and sea excursions. Water scarcity can diminish the appeal of tourist areas, limit available activities, and potentially decrease economic growth, causing negative consequences for local communities that depend on tourism as a source of income (Hoogendoorn and Fitchett, 2018).

### 2.4 The Impact of Climate Change on Archeological Sites in Luxor

The impact of climate change on tourist destinations, particularly in Egypt's Luxor Governorate, cannot be underestimated. This region is known for their cultural heritage and historical sites, drawing millions of tourists annually. However, climate change poses a significant global challenge that affects multiple sectors, including tourism (Jaber et al., 2021; Grimm et al., 2018).

The rise in temperatures stands out as a prominent consequence of climate change in Luxor. This increase in temperature has negative implications for both tourist activities and infrastructure. During the summer months, the intense heat can make outdoor exploration arduous and uncomfortable for tourists, requiring significant physical exertion. Moreover, the elevated temperatures increase health risks, raising the chances of visitors experiencing heat-related illnesses (Kozmal et al., 2021; Hussein et al., 2020).

Climate change also brings about changes in the water levels of the Nile River, which is of vital importance to Egypt. Adequate water availability is essential for agriculture and the preservation of historical sites in Luxor. However, climate change has resulted in unpredictable rainfall patterns and decreased water flow in the Nile. Consequently, this can give rise to water scarcity, negatively impacting irrigation systems, agricultural activities, and ultimately affecting the overall attractiveness and appeal of the tourist destinations (Jaber et al., 2021);( Shedded, 2022),(Mohamed et al., 2022).

In addition, climate change has the capacity to disturb the fragile ecological equilibrium in the area. The escalating sea levels and heightened erosion pose a threat to the coastal region of Luxor and these natural wonders hold significance not only for tourism but also for sustaining local ecosystems (Upadhyay, 2020), (Held et al., 2018).

Furthermore, climate change is leading to an increase in the frequency of extreme weather events such as sandstorms and flash floods. These events have the potential to disrupt transportation, inflict damage on infrastructure, and pose risks to the safety of tourists. The historical sites and monuments, including the temples of Luxor are particularly susceptible to these weather events, putting them at risk of structural damage and jeopardizing their long-term preservation (Fazel, 2020).

The presence of relative humidity led to the obscuration and distortion of the colors on the walls of the Temple of Habu, forming a solid black layer. This layer has a destructive effect, as it has been proven to play a significant and activating role in the oxidation reactions of atmospheric pollution gases. (Abdel Aal, 2010).

Stains resulting from the influence of salt weathering. The danger of these salts forming on the surfaces of the mural carvings lies in the pressure resulting from their uniqueness or from their crystallization in the presence of high temperatures and humidity. This led to the formation of efflorescent salt layers that distorted the surfaces of the temple's mural carvings. (Abdel Kader, 2019).

Black spots resulted from the influence of iron oxides, the geological binding material of the sandstone substrate. These oxides migrated to the surface under high humidity conditions, and in the presence of salts, they formed solid black layers that distorted the temple's mural carvings. (Arabi, 2017).

## 2.5 Climate adaptation, policy and management

Climate adaptation is the process of taking actions to reduce damage to natural or human systems caused by climate change, or to take advantage of any opportunities that may arise. This includes adapting to extreme weather events such as floods, heat waves, and rising sea levels. These actions can be at individual, local, national, or global levels, and range from incremental adaptations that aim to preserve the core of systems to transformative actions that bring about fundamental changes in response to climate change (United Nation Development programmer, 2023).

Climate adaptation strategies to mitigate its impact on cultural heritage in Egypt

Cultural heritage plays an important role in economic development and growth through tourism and recreation industries, including urban and rural revitalization.(Alexandrakis et al, 2012).

Climate change, on the other hand, has a proven effective impact on climate change tourism in general, affecting operators, destinations, and visitors. Climate change is already becoming a threat for cultural heritage management around the world, hastening the degradation and deterioration of various aspects of cultural heritage.(Bosher,et al,2019) .

To make cultural heritage more resilient to climate change, proactive climate adaptation is needed (Chmutina,et al, 2018). This can minimize degradation and possible loss while optimizing heritage benefits for current and future generations (International Council on Monuments and Sites, 2019).

Climate change adaptation of cultural heritage is a mechanism that aims to reduce the harm or exploit opportunities associated with current or potential future climate change impacts. Climate change adaptation science, practices, and policy have primarily centered on numerous vulnerable sectors over the last three decades, however research on adaptation of various cultural heritage types is still relatively weak (Heathcote et al., 2017).

The majority of research to date has concentrated on developing mechanisms, instruments, or methods for assessing climate threats and vulnerabilities of various cultural heritage types (Fatorić and Seekamp, 2017).

Although these studies are important in understanding climate change risks and raising awareness, there have been limited efforts to understand the design of feasible adaptation measures, as well as the governance challenges encountered in implementation to increase cultural heritage resilience (Fatorić and Seekamp, 2019).

In order to bridge the gap between climate change science and climate change adaptation preparation and implementation for cultural heritage, it is critical to recognize the various types of obstacles that emerge during the adaptation process (Xiao X et al, 2019).

### 2.6 Sustainable heritage framework of climate change.

Sustainable solutions are being offered within the framework of unconventional policies for natural and cultural heritage to address the impacts of climate change. By integrating ecosystem services and natural elements into climate change adaptation strategies, these solutions not only enhance resilience but also contribute to the preservation of cultural biodiversity for future generations. These solutions also offer additional benefits that promote community well-being and can act as carbon sinks and support heritage conservation (Kabisch et al., 2016).

Examples include river restoration and the restoration of mangroves and native forests It also includes green infrastructure and urban greening, such as the use of green spaces and vegetation in urban areas to reduce the effects of heat islands, storm water management around heritage sites, incorporating green elements into cultural heritage conservation and management practices in cities (Coombs and Viles , 2021).

Focusing on the restoration and protection of coastal ecosystems, such as mangroves and salt marshes, to reduce flood risks to coastal heritage sites using traditional land management practices to enhance the resilience of cultural landscapes (British Council, 2023), as well as “soft engineering” techniques such as beach feeding to protect coastal heritage from sea-level rise (Walsh, 2018).

Other solutions include ecological restoration of degraded ecosystems and habitats surrounding natural heritage sites to enhance their resilience, reintroducing native species and traditional management practices into cultural landscapes as well as incorporating indigenous, traditional and local knowledge into cultural heritage adaptation strategies, such as reviving traditional water management systems to enhance water security around heritage sites (Moore, and Dawson, 2022).

Solutions for agricultural heritage systems include agroforestry, traditional water management, soil conservation practices and use of native and local species Other adaptive responses include using nature-based and more climate-resilient materials and techniques such as traditional, locally sourced materials and applying bio-based treatments and 'green' conservation materials in heritage conservation (Vuik et al., 2019).

Conservation strategies for earthen heritage sites include NbA like windbreaks and natural vegetation coverage to mitigate deterioration risks Restoration of wetlands in estuarine areas is highlighted as a nature-based coastal adaptation option (Liski et al., 2019).

### 2.7 The Efforts made by the Egyptian Government to reduce the Negative Effects of Climate Change

Sustainable water resource management projects to improve water resource efficiency construction of seawater desalination plants, sewage networks, tertiary treatment, and rehabilitation and renewal of the national network of canals and waterways ( Al ahram,2022).

Low-income populations, both in Egypt and around the world, are disproportionately affected by a number of climate change-related risks. Due to the projected rise in heat waves, dust storms, and other extreme weather events, Egypt is particularly exposed to the effects of global warming. Hosting COP27 Since 1995, COP summits have served as the principal international platform for climate negotiations. In the 2015 Paris Agreement, the goal of limiting the increase in the average global temperature to 1.5C (2.7F) over preindustrial levels was established. (Earth, 2022).

### 2.8 Study Area: Luxor Governorate

The story goes back thousands of years when it was named "Thebes". In Ancient Egypt, the Eastern Bank was Known as the city of the living where temples, palaces of kings and houses of nobles, workers, and local people could be found. On the other side, the West Bank was called the land of the dead and it was the site of tombs, including those in the Valley of the Kings, Valley of Queens, Tombs of Nobles, and other funerary temples (Ahmed, 2014).

Luxor City dates back to the Prehistoric times, it is one of the world's most iconic majestic cities, a symbol of civilization; its origins are deeply rooted in history, witnessing the splendor of man's arts and science 7,000 years ago ( Luxor was a city that belonged to the Qena Governorate but was administratively divided and in December 2009 it became a new governorate called Luxor Governorate.( Egypt Information Portal, 2014).

The city of Luxor has been named as the governorate's capital. Agricultural land accounts for around 73.8 percent of the total area, while urban areas cover around 19.4 percent, while barren land on both sides of the Nile Valley accounts for about 6.8 percent (Ahmed, et al., 2014).

Luxor region is a primary center of ancient Egyptian culture where the ancient Egyptian civilization was influenced along the Nile Valley by means of the famous ancient Egyptian temples that remain in a good state of preservation. The research area includes numerous archaeological sites on both sides of the Nile, such as Luxor temple, Karnack complex, Medinet Habu, Ramesseum, Memnon Colossi. (World monuments fund, WMF, 2025).

## 3. Methodology

The researcher used the descriptive-analytical approach to describe Tourism is a highly climate-sensitive sector, climate change is not a remote future event for tourism, however, varied impacts becoming evident at destinations. The impacts of climate change on the tourism and hospitality sector are expected steadily to intensify affecting major tourism flows. Moreover, least developed countries and small island developing states might be particularly affected (Lyle, 2013).

Climate change threatens all life, as well as destinations that tourism relies on could be at risk. As the earth warms, snow melts causing rising sea levels, extreme weather, and increasing temperatures which are impacting ecosystems and communities around the world. Beaches are shrinking, coral reefs are bleaching, and ancient monuments and antiquities are deteriorating. (Samir, 2022), This study aims to assess the impact of climate change on the sustainability of archaeological sites in Luxor. In this approach, the researcher is trying to describe the subject of the study, analyze the data, and compare, explain, and assess, hoping to reach meaningful generalizations to increase and enrich knowledge on the subject.

**Designing the instrument of the study**

The study relied on distributing a questionnaire to academics specializing in tourism and antiquities at Egyptian universities and those working in archaeological sites and meteorology. The questionnaire was divided into two parts: the first addressed the demographic characteristics of the study sample, and the second addressed the impact of climate change on Egyptian tourist destinations in general and archaeological sites in particular. The first section, which addressed demographic characteristics, included gender, age, educational level, job title, and work experience. The second section, which addressed the impact of climate change on Egyptian tourist destinations, was divided into two parts. The first section evaluated the various impacts of climate change on Egyptian tourist destinations in general, using 10 statements that were prepared and modified based on the study by Hollesen et al. (2017) . The second part addressed the impact of climate change on archaeological sites in Luxor using eight statements that were prepared and modified based on the studies of, Carmichael et al. (2018), and Hollesen et al. (2018). The questionnaire was designed using a five-point Likert scale, which was based on five points between agreement and disagreement (5 = completely agree, 4 = agree, 3 = somewhat agree, 2 = disagree, 1 = completely disagree).

To fulfill the research, aim for assessing the impact of climate change on the sustainability of archaeological sites in Luxor. To achieve that, this research employed a method of descriptive analytical methodology by using a questionnaire tool. A survey consisting of seven sections was used as a data collection tool. The first section includes respondents' demographic characteristics (gender, age, educational level, and job of experiences). The second section represents data on your awareness of climate change. The third section included nine variables representing Causes of climate changes in Luxor. The four-section included 10 variables representing the impact of climate changes on tourist destinations. The fifth section included 8 variables representing impacts of climate changes on archaeological sites in Luxor. The sixth section included 7 variables representing challenges facing tourist destinations due to climate changes. The seventh section included 12 variables representing Solutions to mitigate climate changes. The questionnaire items were anchored according to the Five-Point Likert Scale: "1 = strongly disagree", "2 = disagree", "3 = neutral", "4 = agree", and "5 = strongly agree"

**Determining the Population and Sample of the study**

The target population for this is across various workers in archaeological areas, and a number of faculty members at the Faculty of Archaeology at Luxor University. totaling 500 respondents. The researchers used Stephen K. Thompson's equation to calculate the sample size from the next formula:

$$\boxed{n = \frac{N \times p(1-p)}{\left[\left[N - 1 \times \left(d^2 \div z^2\right)\right] + p(1-p)\right]}}$$

**Source: (Thompson, 2014)**

Where:

(n) Sample size (162)

(N) Indicates Population size (500)

(Z) Confidence level at 95% (standard value of 1.96)

(d) Error proportion =0.05

(p) Is the probability 50%.

As a result, a sample of is 162 workers in archaeological areas, and a number of faculty members at the Faculty of Archaeology at Luxor University were selected randomly. All the responses were obtained valid.

**Data collection**

The researcher used the descriptive analytical approach, where a questionnaire was prepared and distributed to a random sample of one hundred sixty two (162). to an academics specialized in the tourism and archaeological sector at Egyptian universities and employee in archaeological and meteorological areas The statistical analysis of the responses was carried out via SPSS v25. Data has been collected through questionnaires that were prepared in an approach that is relevant to the situation so as to decrease invalid responses. during the period from January 2025 to March 2025,

**Data Processing and Analyzing**

The introductory step is important in order to prepare the data for analysis and allow the result to be meaningfully interpreted. This stage includes checking and coding the quantitative data. Qualitative data can be analyzed by some software packages as well as manual analytical procedures.

The collected data was processed and analyzed. This included steps like editing, coding the replies, classification, tabulating the data, and performing several statistical computations such as frequencies, percentages, and various coefficients. The appropriate statistical operations, along with the use of appropriate tests of significance, are carried out to safeguard the drawing of conclusions concerning the study. After the collection of the questionnaire lists, the researcher has analyzed all the data using the Statistical Package for Social Science (SPSS) analysis system, version (25), and used the frequencies, percent, means, standard deviation, rank, attitude, correlation analyses, and charts of respondents to the questionnaire.

## Data Validity and Reliability

### Data Validity

To validate the data collection instrument used in this study in terms of its readability, format, and ability to measure the study's constructs, the researcher distributed the questionnaire instrument to workers at archaeological sites, academics at Egyptian universities specializing in tourism and antiquities, employees of the Meteorological Authority, and researchers in archaeology, and to those who have specializations and expertise in the field of this study. The questionnaire instrument was then updated and refined to reflect the comments and suggestions received by the domain experts. Moreover, the experts showed interest and interacted with the researcher concerning the questionnaire instrument, which added to its validity.

### Data Reliability

Before proceeding with further analysis, the reliability testing was leaded in order to ensure consistent measurement across various items in the questionnaire. Indeed, the reliability of a measure indicates stability and consistency of the instrument. Consequently, this method determines reliability through examining the internal consistency of the research instrument such as questions (items) in the questionnaire, which are normally presented. Cronbach's Alpha is one of the most frequently applied metrics to measure a scale's reliability, in which its index ranges from 0.0 to 1.0. Researcher should target a value closer to 1.0, as Alpha value proves that the instrument of the study is strong and consistent. However, it's important to note that in social sciences the threshold value of 0.7 is considered acceptable

**Table (1) Cronbach's Alpha Value**

| Variables | No. of items | Cronbach's Alpha | Validity Coefficient* |
|---|---|---|---|
| Causes of climate changes in Luxor | **9** | **0.851** | **0.922** |
| The impact of climate changes on tourist destinations | **10** | **0.919** | **0.959** |
| The impacts of climate changes on archaeological sites in Luxor | **8** | **0.939** | **0.969** |
| The challenges facing tourist destinations due to climate changes | **7** | **0.949** | **0.974** |
| The Solutions to mitigate climate changes | **12** | **0.981** | **0.990** |
| **Total** | **46** | **0.980** | **0.989** |

* Validity coefficient = √ Reliability coefficient

In order to measure the internal consistency and reliability of the study's constructs. Cronbach's alpha (α) measure was used. The scales' reliabilities were measured and the Cronbach's Alpha of all scales in Table (2) ranged from 0.851 to 0.981, and for total questionnaire items was (0.980), this indicate an acceptable Cronbach's Alpha value for each field, whenever Cronbach's Alpha value is acceptable if it's more than (0.7).

The following part explains the results concerning the seven sections representing the impact of climate change on the sustainability of archaeological sites in Luxor.

**Results and discussion**.

In this section, the researcher relied mainly on the descriptive analysis to get the means and the standard deviations for the study constructs along with their items. The items were measured using a Likert-type scale as follows.

**First Section: Respondent Demographic Characteristics**

**Table 2: Demographic profile of sample elements**

| Variable | | Frequency | Percentage (%) |
|---|---|---|---|
| **Gender** | | | |
| | Male | 80 | 49.4 |
| | Female | 82 | 50.6 |
| **age group** | | | |
| | Less than 30 years | 50 | 30.9 |
| | from 30 to 39 years | 64 | 39.5 |
| | From40 to 49 years | 38 | 23.5 |
| | 50 years and above | 10 | 6.2 |
| **Educational level** | | | |
| | High School | 2 | 1.2 |
| | Bachelor's Degree | 92 | 56.8 |
| | Master's Degree | 38 | 23.5 |
| | Ph.D. | 30 | 18.5 |
| **Job experiences** | | | |
| | From 1 to 2 years | 36 | 22.2 |
| | From 3 to 5 years | 30 | 18.5 |
| | From 6 to 9 years | 26 | 16.0 |
| | From 10 years and above | 70 | 43.2 |

As depicted in Table (2), the discussion of the research findings begins with a brief demographic profile of respondents in terms of gender. The majority of the respondents were female (50.60%) rather than male respondents (49.40%) of this sample. In analyzing the age bracket of between 30 and 39 had the greatest number of respondents (39.50%), followed by the age bracket of less than 30 years (30.90%). In analyzing the level of education, the most representative degree is the Bachelor's Degree, with 56.80% of the respondents, whilst 23.50% of respondents had Master's Degrees in the sample. The table describes the job experience in the study sample that the majority (43.20%) of the sample spent around more than 10 years, while 22.20% of respondents spent around 1 to 2 years.

**Section 2: Data on your awareness of climate change**

By asking the workers in archaeological areas and a number of faculty members at the Faculty of Archaeology at Luxor University if they are familiar with the climate change concept, 70.40 percent of them are familiar with the climate change concept. See figure (1).

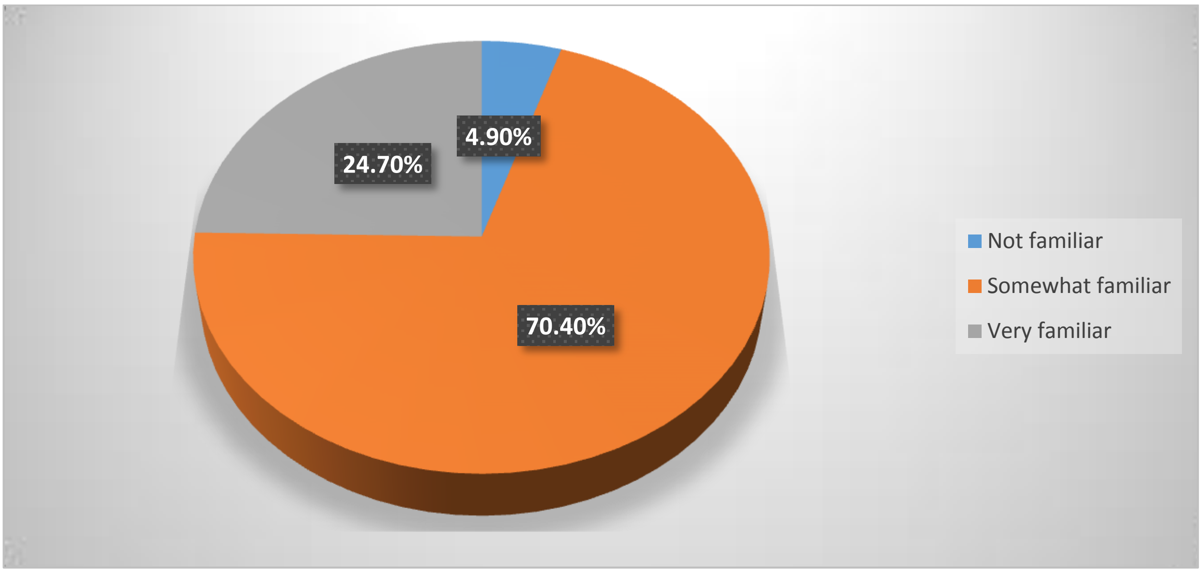


**Fig 1: Familiarity with the concept of climate change**

By asking the workers in archaeological areas and a number of faculty members at the Faculty of Archaeology at Luxor University, how significant is the impact of climate change on archaeological sites in Luxor? 29.60 percent of them are significant, and 27.20 percent of them have a very significant Impact of climate change on archaeological sites in Luxor. See figure (2).

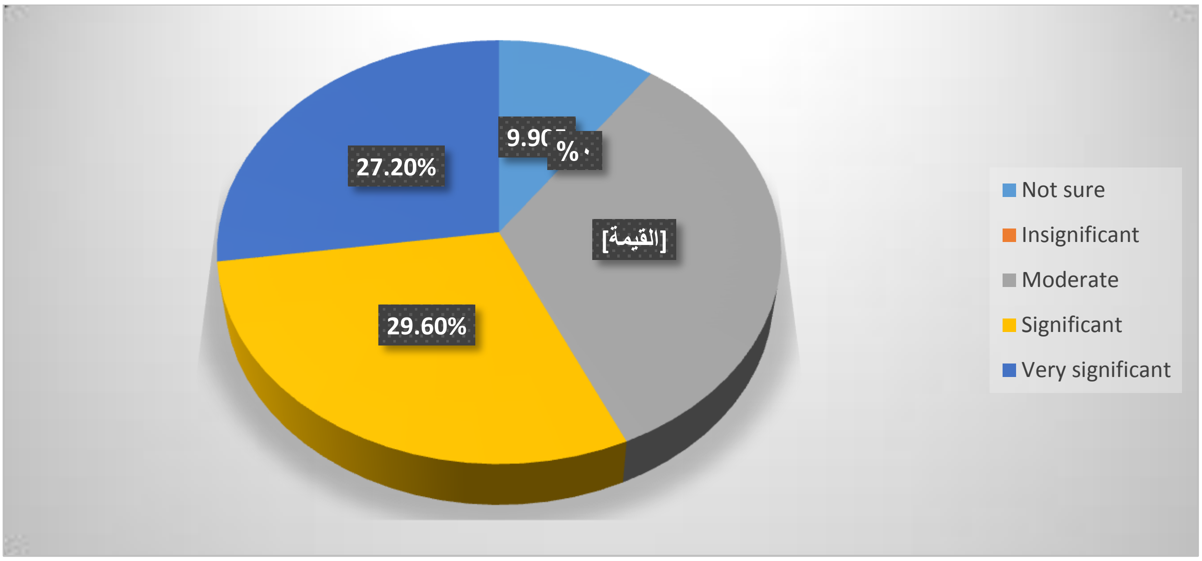


**Fig2: significant impact of climate change on archaeological sites in Luxor**

By asking the workers in archaeological areas and a number of faculty members at the Faculty of Archaeology at Luxor University, have you observed any of the following changes in archaeological sites over the past decade? 27.20 believed that the most significant change was in the color of tombs and temples, and 24.70% of the changes were in the erosion of buildings. See Figure 3.

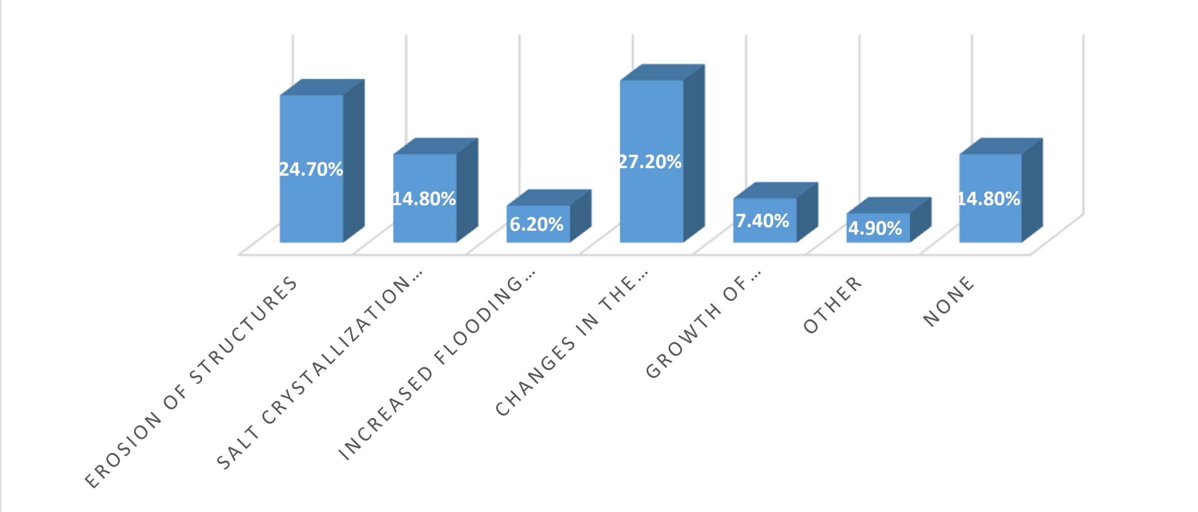


**Fig3: changes in archaeological sites over the past decade**

## Section 3: Causes of climate changes in Luxor

**Table 3: Causes of climate changes in Luxor**

| Variables | SD | D | N | A | SA | Mean | Std. Deviation | Rank | Attitude |
|---|---|---|---|---|---|---|---|---|---|
| Climate changes are caused by emissions of greenhouse gases such as carbon | 2.5 | 6.2 | 22.2 | 50.6 | 18.5 | 3.77 | .909 | 4 | Agree |
| Climate changes is a result of increased human consumption of fossil fuels | 2.5 | 8.6 | 29.6 | 42 | 17.3 | 3.63 | .952 | 5 | Agree |
| Climate changes occur due to changes in the components of the atmosphere | 1.2 | 4.9 | 25.9 | 46.9 | 21 | 3.81 | .865 | 3 | Agree |
| Climate changes as a result of poor human environmental practices | 3.7 | 6.2 | 13.6 | 45.7 | 30.9 | 3.94 | 1.014 | 1 | Agree |
| Climate changes may be caused by the expansion of the tourism industry and its associated services and facilities | 1.2 | 19.8 | 37 | 30.9 | 11.1 | 3.31 | .954 | 8 | Neutral |
| Climate changes are caused by the expansion in industrial activities | 2.5 | 7.4 | 14.8 | 51.9 | 23.5 | 3.86 | .942 | 2 | Agree |
| Climate changes is one of the causes of population growth | 11.1 | 14.8 | 48.4 | 40.7 | 4.9 | 3.14 | 1.089 | 9 | Neutral |
| Climate changes is mainly caused by the use of different means of | 1.2 | 11.1 | 32.1 | 39.5 | 16 | 3.58 | .931 | 7 | Agree |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| transportation | | | | | | | | | |
| Climate changes is caused by natural factors such as hurricanes, floods, and volcanoes | **6.2** | **7.4** | **25.9** | **40.7** | **19.8** | **3.60** | **1.077** | **6** | **Agree** |
| **Total Mean** | | | | | | **3.63** | | | **Agree** |

Table (3) presents the means and standard deviations of Causes of climate changes in Luxor, where the means ranged between (3.94–3.14) compared with the total instrument mean for the domain (3.63). The item "Climate changes as a result of poor human environmental practices" ranked first with a mean and standard deviation (mean = 3.94, standard deviation = 1.014) compared with the total instrument mean and the standard deviation. The item "Climate changes is one of the causes of population growth." ranked last, reaching a mean (3.14) and the standard deviation was (1.089) compared with the mean and standard deviation of the total instrument.
The results of the analysis in Table 4 of the study agree with E. Mann and Toles (2016) who stated in their book The Made House Effect that human pollutants, especially carbon dioxide and methane, are the main cause of climate change.

**Section 4: The impact of climate changes on tourist destinations**

**Table 4: The impact of climate changes on tourist destinations**

| Variables | SD | D | N | A | SA | Mean | Std. Deviation | Rank | Attitude |
|---|---|---|---|---|---|---|---|---|---|
| Climate changes lead to loss of natural attractions | **0** | **6.2** | **28.4** | **44.4** | **21** | **3.80** | **.840** | **3** | **Agree** |
| Climate changes is degrading tourism infrastructure | **1.2** | **6.2** | **30.9** | **42** | **19.8** | **3.73** | **.892** | **4** | **Agree** |
| Climate changes make tourist attractions less accessible | **1.2** | **11.1** | **25.9** | **50.6** | **11.1** | **3.59** | **.874** | **8** | **Agree** |
| Winds and hurricanes caused by climate changes affect tourism activities | **1.2** | **7.4** | **21** | **49.4** | **21** | **3.81** | **.893** | **2** | **Agree** |
| Climate changes cause devastating floods that close roads between tourist areas | **3.7** | **7.4** | **23.5** | **43.2** | **22.2** | **3.73** | **1.009** | **5** | **Agree** |
| Climate changes is a major factor in the destruction of antiquities | **3.7** | **4.9** | **27.2** | **46.9** | **17.3** | **3.69** | **.941** | **7** | **Agree** |
| Climate change leads to changes in rainfall amounts and locations | **1.2** | **4.9** | **21** | **53.1** | **19.8** | **3.85** | **.836** | **1** | **Agree** |
| Climate change leads to increasing pressure on water resources | **0** | **11.1** | **32.1** | **44.4** | **12.3** | **3.58** | **.847** | **8** | **Agree** |
| Climate change causes loss of biodiversity | **2.5** | **9.9** | **24.7** | **54.3** | **8.6** | **3.57** | **.877** | **9** | **Agree** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Climate change leads to severe drought in some tourist destinations | **2.5** | **6.2** | **23.5** | **54.3** | **13.6** | **3.70** | **.870** | **6** | **Agree** |
| **Total Mean** | | | | | | **3.71** | | | **Agree** |

Table (4) presents the means and standard deviations for the impact of climate changes on tourist destinations, ranging from 3.85 to 3.57. Compared to the overall mean of 3.71, the statement "Climate change leads to changes in rainfall amounts and locations." achieved the highest ranking (mean = 3.85, SD = 0.836). Meanwhile, the statement "Climate change causes loss of biodiversity." ranked last (mean = 3.57, SD = 0.877), indicating limited the impact of climate changes on tourist destinations.

The results of the analysis in Table 5 of the study are consistent with what the World Tourism Organization, UNWTO,(2008) that climate change can affect tourist destinations in different ways.

**<u>Section 5: The impact of climate changes on archaeological sites in Luxor</u>**

**Table 5: The impact of climate changes on archaeological sites in Luxor**

| **Variables** | **SD** | **D** | **N** | **A** | **SA** | **Mean** | **Std. Deviation** | **Rank** | **Attitude** |
|---|---|---|---|---|---|---|---|---|---|
| Climate changes can lead to the destruction of some archaeological sites | **2.5** | **6.2** | **18.5** | **49.4** | **23.5** | **3.85** | **.934** | **5** | **Agree** |
| Climate changes can affect the soil or terrain surrounding archaeological sites | **1.2** | **2.5** | **22.2** | **44.4** | **29.6** | **3.99** | **.856** | **1** | **Agree** |
| Climate changes can affect the colors of tombs | **2.5** | **2.5** | **27.2** | **42** | **25.9** | **3.86** | **.916** | **4** | **Agree** |
| Climate changes can affect the ability to explore and discover new archaeological sites | **1.2** | **8.6** | **21** | **50.6** | **18.5** | **3.77** | **.895** | **7** | **Agree** |
| Climate changes can affect the ability to preserve and maintain archaeological sites | **2.5** | **7.4** | **23.5** | **44.4** | **22.2** | **3.77** | **.962** | **8** | **Agree** |
| Climate changes affects the environmental sustainability of archaeological sites and the surrounding areas | **2.5** | **6.2** | **27.2** | **38.3** | **25.9** | **3.79** | **.981** | **6** | **Agree** |
| Climate changes damage to antiquities may occur due to floods or droughts | **2.5** | **4.9** | **19.8** | **38.3** | **34.6** | **3.98** | **.984** | **2** | **Agree** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Climate changes have a negative impact on archaeological sites | **2.5** | **4.9** | **19.8** | **43.2** | **29.6** | **3.93** | **.956** | **3** | **Agree** |
| **Total Mean** | | | | | | **3.87** | | | **Agree** |

Table No. 6 summarizes the attitudes, means, and standard deviation The impact of climate changes on archaeological sites in Luxor. The overall mean value of 3.87 showed the impact of climate changes on archaeological sites in Luxor. In addition, the greatest mean was for "Climate changes can affect the soil or terrain surrounding archaeological sites," with a value of 3.99 and a standard deviation of 0.856, while the lowest mean value was for "Climate changes can affect the ability to preserve and maintain archaeological sites," with a low mean value of 3.77 and a standard deviation of 0.962.'

The results of the analysis in Table 6 agree with (Jaber et al., 2021; Grimm et al., 2018), as they stated that climate change affects many sectors, especially tourism.

**<u>Section 6: Challenges facing Luxor as a destination due to climate changes</u>**

**Table 6: Challenges facing Luxor as a destination due to climate changes**

| **Variables** | **SD** | **D** | **N** | **A** | **SA** | **Mean** | **Std. Deviation** | **Rank** | **Attitude** |
|---|---|---|---|---|---|---|---|---|---|
| Climate changes lead to hiding and changing the colors of monuments due to different weather fluctuations | **1.2** | **6.2** | **22.2** | **44.4** | **25.9** | **3.88** | **.911** | **5** | **Agree** |
| Climate changes caused melting polar ice and rising sea levels threaten to submerge many archaeological sites | **0** | **7.4** | **24.7** | **39.5** | **28.4** | **3.89** | **.905** | **3** | **Agree** |
| Climate changes lead to low level of comfort for tourists in tourist destinations, which negatively affects the frequency of visits to them | **0** | **6.2** | **24.7** | **45.7** | **23.5** | **3.86** | **.845** | **6** | **Agree** |
| Climate changes caused to difficulty in reaching tourist destinations by various means of transportation | **1.2** | **7.4** | **24.7** | **43.2** | **23.5** | **3.80** | **.925** | **7** | **Agree** |
| Climate changes causes natural disasters such as floods, hurricanes and forest fires, which negatively affect archaeological sites in Luxor | **1.2** | **9.9** | **16** | **44.4** | **28.4** | **3.89** | **.972** | **4** | **Agree** |
| The proximity of many archaeological sites to | **1.2** | **6.2** | **19.8** | **45.7** | **27.2** | **3.91** | **.908** | **1** | **Agree** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| water bodies threatened with submergence | | | | | | | | | |
| Climate changes cause to loss and destruction of natural attractions | **3.7** | **4.9** | **18.5** | **43.2** | **29.6** | **3.90** | **1.004** | **2** | **Agree** |
| **Total Mean** | | | | | | **3.88** | | | **Agree** |

It's declared from this table that respondent's see that Challenges facing Luxor as a destination due to climate changes and the most Challenges are: "The proximity of many archaeological sites to water bodies threatened with submergence", "Climate changes cause to loss and destruction of natural attractions" and "Climate changes caused melting polar ice and rising sea levels threaten to submerge many archaeological sites" with mean 3.91, 3.90 and 3.89 respectively.
The analysis results in Table 7 are consistent with Upadhyay, 2020; Held et al., 2018, who stated that rising sea levels pose a threat to the coastal area of Luxor.

**Section 7: Solutions to mitigate climate changes**

**Table 7: Solutions to mitigate climate changes**

| **Variables** | **SD** | **D** | **N** | **A** | **SA** | **Mean** | **Std. Deviation** | **Rank** | **Attitude** |
|---|---|---|---|---|---|---|---|---|---|
| Developing appropriate plans and strategies to adapt to climate change | **3.7** | **1.2** | **16** | **34.6** | **44.4** | **4.15** | **.986** | **9** | **Agree** |
| Investing in sustainable corporate jobs to eliminate all carbon emissions | **2.5** | **3.7** | **17.3** | **35.8** | **40.7** | **4.09** | **.974** | **12** | **Agree** |
| Climate consideration in all government decisions | **1.2** | **2.5** | **16** | **34.6** | **45.7** | **4.21** | **.888** | **6** | **strongly Agree** |
| Building early warning systems using innovative technologies such as digitization and artificial intelligence to reduce the risks of climate disasters | **2.5** | **4.9** | **14.8** | **30.9** | **46.9** | **4.15** | **1.011** | **10** | **Agree** |
| Keeping up with global events related to climate change and participating in all global climate conferences | **2.5** | **2.5** | **14.8** | **38.3** | **42** | **4.15** | **.934** | **8** | **Agree** |
| Cooperation and benefiting from international expertise to preserve antiquities and apply the advanced mechanisms that the world has reached in protecting archaeological heritage | **1.2** | **3.7** | **11.1** | **34.6** | **49.4** | **4.27** | **.792** | **1** | **strongly Agree** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Benefiting from international experts in the restoration and maintenance of antiquities and keeping up with the latest global technologies in their protection, such as (nan technology - laser - enzyme technology) | **2.5** | **2.5** | **14.8** | **33.3** | **45.7** | **4.16** | **.977** | **7** | **Agree** |
| Forming a committee from the authorities concerned with Egyptian antiquities to handle the file of protecting antiquities from the repercussions of climate change | **2.5** | **1.2** | **12.3** | **35.8** | **46.9** | **4.22** | **.933** | **5** | **strongly Agree** |
| Developing a strategy for adapting to climate change in the antiquities sector and dividing it into stages (near, medium, and long term) | **2.5** | **2.5** | **12.3** | **39.5** | **44.4** | **4.22** | **.892** | **4** | **strongly Agree** |
| Shifting to greener technology in the creation and operation of building materials and buildings | **2.5** | **4.9** | **13.6** | **35.8** | **43.2** | **4.12** | **.989** | **11** | **Agree** |
| Preserving natural resources and green spaces | **1.2** | **2.5** | **14.8** | **33.9** | **50.6** | **4.25** | **.892** | **2** | **strongly Agree** |
| Developing resilient infrastructure and services in the face of climate change impacts | **1.2** | **1.2** | **19.8** | **28.4** | **49.4** | **4.23** | **.895** | **3** | **strongly Agree** |
| **Total Mean** | | | | | | **4.19** | | | **Agree** |

It's declared from this table that respondent's see that Solutions to mitigate climate changes and the most Solutions are: "Cooperation and benefiting from international expertise to preserve antiquities and apply the advanced mechanisms that the world has reached in protecting archaeological heritage", "Preserving natural resources and green spaces" and "Developing resilient infrastructure and services in the face of climate change impacts" with mean 4.27, 4.25 and 4.23 respectively.

## Pearson Correlation analysis

**Table 8: Correlation between Causes of climate changes in Luxor and the impact of climate changes on tourist destinations**

| | | Causes of climate changes in Luxor | The impact of climate changes on tourist destinations |
|---|---|---|---|
| Causes of climate changes in Luxor | Pearson Correlation | **1** | **.745**** |
| | Sig. (2-tailed) | | **.000** |
| | N | **162** | **162** |
| The impact of climate changes on tourist destinations | Pearson Correlation | **.745**** | **1** |
| | Sig. (2-tailed) | **.000** | |
| | N | **162** | **162** |

**. Correlation is significant at the 0.01 level (2-tailed).

As seen in the table (8), there is a positive and significant relationship between Causes of climate changes in Luxor and the impact of climate changes on tourist destinations. The value of the Pearson correlation coefficient was (.745** - sig = 0.000). These results showed that there is a strong positive relation between Causes of climate changes in Luxor and the impact of climate changes on tourist destinations. This positive correlation indicates that as Causes of climate changes in Luxor increases, the impact of climate changes on tourist destinations increases.

**Table (9) Correlation between Causes of climate changes in Luxor and the impact of climate changes on archaeological sites in Luxor**

| | | Causes of climate changes in Luxor | The impact of climate changes on archaeological sites in Luxor |
|---|---|---|---|
| Causes of climate changes in Luxor | Pearson Correlation | **1** | **.757**** |
| | Sig. (2-tailed) | | **.000** |
| | N | **162** | **162** |
| The impact of climate changes on archaeological sites in Luxor | Pearson Correlation | **.757**** | **1** |
| | Sig. (2-tailed) | **.000** | |
| | N | **162** | **162** |

****. Correlation is significant at the 0.01 level (2-tailed).**

As seen in the table (10), there is a positive and significant relationship between Causes of climate changes in Luxor and the impact of climate changes on archaeological sites in Luxor. The value of the Pearson correlation coefficient was (.757** - sig = 0.000). These results showed that there is a strong positive relation between Causes of climate changes in Luxor and the impact of climate changes on archaeological sites in Luxor. This positive correlation indicates that as Causes of climate changes in Luxor increases, the impact of climate changes on archaeological sites in Luxor increases.

**Table (10) Correlation between Causes of climate changes in Luxor and Challenges facing Luxor as a destination due to climate changes**

| | | Causes of climate changes in Luxor | Challenges facing Luxor as a destination due to climate changes |
|---|---|---|---|
| Causes of climate changes in Luxor | Pearson Correlation | **1** | **.671**** |
| | Sig. (2-tailed) | | **.000** |
| | N | **162** | **162** |
| Challenges facing Luxor as a destination due to climate changes | Pearson Correlation | **.671**** | **1** |
| | Sig. (2-tailed) | **.000** | |
| | N | **162** | **162** |

**. Correlation is significant at the 0.01 level (2-tailed).

As seen in the table (10), there is a positive and significant relationship between Causes of climate changes in Luxor and Challenges facing Luxor as a destination due to climate changes. The value of the Pearson correlation coefficient was (.671** - sig = 0.000). These results showed that there is a medium positive relation between Causes of climate changes in Luxor and Challenges facing Luxor as a destination due to climate changes. This positive correlation indicates that as Causes of climate changes in Luxor increases, Challenges facing Luxor as a destination due to climate changes in Luxor increases.

**Table 11: Correlation between Causes of climate changes in Luxor and Solutions to mitigate climate changes**

| | | Causes of climate changes in Luxor | Solutions to mitigate climate changes |
|---|---|---|---|
| Causes of climate changes in Luxor | Pearson Correlation | **1** | **.678**** |
| | Sig. (2-tailed) | | **.000** |
| | N | **162** | **162** |
| Solutions to mitigate climate changes | Pearson Correlation | **.678**** | **1** |
| | Sig. (2-tailed) | **.000** | |
| | N | **162** | **162** |

**. Correlation is significant at the 0.01 level (2-tailed).

As seen in the table (11), there is a positive and significant relationship between Causes of climate changes in Luxor and Solutions to mitigate climate changes. The value of the Pearson correlation coefficient was (.678** - sig = 0.000). These results showed that there is a medium positive relation between Causes of climate changes in Luxor and Solutions to mitigate climate changes. This positive correlation indicates that as Causes of climate changes in Luxor increases, Solutions to mitigate climate changes increases.

**Table (12) Correlation between the impact of climate changes on tourist destinations and the impact of climate changes on archaeological sites in Luxor**

| | | The impact of climate changes on tourist destinations | The impact of climate changes on archaeological sites in Luxor |
|---|---|---|---|
| The impact of climate changes on tourist destinations | Pearson Correlation | **1** | **.779****[**]** |
| | Sig. (2-tailed) | | **.000** |
| | N | **162** | **162** |
| The impact of climate changes on archaeological sites in Luxor | Pearson Correlation | **.779****[**]** | **1** |
| | Sig. (2-tailed) | **.000** | |
| | N | **162** | **162** |

**. Correlation is significant at the 0.01 level (2-tailed).

As seen in the table (13), there is a positive and significant relationship between the impact of climate changes on tourist destinations and the impact of climate changes on archaeological sites in Luxor. The value of the Pearson correlation coefficient was (.779** - sig = 0.000). These results showed that there is a strong positive relation between the impact of climate changes on tourist destinations and the impact of climate changes on archaeological sites in Luxor. This positive correlation indicates that as the impact of climate changes on tourist destinations increases, the impact of climate changes on archaeological sites in Luxor increases.

**Table (13) Correlation between the impact of climate changes on tourist destinations and Challenges facing Luxor as a destination due to climate changes**

| | | The impact of climate changes on tourist destinations | Challenges facing Luxor as a destination due to climate changes |
|---|---|---|---|
| The impact of climate changes on tourist destinations | Pearson Correlation | **1** | **.829**** |
| | Sig. (2-tailed) | | **.000** |
| | N | **162** | **162** |
| Challenges facing Luxor as a destination due to climate changes | Pearson Correlation | **.829**** | **1** |
| | Sig. (2-tailed) | **.000** | |
| | N | **162** | **162** |

**. Correlation is significant at the 0.01 level (2-tailed).

As seen in the table (13), there is a positive and significant relationship between the impact of climate changes on tourist destinations and Challenges facing Luxor as a destination due to climate changes. The value of the Pearson correlation coefficient was (.829** - sig = 0.000). These results showed that there is a strong positive relation between the impact of climate changes on tourist destinations and Challenges facing Luxor as a destination due to climate changes. This positive correlation indicates that as the impact of climate changes on tourist destinations increases, Challenges facing Luxor as a destination due to climate changes increases.

**Table (14) Correlation between the impact of climate changes on tourist destinations and Solutions to mitigate climate changes**

| | | The impact of climate changes on tourist destinations | Solutions to mitigate climate changes |
|---|---|---|---|
| The impact of climate changes on tourist destinations | Pearson Correlation | **1** | **.662**** |
| | Sig. (2-tailed) | | **.000** |
| | N | **162** | **162** |
| Solutions to mitigate climate changes | Pearson Correlation | **.662**** | **1** |
| | Sig. (2-tailed) | **.000** | |
| | N | **162** | **162** |

**. Correlation is significant at the 0.01 level (2-tailed).

As seen in the table (14), there is a positive and significant relationship between the impact of climate changes on tourist destinations and Solutions to mitigate climate changes. The value of the Pearson correlation coefficient was (.662** - sig = 0.000). These results showed that there is a medium positive relation between the impact of climate changes on tourist destinations and Solutions to mitigate climate changes. This positive correlation indicates that as the impact of climate changes on tourist destinations increases, Solutions to mitigate climate changes increases.

**Table (15) Correlation between the impact of climate changes on archaeological sites in Luxor and the impact of climate changes on archaeological sites in Luxor**

| | | The impact of climate changes on archaeological sites in Luxor | Challenges facing Luxor as a destination due to climate changes |
|---|---|---|---|
| The impact of climate changes on archaeological sites in Luxor | Pearson Correlation | **1** | **.854**** |
| | Sig. (2-tailed) | | **.000** |
| | N | **162** | **162** |
| Challenges facing Luxor as a destination due to climate changes | Pearson Correlation | **.854**** | **1** |
| | Sig. (2-tailed) | **.000** | |
| | N | **162** | **162** |

**. Correlation is significant at the 0.01 level (2-tailed).

As seen in the table (15), there is a positive and significant relationship between the impact of climate changes on archaeological sites in Luxor and Challenges facing Luxor as a destination due to climate changes. The value of the Pearson correlation coefficient was (.854** - sig = 0.000). These results showed that there is a strong positive relation between the impact of climate changes on archaeological sites in Luxor and Challenges facing Luxor as a destination due to climate changes. This positive correlation indicates that as the impact of climate changes on archaeological sites in Luxor increases, Challenges facing Luxor as a destination due to climate changes increases.

**Table (16) Correlation between the impact of climate changes on archaeological sites in Luxor and Solutions to mitigate climate changes.**

| | | The impact of climate changes on archaeological sites in Luxor | Solutions to mitigate climate changes |
|---|---|---|---|
| The impact of climate changes on archaeological sites in Luxor | Pearson Correlation | **1** | **.801$^{**}$** |
| | Sig. (2-tailed) | | **.000** |
| | N | **162** | **162** |
| Solutions to mitigate climate changes | Pearson Correlation | **.801$^{**}$** | **1** |
| | Sig. (2-tailed) | **.000** | |
| | N | **162** | **162** |

**. Correlation is significant at the 0.01 level (2-tailed).

As seen in the table (17), there is a positive and significant relationship between the impact of climate changes on archaeological sites in Luxor and Solutions to mitigate climate changes. The value of the Pearson correlation coefficient was (.801$^{**}$ - sig = 0.000). These results showed that there is a strong positive relation between the impact of climate changes on archaeological sites in Luxor and Solutions to mitigate climate changes. This positive correlation indicates that as the impact of climate changes on archaeological sites in Luxor increases, Solutions to mitigate climate changes increases.

**Achieving the research objectives**

The research aims to understand the impact of climate change on the sustainability of archaeological sites in Luxor. The table indicates the five research objectives, from 1 to 5, achieved through collecting primary data from a questionnaire, with the exception of the first objective, which was

## 4. Results of the Study

1. **Increased Environmental Deterioration:**
   The study revealed that rising temperatures and fluctuations in humidity have accelerated the deterioration of stone surfaces, pigments, and wall paintings in several archaeological sites such as the Karnak and Luxor Temples. Thermal stress and salt crystallization were identified as major factors contributing to structural damage.
2. **Flooding and Groundwater Impacts:**
   Climate change–induced variations in the Nile River's flow and occasional flash floods have caused rising groundwater levels in some areas, leading to moisture infiltration, salt efflorescence, and erosion of foundations in ancient structures and tombs.
3. **Wind and Sandstorm Effects:**
   The frequency and intensity of sandstorms have increased, leading to the abrasion and physical weathering of open-air monuments. This has particularly affected statues, columns, and inscriptions exposed to the desert environment.
4. **Biological Growth and Microbial Activity:**
   Changes in temperature and humidity created favorable conditions for

biological growth such as algae, lichens, and bacteria, especially in tombs and enclosed spaces, accelerating the decay of wall decorations.

5. **Inadequate Adaptation Measures:**
   The study found that existing conservation and management strategies are limited and reactive rather than proactive. There is a lack of integrated climate risk management plans, monitoring systems, and sustainable conservation materials adapted to local environmental changes.
6. **Need for Sustainable Management Strategies:**
   Results emphasize the urgent need to adopt sustainable preservation practices, including improved site drainage, regular environmental monitoring, the use of climate-resistant conservation materials, and awareness programs for local staff and visitors.

## 5. Recommendations

1. **Develop a Comprehensive Climate Risk Management Plan**
   - Establish a long-term strategy for monitoring and managing the effects of temperature fluctuations, humidity, flooding, and wind erosion on Luxor’s archaeological sites.
   - Integrate climate data with heritage preservation plans to anticipate and mitigate future risks.
2. **Enhance Monitoring and Early Warning Systems**
   - Install advanced environmental monitoring systems to track microclimatic changes around major monuments such as the Karnak and Luxor Temples and the Valley of the Kings.
   - Use satellite imagery and remote sensing to detect early signs of structural deterioration.
3. **Promote Sustainable Conservation Practices**
   - Encourage the use of eco-friendly materials and techniques in restoration to ensure minimal environmental impact.
   - Implement green infrastructure, such as controlled vegetation and water drainage systems, to protect sites from flash floods and soil erosion.
4. **Increase Awareness and Capacity Building**
   - Train archaeologists, conservators, and site managers in climate adaptation techniques and sustainable heritage management.
   - Raise community awareness about the importance of protecting heritage from climate-related threats.
5. **Strengthen Collaboration Among Stakeholders**
   - Foster cooperation between the Ministry of Tourism and Antiquities, the Egyptian Environmental Affairs Agency, UNESCO, and local authorities to coordinate climate resilience projects.
   - Encourage international partnerships for technical and financial support in implementing adaptation measures.
6. **Encourage Research and Innovation**
   - Support interdisciplinary research on climate modeling, conservation science, and sustainable tourism in heritage areas.
   - Utilize new technologies such as 3D scanning, digital documentation, and AI for monitoring and restoration planning.
7. **Integrate Heritage Protection into Sustainable Tourism Policies**

- Ensure that tourism development in Luxor adheres to environmental and sustainability standards that protect archaeological sites from additional stress.
- Promote responsible tourism practices that balance economic benefits with heritage preservation.

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# تأثير التغيرات المناخية على استدامة المواقع الأثرية بالأقصر

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**الكلمات الدالة**

**التغير المناخي؛ الاستدامة؛ المواقع الاثرية.**

**المستخلص**

يؤثر تغير المناخ بشكل كبير على استدامة المواقع الأثرية، مثل ارتفاع مستوى سطح البحر، مما يؤثر سلباً على النظم البيئية والمجتمعات البشرية وقد يؤدي إلى غرق بعض الآثار. يتعاون العلماء والباحثون والحكومات لدراسة آثار تغير المناخ وتقييم آثارها ووضع تدابير للتكيف معها والتخفيف من آثارها. تهدف هذه الدراسة إلى تحليل تأثير تغير المناخ على استدامة المواقع الأثرية في الأقصر. ولتحقيق ذلك، استخدم هذا البحث المنهج الوصفي التحليلي، حيث تم إعداد استبيان وتوزيعه على عينة عشوائية من مائة واثنين وستين (١٦٢) عضوًا من أعضاء هيئة التدريس من كليات السياحة والفنادق وكليات الآثار وخبراء من وزارة السياحة والآثار في عدة محافظات داخل مصر، بالإضافة إلى العاملين في المواقع الأثرية بمحافظة الأقصر. تم تحليل نتائج الأدوات باستخدام الإحصاء الوصفي وتحليل العوامل وتحليل الموثوقية وتحليل المعاملات وتحليل ارتباط بيرسون بدعم من SPSS25.0. تُظهر نتائج البحث وتؤكد على الحاجة الملحة إلى تبني ممارسات الحفاظ المستدامة، بما في ذلك تحسين تصريف الموقع والمراقبة البيئية المنتظمة واستخدام مواد الحفظ المقاومة للمناخ وبرامج التوعية للموظفين المحليين والزوار، ووجدت الدراسة أن الحفظ الحالي استراتيجيات إدارة المخاطر البيئية محدودة، وتعتمد على ردود الفعل أكثر من كونها استباقية. هناك نقص في خطط إدارة مخاطر المناخ المتكاملة، وأنظمة الرصد، ومواد الحفظ المستدامة الملائمة للتغيرات البيئية المحلية. أوصى البحث بوضع استراتيجية طويلة المدى لرصد وإدارة آثار تقلبات درجات الحرارة، والرطوبة، والفيضانات، وتآكل الرياح على رمال الموقع الأثري في الأقصر. تركيب أنظمة رصد بيئي متطورة لتتبع التغيرات المناخية المحلية حول المعالم الأثرية الرئيسية، مثل معبدي الكرنك والأقصر ووادي الملوك.

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