

Identifying Main Driving Forces Affecting Urban Sprawl in the Vicinity of Cultural Heritage Sites in Egypt

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Abstract In 2021, reporting trends of World Heritage Committee indicate urban development is one of the challenges threatening the integrity of Egypt's cultural heritage sites (CHS). Urban sprawl (US) is one of the concerns affecting the integrity of Egypt's cultural heritage monuments. The aim of this research is to identify the main driving forces (DFs) in three locations (Giza zone, Sakkara zone and Thebes zone). The amount of US growth was measured and a survey was conducted to identify the main DFs affecting US in the vicinity of CHS in Egypt. Responses were weighted using AHP method to achieve the impact ranking of DFs. To measure the US, three images for each case study were used from Google Earth in 2003–2013–2022. The results showed that from 11 DFs, availability of basic services in the vicinity of US areas has the highest impact ranking DF with 15.85%, while flat land nature, free of topographic variations has the lowest impact factor DF with 0.38%. The amount of growth from 2003-2022 in Giza, Sakkara and Thebes zones was 96.80%, 164.63%, and 81.23%, respectively. This research can be used by decision-makers as a decision support system in managing the development areas in the vicinity of CHS in Egypt.

Keywords Urban Sprawl (US), Driving Forces (DFs), Cultural Heritage Sites (CHS), Analytical Hierarchy Process (AHP), Geographic Information System (GIS)

1. Introduction

Cultural heritage usually conjures up images of a single society and its inhabitants communicating with one another. However, cultural boundaries are not always well defined. The cultural heritage that our parents have passed down to us must be conserved for the benefit of all [1-3]. Cultural heritage helps us remember our cultural diversity, in an age of globalization, and understanding it fosters mutual tolerance and renewed communication between civilizations. In spite of the various definitions available, cultural heritage is still regarded as an important source of innovation, growth, competitiveness and social welfare [4]. Such sites are widely recognized as being integral to the world's cultural heritage, which should be preserved for future generations as well as those living today. Globalization and tourism industry have been threatening these regions already, especially in developing countries.[1] Despite UNESCO's efforts to define and implement guidelines for the preservation of these outstandingly valued sites for all people, it is the responsibility of state parties to conserve the sites and hence make decisions concerning suitable preservation and conservation techniques [5].

Diversity and richness are hallmarks of Egypt's heritage [6]. Egyptian civilization has influenced the cultures of Europe, the Middle East, and Africa for millennia. Although ancient Egyptian archaeological sites have been

looted for centuries by the black-market trade in antiquities, Egyptian antiquities rank among the most valuable and vulnerable in the world [7]. Heritage sites in general and world heritage properties in particular face the risks of natural and man-made catastrophes, which threaten their integrity and can compromise their value [8]. The loss or dilapidation of these outstanding properties has severe negative impacts on local and national communities, both in terms of cultural and socioeconomic importance [9]. Natural threats such as earthquakes, flooding and fires, armed conflict, war, pollution, poaching, uncontrolled urbanization -that leads to the US- and untrammelled and unregulated tourist development poses serious threats to World Heritage Sites that make it fragile and vulnerable [10,11].

According to World Heritage Committee, factors affecting property indicators in 2021 reporting trends [12] includes, (Housing, Interpretative and visitation facilities, Major visitor accommodation and associated infrastructure, Management systems/ management plan, Development and urban infrastructure projects, Underground transport infrastructure and Urban encroachment). Urban development is one of the challenges threatening the integrity of Egypt's cultural heritage sites.

Adding to the dangers of archaeological sites is encroachment on the land-urban sprawling- by residents seeking to expand their homes or properties or to utilize the land for landfills or car parks. In addition to damaging unexcavated sites, archaeologists are forced to work faster, and they might miss finding crucial artifacts. It may take decades or even centuries for ancient artifacts to be found after a new building is constructed on top of an unexcavated site [7].

The term "urban sprawl" is a bit of a misnomer. Nonetheless, there is widespread agreement that US refers to the development of low urban density marked by an uneven pattern of expansion between an urban region and its population, resulting in inefficient land resource utilization [13]. Although the correct definition of US is debated, most agree that it is distinguished by an unplanned and uneven pattern of growth impelled by various processes and leading to inefficient resource usage. It also refers to a low-density and inefficient expansion of the city. There is a key aspect to US in which the growth rate of the urban area exceeds that of the urban population. As a result, many environmental problems occurred, [14,15] and a significant change in LULC occurs as sprawl promotes the growth in built-up and paved areas [16]. Research scientists, policymakers, activists, and the public holds radically different opinions on sprawl, and this lack of agreement over how to define sprawl hinders efforts to classify and restrict this type of development [13]. There have been many attempts to characterize sprawl over the past few decades [13].

In today's increasingly interconnected planet, more than half of the world's population live in metropolitan areas,

with that percentage expected to rise to 66 percent by the year 2050. More than 2.5 billion people will be added to the world's population, with approximately 90 percent of the growth occurring in developing countries [17]. Even though urbanization has just recently begun in underdeveloped countries, the rate of urbanization is far faster than in industrialized countries. These countries are the least urbanized and are characterized by unplanned urbanization, as seen by a misalignment of urbanization with economic and industrial development [18,19]. The US is a serious danger to agricultural areas, which has an impact on agricultural commodities and markets. It also has an impact on the long-term ability to produce food and natural fiber, leading to food security issues. As the population grows, more agricultural lands are transformed into urban areas, resulting in agricultural land losses [20] and changes in agricultural activity on the remaining land.

The US is a concern affecting the integrity of Egypt's cultural heritage monuments, according to the World Heritage Committee indicators in 2021 reporting trends [12]. Urban sprawl has a negative impact on natural and man-made landscapes, as well as the attraction of visiting and touristic places. The expansion of urban land use has resulted in severe biodiversity loss and increased vulnerability of fragile natural and man-made systems. The urban strain on Cairo's Giza pyramid complex is a clear illustration of this hazard to the cultural heritage [21]. Despite some efforts to address the reasons and drivers of US, little has been done to address the issue of cultural heritage sites.

There are multiple laws discussing the importance of institutional legislative management system internationally-perational Guidelines for the Implementation of the World Heritage Convention in 2012- [22] in (II.F) section- protection and management-point 97 and 99 states that "The delineation of boundaries is an essential requirement in the establishment of effective protection of nominated properties. Boundaries should be drawn to ensure the full expression of the Outstanding Universal Value and the integrity and/or authenticity of the property". And locally, the antiquities protection laws and its amendments law No. 117 in 1983, law No.3 in 2010, Law 61 in 2010 and law No. 91 in 2018- article 19, 22- which discusses the significance of setting proper boundray by the authorities and how to properly protect our national treasure. Even though the availability of these laws, there are driving forces to urban sprawl towards these sites. Driving forces are anything that can cause a significant change or has an impact on keystone landscape processes. There are two categories of driving forces: human and natural [23, 24]. In this paper, only human factors will be tackled.

There are few papers that tackled the problem of the US in relation to the CHS in Egypt, therefore this research is an empirical attempt to bridge the scientific gap and contribute to knowledge in this area. This research aims to measure the driving forces of US in the vicinity of cultural

heritage sites in Giza Pyramids zone and Ancient Thebes zone in Upper Egypt.

2. Materials and Methods

To identify the main driving forces (DFs) affecting US in the vicinity of cultural heritage sites in Egypt, the

research used a mixed process of induction and deduction methodology (Figure 1). The research is divided into two main parts (Table 1) to achieve the aim of the study. The first part is to narrow down the most affecting driving forces of US in the vicinity of cultural heritage sites. The second part is to measure US in the vicinity of cultural heritage sites.

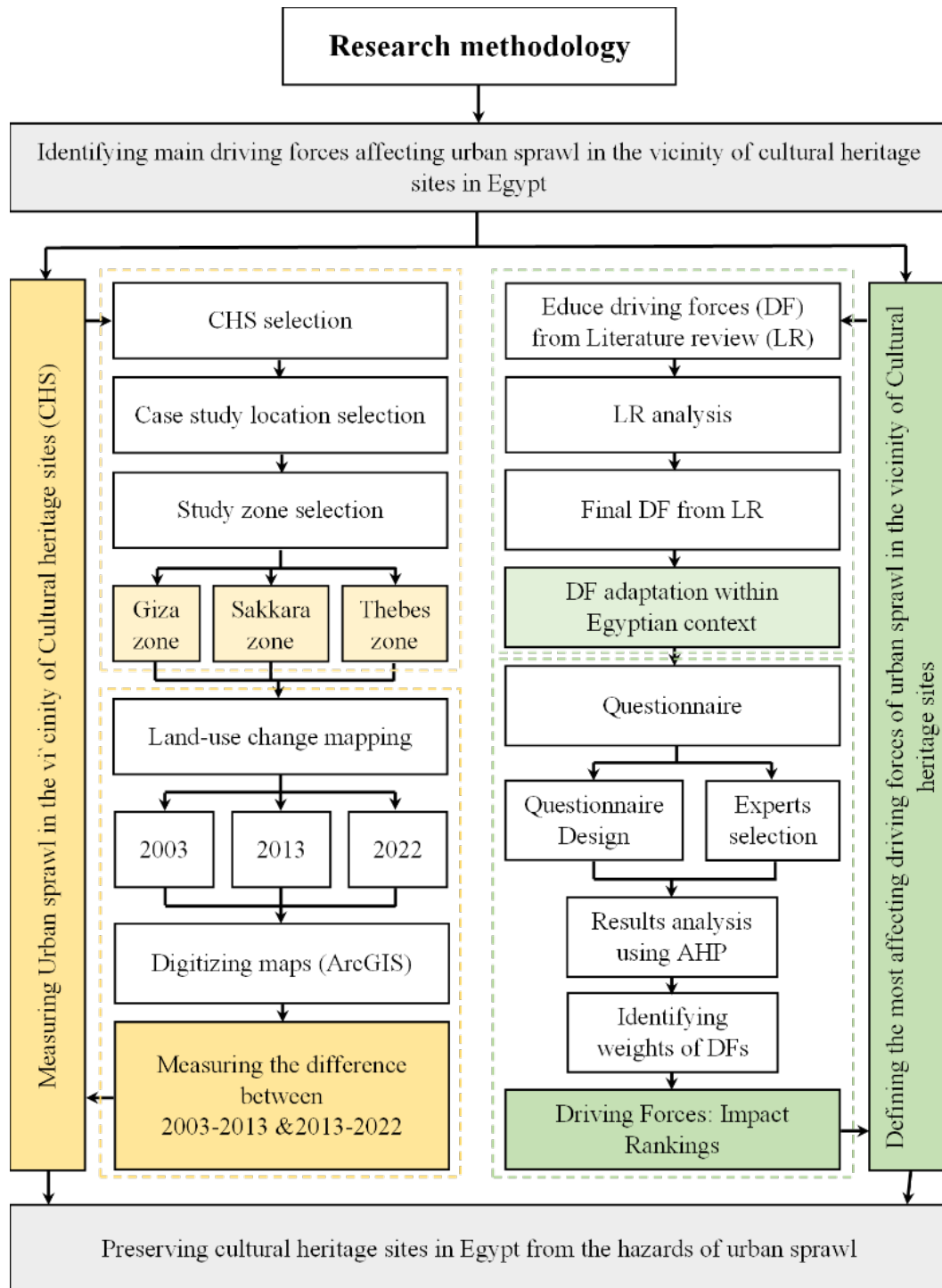


Figure 1. Research methodology

The first part adopts quantitative deductive approach, through reviewing and analysing DFs affecting US from the most recent and related literature. This part is composed of three steps (literature review analysis - adaptation to the Egyptian context through questionnaire - analysing and weighing responses to achieve the most affecting DFs).

The second part adopts analytical approach, through monitoring the amount of US in the vicinity of cultural heritage sites. This part is composed of three steps (case study selection - Digitizing layers of these cases in three different periods (2003-2013-2022) these periods were chosen based on image clarity on Google Earth Pro cadastral maps, processing layers in ArcGIS to measure the amount of sprawl). Finally, the study discusses the findings in order to give insight into the topic.

2.1. Study Area Selection

To select the most suitable area for analysis, this research conducted a three phase analysis:

2.1.1. Cultural heritage site selection

This research seeks to identify the main DFs affecting the US in the vicinity of cultural heritage sites in Egypt, thus multiprocess procedures were implemented to find the optimum case studies. According to UNESCO, there are 7 Properties inscribed on the World Heritage List, 6 cultural heritage sites, and 1 is natural heritage site [25]. Cultural heritage sites are (Abu Mena - Ancient Thebes with its Necropolis- Historic Cairo Memphis and its Necropolis - the Pyramid Fields from Giza to Dahshur - Nubian Monuments from Abu Simbel to Philae- Saint Catherine Area) unlike Wadi Al-Hitan (Whale Valley), which is a natural heritage site [12].

Heritage sites attached to the current urban fabric from satellite aerial images 2022 were analysed by the author according to their proximity to urban fabric (Table 2). To achieve this research goal, sites far from urban fabric were excluded, only 5 sites were prominent as a case study:

- a) Ancient Thebes with its Necropolis “Karnak temple”
- b) Ancient Thebes with its Necropolis “Luxor temples”
- c) Historic Cairo
- d) Memphis and its Necropolis “the Pyramid Fields from Giza to Dahshur

Nubian Monuments from Abu Simbel to Philae “Islamic Cemetery”

2.1.2. Case study location selection

To identify the main driving forces affecting US in the vicinity of cultural heritage sites in Egypt, the urban area is selected, based on (Table 3) criteria:

- a) The urban area surrounding CHS has a negative influence according to UNESCO annual reports.
- b) Availability of empty lands surrounding the study zone (to be able to test driving forces towards cultural heritage sites)

- c) Growing area/remarkable urban growth detected over the last 20 years (From Google Earth maps)
- d) Availability of data (Database maps and previous studies)

Based on analysis, two cultural heritage sites were excluded (Historic Cairo -Islamic Cemetery) due to the lack of empty lands surrounding the study zone, the availability of data, respectively.

2.1.3. Study zone selection

Study zone selection was based on the following criteria:

- a) Within the vicinity of cultural heritage site
- b) Defined by main roads of major barriers (natural or manmade)
- c) Availability of data

Three study zones were chosen to test the main driving forces affecting US in the vicinity of cultural heritage sites. Two cases were selected in (Pyramid Fields from Giza to Dahshur) to test these forces in relation to location. Karnak temple and Luxor temple were grouped into one zone.

To identify the main driving forces affecting US in the vicinity of cultural heritage sites in Egypt, this research focused on two main methods (Table 1)

2.2. Measuring Urban Growth

The US is one of the main problems that threaten CHS (Figure 2) according to UNESCO’s annual report [12]. Uncontrolled US, in and around the cities has contributed to an increasingly unsustainable environment for CHS [26]. The US is actually a phenomenon that can be expressed and quantified using a series of special parameters [27]. In order to uncover and evaluate the dynamic spatiotemporal changes in a land-use, it is necessary to examine and monitor previous patterns of change from one point in time to the next. Therefore, this study utilized data from the US - land use changes (LUCs) over two-time frames, from 2003 to 2013 and 2013 to 2022, to determine whether and how land-uses have changed quantitatively and spatially over time. That’s why exploring changes in land-use type and then spotting the most affecting DFs is highly significant. These two time periods were chosen primarily for pragmatic purposes, since high-quality photographs and land-use maps were readily accessible as a way of comprehending the US-LUCs phenomena in the research region. The largest rate of US-LUCs in the research regions occurred between January 2011 and December 2013, following the Spring Revolution [28]. Following the counter-revolutionary government's control of the US in 2013, throughout Egypt in general. As a result of the counter-revolution, the government's grip over the US in Egypt has grown strong, which, along with a sluggish

economy, has resulted in US-LUCs reaching their lowest levels in decades [26,29]. The first temporal mapping of land-use change, between 2003, 2013, and 2022, was carried out using images from Google Maps for these years. Second, the author drew the boundary of urban areas in each year manually.

Table 1. Methods Table

Materials and methods	Measuring US in specific locations (giza pyramids zone, Sakkara zone, Thebe zone) using cadastral images from Google Earth Pro and processing it using QGIS to measure the amount of US in each location.	case study selection
		Digitizing layers of these sites in three different period of time (2003–2013–2022)
		Processing layers in ArcGIS to measure the amount of sprawl in each period of time.
	Investigating the driving forces of US and weighing their impact on US in the vicinity of cultural heritage sites.	literature review analysis
		adaptation to Egyptian context through questionnaire
		analysing and weighting responses to achieve the most affecting DFs

Table 2. Properties inscribed in World Heritage List analysis, relation to the urban fabric

	Heritage Sites	Urban attachment	
1	Abu Mena (1979)	C	
2	Ancient Thebes with its Necropolis (1979)	Temple of Karnak	A
		Temple of Luxor	A
		Ancient Thebes Necropolis	C
3	Historic Cairo (1979)	A	
4	Memphis and its Necropolis – the Pyramid Fields from Giza to Dahshur (1979)	Pyramid fields from Giza to Dahshur	B
5	Nubian Monuments from Abu Simbel to Philae (1979)	Abu Simbel	C
		Amada	C
		Wadi Sebuia	C
		Kalabsha	C
		Philae (Island of Agilkia)	C
		Old and Middle Kingdom Tombs	C
		Ruins of town of Elephantine	C
		Stone quarries and obelisk	C
		Monastery of St. Simeon	C
Islamic Cemetery	A		
6	Saint Catherine Area (2002)	C	
7	Wadi el Hitan (the whale valley) (2005)	C	

A (Totally attached CHS to Urban fabric) B (Semi attached CHS to Urban fabric) C (Not attached CHS to Urban fabric)

Table 3. Cultural heritage sites selection

	Urban area surrounding site has negative influence	Availability of empty lands surrounding the study zone	Urban sprawl expanding toward CHS over the years	Availability of data
Karnak temple	✓	✓	✓	✓
Luxor temples	✓	✓	✓	✓
Historic Cairo	✓	*	*	✓
Pyramid Fields from Giza to Dahshur	✓	✓	✓	✓
Islamic Cemetery	✓	✓	✓	*

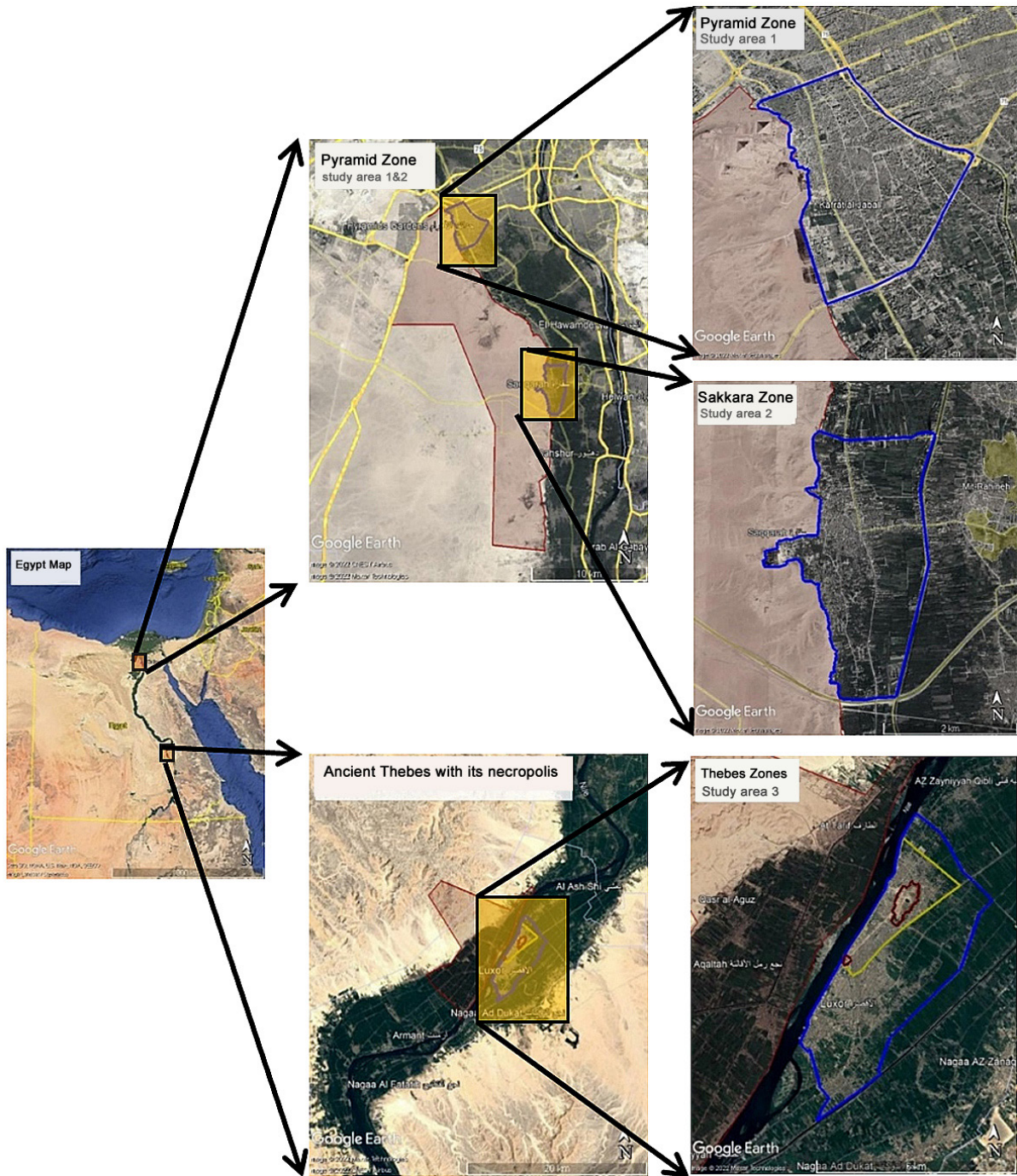


Figure 2. Map showing the location of the study area 1,2 and 3 in Pyramid fields from Giza to Dahshur (upper middle)- in Ancient Thebes with its Necropolis (Lower middle) Pyramids zone (upper right), Sakkara zone ((middle right) and Thebes Zone (Lower middle) (Source: Google Earth Pro)

These data were exported as (.kmz) files. Third, these files were converted to database layers through ArcMap10.3 GIS software. Fourth, the difference between each layer in each case study was extracted to measure the amount of growth in two stages, 2003-2013 and 2013-2022. Fifth, the amount of annual growth was calculated to define the most affected era. As previously mentioned by [30,31] and many researchers previously mentioned in the literature, a variety of biophysical and socioeconomic factors drive land-use change. These driving forces are

critical in determining the rate, amount, and direction of growth. Similar research in other developing countries, [30,32,33,34] yielded an initial tentative list of 11 driving forces forming US and LULC change.

Three images for each case study were used from Google Earth images (Table 4, Table 5) in (2003-2013-2022) to detect urban land cover alteration patterns. These images were obtained from Google Earth Pro as standard products, that is, rectified geometrically and radiometrically.

Table 4. Set of satellite images gathered from the study area

S/N	Location	Aerial Photo/Image	Year	Scale/Resolution	Source
1	Giza	Google Earth Image	January 2022	0.6m by 0.6m	Google Earth website accessed on 2022
2	Giza	Google Earth Image	July 2013	0.6m by 0.6m	Google Earth website accessed on 2022
3	Giza	Google Earth Image	May 2003	0.6m by 0.6m	Google Earth website accessed on 2022
4	Sakkara	Google Earth Image	January 2022	0.6m by 0.6m	Google Earth website accessed on 2022
5	Sakkara	Google Earth Image	May 2013	0.6m by 0.6m	Google Earth website accessed on 2022
6	Sakkara	Google Earth Image	May 2003	0.6m by 0.6m	Google Earth website accessed on 2022
7	Thebes	Google Earth Image	January 2022	0.6m by 0.6m	Google Earth website accessed on 2022
8	Thebes	Google Earth Image	January 2013	0.6m by 0.6m	Google Earth website accessed on 2022
9	Thebes	Google Earth Image	August 2002	0.6m by 0.6m	Google Earth website accessed on 2022

Table 5. Set of spatial data (Vector data) used for the study area

Spatial Data	Format	Source
Urban area 2003	Raster data	Derived from Google Earth image, then converted to Raster by ARC GIS10.1
Urban area 2013	Raster data	Derived from Google Earth image, then converted to Raster by ARC GIS10.1
Urban area 2022	Raster data	Derived from Google Earth image, then converted to Raster by ARC GIS10.1
Major roads	Shapefile	Derived from Google Earth image
Local roads	Shapefile	Derived from Google Earth image

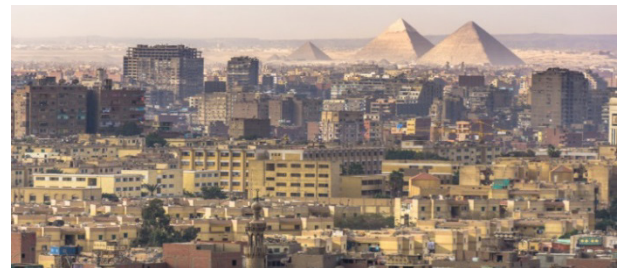
Study area size, study areas 1,2 and 3 had images with the same spatial resolution of 0.6 m by 0.6 m. These images were useful for analysing changes and patterns that developed at the time under study consideration. Then, land-cover polygons comprise urban zones that were scanned from Google Earth pictures and then transformed into raster data using ArcGIS 10.1. The majority of ArcGIS data, including the position of metropolitan regions and existing built-up areas, are sourced from VRH Google Earth. Google Earth was used to collect local road networks [35].

2.3. Questionnaire

2.3.1. Driving forces from literature review

More than 35 similar research studies yielded an initial tentative list of 80 driving forces impacting US and land-use cover change, [36,30,26,31,37]. These studies were analysed to figure out the main driving forces that affect US. 9 papers were related to Egyptian context. Driving forces were grouped in 8 main categories, (social, political, economic, demographic, technological, cultural,

physical and natural). These forces were analysed based on [31].



Urban sprawl in Giza zone, 2017, [38]



Urban sprawl in Sakkara, 2021, [39]



Urban sprawl in Thebes (Luxor) 2019, [40]

Figure 3. Images of US in the vicinity of CHS in Giza zone, Sakkara zone and Thebes zone

This extensive list of 80 driving forces was then whittled down to a more manageable, and context-specific collection of essential drivers for US-LUCs in the study area. All driving forces that are mentioned once or twice were excluded. All papers related to Egyptian context were given a higher value multiplied by 3, as these have higher significance to the scope of the study. Based on the analysis, 35 DFs were conducted. These forces were grouped to downsize it to 11 DFs.

2.3.2. Questionnaire design

The 11 driving forces extracted from literature review were involved in a single round questionnaire [35]. Data were collected using a predesigned questionnaire to measure the impact degree of physical and socioeconomic driving forces [41] based on experts’ experience in the field of cultural heritage site protection. The five-point Likert scale has been used to weigh the importance of the deducted driving forces from the literature review study. All driving forces used the five-point Likert scale. This scale ranged from 1 = (no influence) to 5 = (strong influence) [29, 31,42]. For the collection of data from respondents, a cost-effective, secure, and easy-to-use online survey method was used [43,44] through Google online forms. Respondents were able to access the questionnaire from their smart devices easily, which made it easy for them to complete it [45].

The questionnaire is intended to ensure greater agreement among experts on the most essential factors promoting the US in the vicinity of cultural heritage sites. The aggregated result list indicated four socioeconomic factors and seven physical components as being the most essential in driving change (Table 6). However, based on the responses of these experts, the socioeconomic data at the level of local municipalities became unavailable and unreliable from 2013 to 2022. Although the importance of socioeconomic issues in creating sprawl and land-use change patterns in megacities is recognized, physical driving factors might represent the aggregate effects of such factors on such cities. [46].

2.3.3. Experts’ selection

In this area, experts can often provide accurate information when other sources cannot, especially when it comes to why land use changes and how the driving forces relate to one another [31]. The chosen experts are knowledgeable at both the regional and local levels. Unlike political representatives, who are involved more in ground-level issues, government representatives are relevant driving forces. The ability of university scientists to filter out thematically irrelevant information allows them to provide highly relevant information [47].

The questionnaire sample included multiple criteria [48]. These experts were picked as the representatives to respond to the questionnaire. Experts’ working experience ranges from (10–40) years. These experts are related to the field of culture heritage sites, preservation, conservation, upgrading, regional planning, urban planning, and urban sustainability.

Based on factors such as study setting, and type of methodology employed, sample size differs [49]. The expert sample is not large because it is targeting the most efficient experts in the field of study in Egypt. These experts are sufficient to provide the required information from the questionnaire. Sample size included twenty-six experts as [50] included 24 experts and [51] included 35.

Table 6. Questionnaire Survey Questions

Date	Questions
26 th of January 2022	<ol style="list-style-type: none"> 1. From your field of expertise please rate the driving forces of urban sprawl in the vicinity of cultural heritage sites. <ul style="list-style-type: none"> • Availability of work opportunity • Market policies affecting investment in construction lands • Depreciation of agricultural land value • Fragmentation of agricultural land ownership • Diversity of economic activities • High demand of residential units’ rentals. • Local government policies enforcement regarding implementing building requirements • Availability of infrastructure networks near urban sprawl areas • Connectivity to public transportation networks • Availability of basic services in the vicinity of urban sprawl areas • Flat land nature, free of topographic variations 2. Through your experience are there other reasons causing urban sprawl in the vicinity of cultural heritage sites in Egypt?

2.4. Questionnaire Results Analysis

In this research, multiple indices of US are weighed based on an analytical hierarchy process (AHP). The AHP is a hierarchical paradigm for researching and resolving challenges through synthesis-resolution. The AHP technique is used to rate a set of options or to determine which option is the best among a set of options. Rating is done with an all-encompassing goal in mind, which is then divided into a set of standards. This method (AHP) is a flexible, simple method of multi-criteria decision-making proposed by Saaty in the 1970s. It is widely applied in the fields of sociology, economics and management science [52,53,33,36].

There are four main steps of the AHP technique (Figure 7): Calculating consistency ratios and the definitive significance, along with the AHP hierarchy pairwise comparisons. The respondents' responses using the AHP framework were used to determine the relative relevance of each DF in relation to others [54,55].

3. Results

3.1. Measuring Urban Growth

In this research quest to determine the most significant driving forces affecting US in the vicinity of cultural heritage sites, three case studies were chosen based on selection criteria, Giza Zone, Sakkara Zone, Thebes Zone.

3.1.1. Giza zone

Urban sprawl in Giza zone (Figure 4) reached the highest level from 2003-2013 (Table 7). The urban area increased from 2003, 951.85 Feddans to 1517.79 Feddans. It expanded by 59.46%, with annual increase reached 5.95%. While in the following period from 2013-2022, urban area increased from 1517.79 to 1873.23. The growth decreased to 23.42%, with annual growth reached 2.60%.

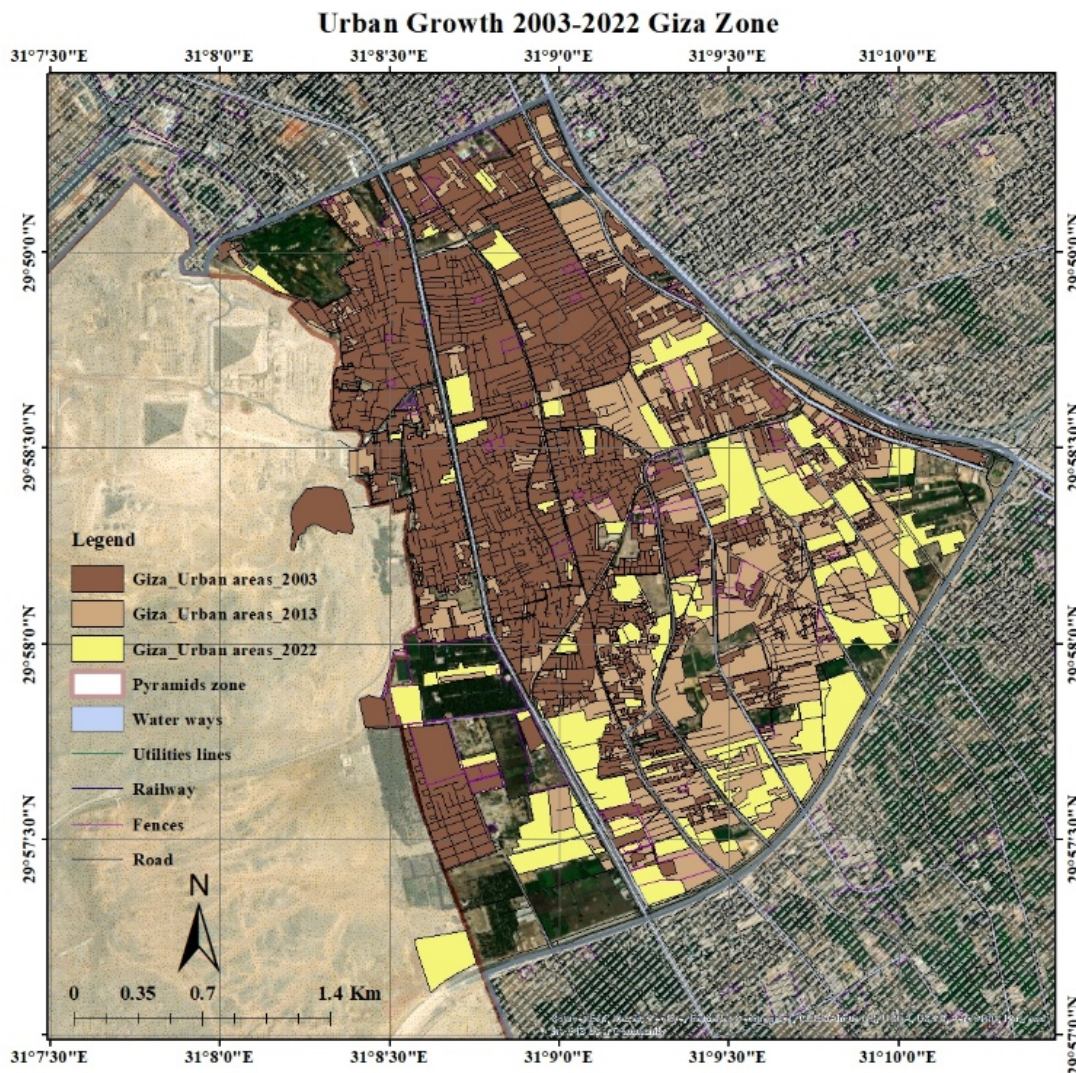


Figure 4. Urban Growth in Giza zone from 2003–2022 (source: author)

Table 7. Giza Zone urban growth from 2003–2022

Giza Zone	Area (Feddans)	Percentage	Total study area
Area 2003	951.85	35.57%	2676.09
Area 2013	1517.79	56.72%	
Area 2022	1873.23	70.00%	
Growth from 2003–2013	565.94	59.46%	
Growth from 2013–2022	355.44	23.42%	
Annual increase from 2003–2013	56.59	5.95%	
Annual increase from 2013–2022	39.49	2.60%	

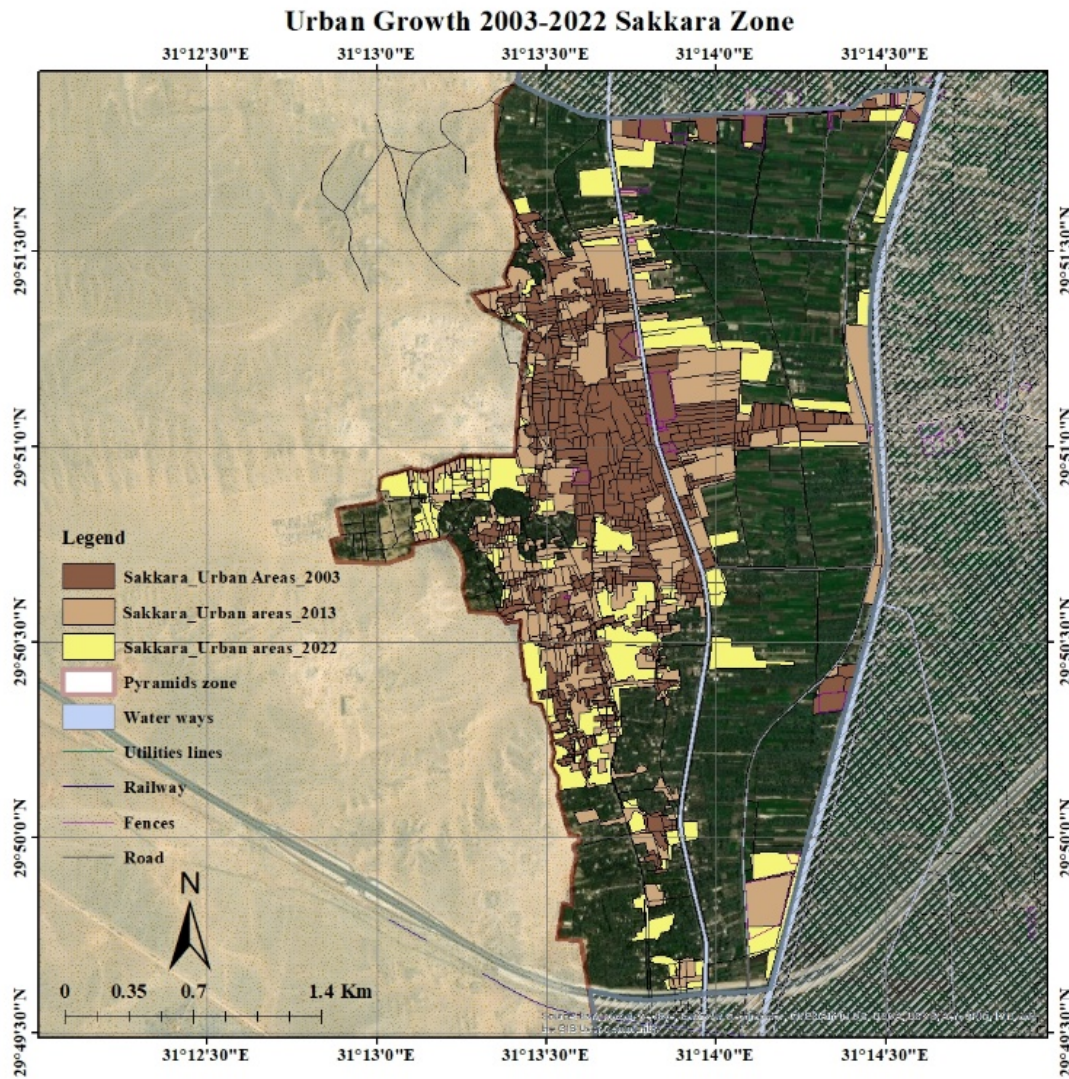


Figure 5. Urban Growth in Sakkara zone from 2003–2022 (source: author)

3.1.2. Sakkara Zone

Urban sprawl in Sakkara zone ((Figure 5) reached the highest peak of US from 2003 to 2013 (Table 8), it increased more than 105% of total study area core zone, it went from 342.4 Feddans in 2003 to 702.79 Feddans in

2013, the annual increase reached 10.53%. This peak decreased in the following period, from 2013 to 2022. Urban sprawl reached only 28.93%. Sakkara zone from 2013 to 2022 increased 203.3 Feddan’s, with annual increase reached only 3.21%.

Table 8. Sakkara Zone urban growth from 2003–2022

Sakkara Zone	Area (Feddans)	Percentage	Total study area
Area 2003	342.4	15.57%	2198.8
Area 2013	702.79	31.96%	
Area 2022	906.09	41.21%	
Growth from 2003–2013	360.39	105.25%	
Growth from 2013–2022	203.3	28.93%	
Annual increase from 2003–2013	36.039	10.53%	
Annual increase from 2013–2022	22.5889	3.21%	

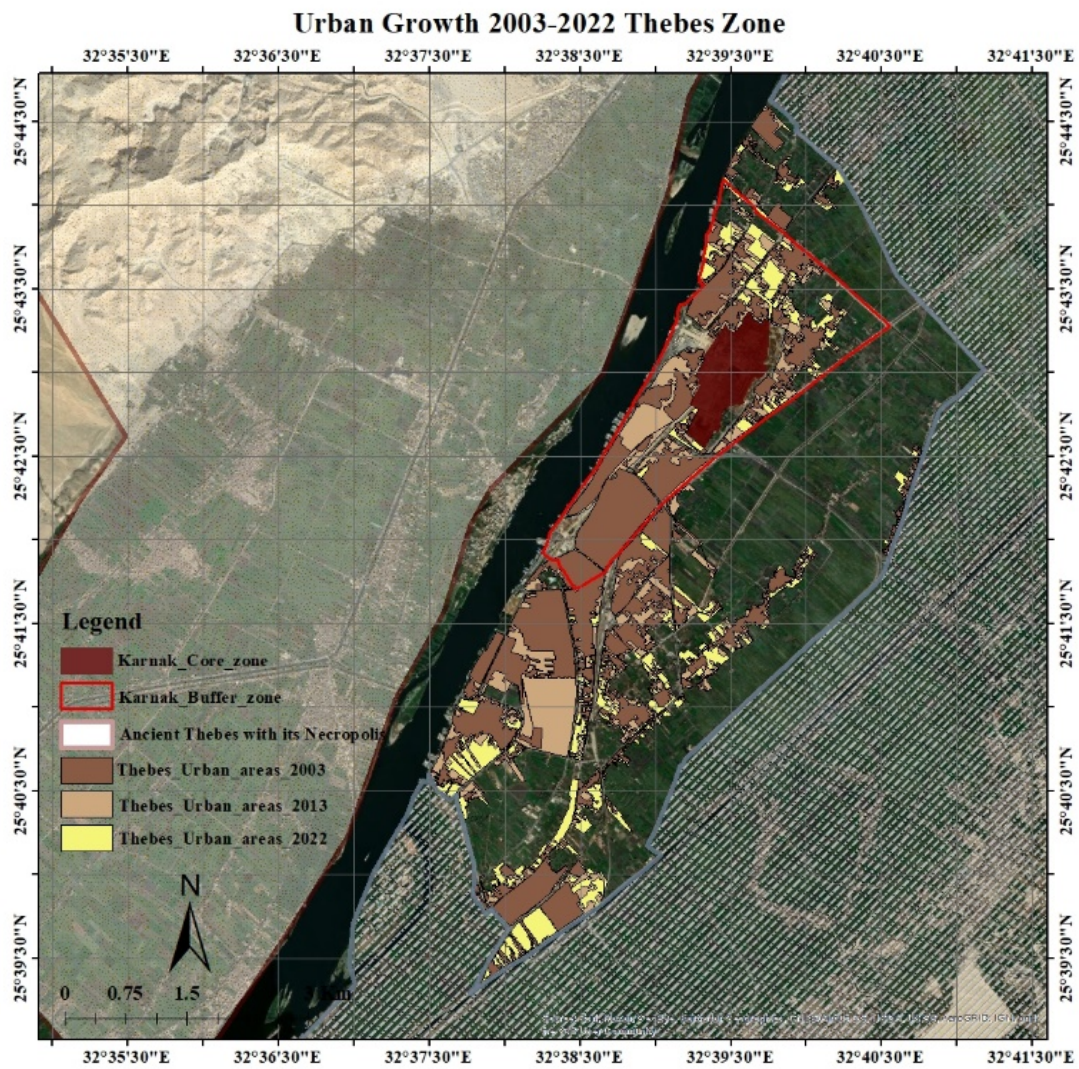


Figure 6. Urban Growth in Thebes zone from 2003–2022 (source: author)

3.1.3. Thebes zone

Urban sprawl in Thebes zone (Figure 6) in 2003 was 1230.40 Feddans, and in 2003 was 1230.40 Feddans (Table 9). The increase reached 1795.77 Feddan, in 2013 increase reached 45.95%. In the period from 2013 to 2022 the amount of sprawl increased from 1795.77 Feddan to 2229.88 Feddan, with increase reached 24.17% and annual increase reached 4.60%. From 2013 to 2022, the amount of growth reached from 1795.77 Feddan to 2229.88 Feddan, increase reached 24.17% and annual increase 2.69%.

Table 9. Thebes Zone urban growth from 2003–2022

Thebes Zone	Area (Feddans)	Percentage	Total study area
Area 2003	1230.40	16.89%	7284.97
Area 2013	1795.77	24.65%	
Area 2022	2229.88	30.61%	
Growth from 2003–2013	565.37	45.95%	
Growth from 2013–2022	434.11	24.17%	
Annual increase from 2003–2013	56.54	4.60%	
Annual increase from 2013–2022	48.23	2.69%	

Table 10. Study areas comparison from 2003–2022

Study Area	Area 2003	Area 2013	Area 2022	Total Area
Giza	951.85	1517.79	1873.23	2676.09
Sakkara	342.4	702.79	906.09	2198.8
Thebes	1230.4	1795.77	2229.88	7284.97

Table 11. Study areas urban growth from 2003–2022

Study Area	Growth from 2003–2013		Growth from 2013–2022	
	Area	Percentage	Area	Percentage
Giza	565.94	59.5%	355.44	23.4%
Sakkara	360.39	105.3%	203.3	28.9%
Thebes	565.37	46.0%	434.11	24.2%

Urban sprawl in Sakkara zone during the period

2003–2013 reached unprecedented levels (Table 11) in all three case studies. The urban area increased from 342.4 to 702.79 Feddan during the period 2003–2013; from 2013–2022, the urban area increased from 702.79 to 906.09 Feddan; the average annual urban growth rates from 2003–2013 was 10.5% and from 2013–2022 was 2.5% (Table 12).

Table 12. Annual increase from 2003–2022

Study Area	Annual increase from 2003–2013		Annual increase from 2013–2022	
	Annual increase	Percentage	Annual increase	Percentage
Giza	56.594	5.9%	39.49	2.6%
Sakkara	36.039	10.5%	22.59	3.2%
Thebes	56.537	4.6%	48.23	2.7%

3.2. Identifying the Driving Forces of Urban Sprawl Based on the Questionnaire Survey

In the questionnaire survey, 96% of valid responses indicated that (availability of basic services in the vicinity of US areas) is the most effective DF. While 88% of valid responses were identified (Availability of work opportunity-Availability of infrastructure networks near US areas- Connectivity to public transportation networks) as the driving forces for US. Moreover, (Market policies affecting investment in construction lands) was identified as a driving force of US 80% of valid responses). Additionally, 64% of valid responses indicated (diversity of economic activities) as one of the main DFs in US. Furthermore, (Depreciation of agricultural land value) and (fragmentation of agricultural land ownership) were selected by 60% of valid responses as a driving force. Lastly, (high demand of residential units' rentals), (local government policies enforcement regarding implementing building requirements) and (flat land nature) were identified as driving forces by valid responses of 56%, 48%, and 36% respectively.

3.3. Identifying the Weights of the Urban Sprawl Driving Forces

Weights for each of the driving forces of US were identified using the AHP method. Driving forces are presented in a radar chart (Figure 7), (Table 13) is to illustrate the correlation among the driving forces in US according to survey responses. Significant divergences among driving forces were observed.

Table 13. Driving Forces ranking based on questionnaire responses

Driving Forces	Questionnaire respondent scores					Impact Rankings
	1	2	3	4	5	
Availability of basic services in the vicinity of urban sprawl areas	5	18	1	0	2	15.85%
Connectivity to public transportation networks	0	2	7	16	1	14.72%
Availability of infrastructure networks near urban sprawl areas	16	1	3	9	5	13.96%
Availability of work opportunity	2	4	8	12	1	13.58%
Market policies affecting investment in construction lands	5	2	6	9	0	11.32%
Diversity of economic activities	9	6	1	2	6	8.30%
High demand of residential units' rentals.	5	8	0	5	6	6.04%
Local government policies enforcement regarding implementing building requirements	7	16	1	3	9	6.04%
Fragmentation of agricultural land ownership	6	1	2	6	8	5.66%
Depreciation of agricultural land value	6	8	9	2	2	4.15%
Flat land nature, free of topographic variations	0	4	5	8	4	0.38%

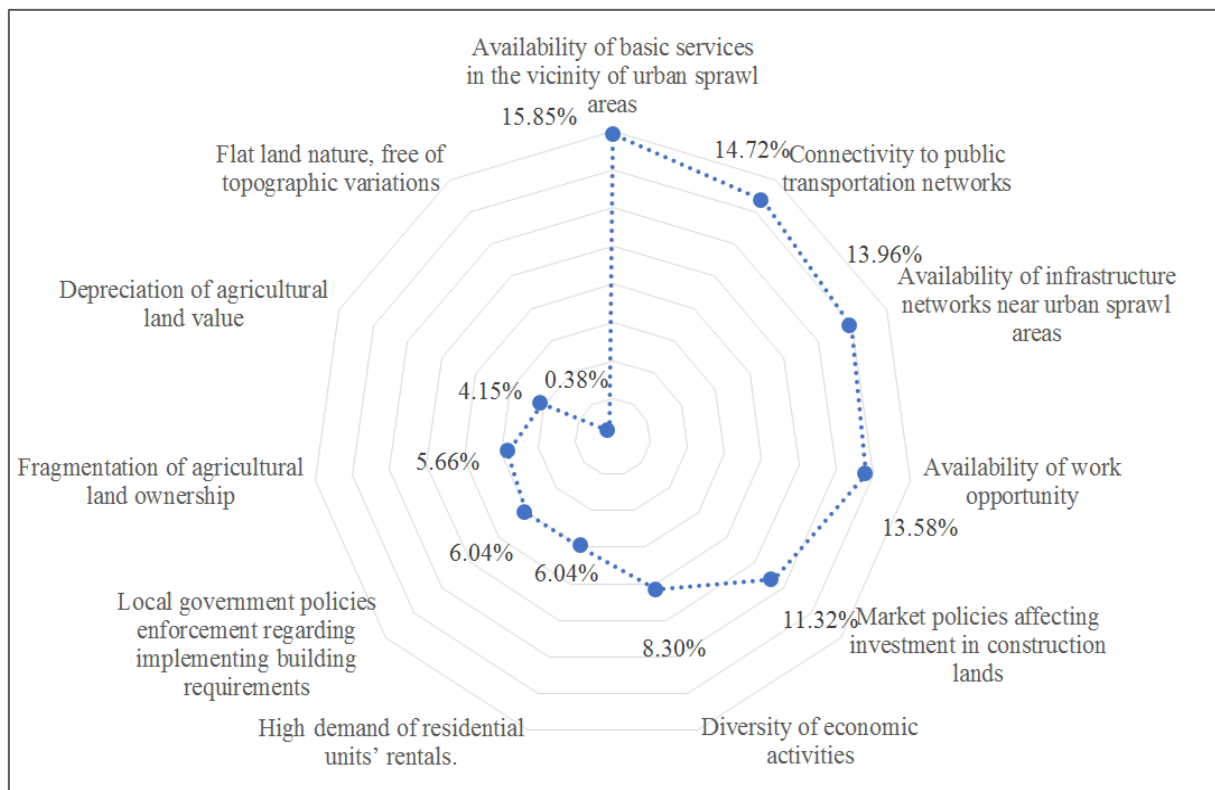


Figure 7. Driving Forces: Impact Ranking

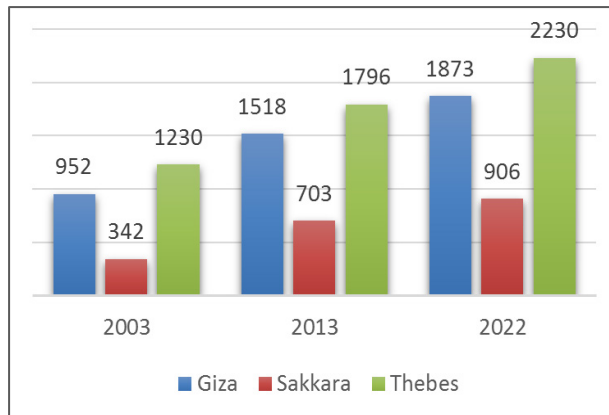


Figure 8. Study areas urban growth from 2003–2022

4. Discussion

4.1. Measuring Urban Growth

The results revealed a significant growth of US (Figure 8,9) in Giza zone in the first period from 2003–2013 by 59.46% and 5.95% annually (Table 7). According to [26], [28]. After the 25 January 2011 Spring's Revolution, US appeared to be accelerating. Consequently, it led to greater instability in the region as people began to build within agricultural lands, which according to law were prohibited. Most US has taken place around major roads and urban centres. Few buildings began as scattered patches along major roads that cut through rural areas. As a result of rapid growth rates, these patches quickly merged into significant build-up areas within a brief period. This result is incompatible with [26] as this research showed 49.8% increase from 2004 to 2013 in whole Giza Governorate. Adding to that, [56], the results showed that the amount of US in the middle section in Giza governorate is 42.5%. While, according to [57] urban growth increased 59.08% in the period from 2005 to 2015 in Nile Delta area, similarly to study area in Giza with an increase in US of 59.46%, this increase is due to high accessibility of roads and availability of agricultural land [58].

The second period from 2013 to 2022 showed decreased growth 3.35% compared to the first period. Following 2011, agricultural land showed massive unplanned growth, forcing the government to modify the regulations [59]. In accordance with Ministerial Decree 1836/2011, a residential building can be constructed on less than 2% of the total land area owned. In Ministerial Decree 615/2016, the 985/2009 rules were reinstated [60]. In 2018, penalties for unauthorized construction were further increased. A fine was required for the formalization of a planned building on agricultural land built before June 2017 under the Reconciliation Law for Informal Buildings (2019); however, under the Law 1/2020, the fee is no longer necessary regardless of the

construction date [61].

Urban growth analysis of Sakkara zone (Figure 5) showed a leap in US from 2003 to 2013 by 105.25% and 10.53% annually (Table 8). As previously mentioned by [57,26,28] and [58]. During the 2011 revolution, there was a tremendous surge in US due to lax law enforcement. Since 2011, Egypt has lost almost 90,000 feddans due to encroachment on agricultural fields, according to the prime minister, who also revealed that the government has recorded 2 million cases of constructions on farmlands since 2011 [62].

As previously mentioned, the government intended to mitigate the loss in agricultural land. Following 2011 revolution, Ministerial Decree 1836/2011 was reinstated in 615/2016 and modified one more time in Law 1/2020 [59]. Therefore, from 2013–2022 urban growth decreased to 28.93% and 3.21% annually due to new law amendments from 2011 to 2020.

Thebes's zone (Figure 6) also had a significant increase in the period from 2003 to 2013 by 45.95% and 4.60% annually

(Table 9). Results are coherent with [63], amount of urban growth in this period was 49.07% in west Luxor due to the same reasons previously mentioned as well. Urban growth from 2013–2022 is 24.17% with an annual increase of 2.69%. The decrease in the amount of growth resulted from the new amendments to the Ministerial Decree 1836/2011 to the final amendment in Law 1/2020 [60,61].

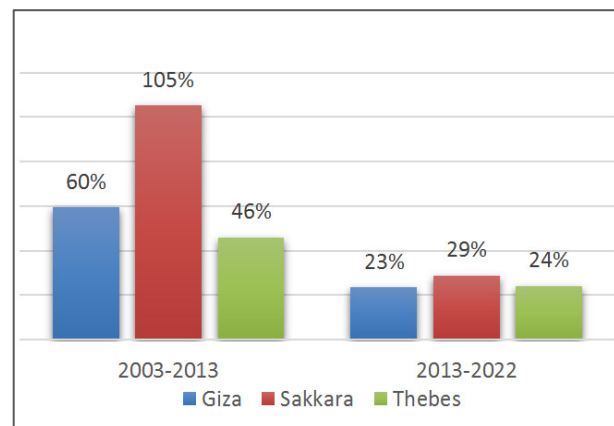


Figure 9. Study areas comparison from 2003–2022

4.2. Driving Forces of Urban Sprawl Based on the Questionnaire Survey

The availability of basic services in the vicinity of US areas has the highest score with 15.85% according to experts in the questionnaire. This result can be clearly associated with the sprawl that surround cultural heritage sites, where most of the housing units are low-cost and not covered by planning regulations. There are a variety of low-cost commercial, entertainment, transportation, and primary services offered in these informal areas that

are cheap alternatives to the formal CBD. Such attributes are congruent with the informal development pattern. For example, Giza's CBD has potential value to high-class residential use that can afford these expensive services. This result is compatible with multiple references such as [56,27,55,64,41].

The second affecting driving force is connectivity to public transportation networks, with 14.72% considered as a primary driving force consistent with those found by previous studies in, [27,65,56,64,28,23]. Despite technological improvements and falling transport costs, businesses and industries have been able to relocate outside city centres and infrastructure hubs. Consequently, they have become a haven for low-income people to live, which contributes to the growth of US. The fact that it is now possible to travel to longer distances within the same time is another driving force.

This result is contradicting only with [31] as this research considered road networks a DF to US to only 3 experts out of 13 experts due to different study area conditions in West Africa, Ghana. The availability of infrastructure networks near US areas is the third driving force with 13.96%. This result is also coherent with the previous literature. As previously mentioned, US patterns in these areas can be related to the low-income population, therefore infrastructure facilities have become an effective means of promoting US [65,56]. Availability of job opportunities gained 13.58% of expert responses, which is the fourth factor, unlike [23], population working in the third sector, which was the second driving factor in Mexico city. Study as this case has a high immigrant population growth rate. According to [41], as there are many commercial and governmental foundations in these areas, therefore, various types of jobs have been created by these foundations, contributing to the increase in population indirectly [55].

According to experts' study sample, market policies affecting investment in construction lands is the fifth driving factor for US with 11.32%, as [66] explained in China, that in this period, urban development has been most significantly affected by the implementation of the national macroscale urban growth control strategy. Urban expansion has led to the displacement of agricultural land. Within the last two decades, rapid urbanization and sprawl have been witnessed due to changes in market policies. Unlike [19], which considered land use policy as the first driving force factor in the study, which can be related to the fact that Ethiopia's US and growth pattern in Bahir Dar is different from the Egyptian US pattern type in the vicinity of cultural heritage sites.

The result of the diversity of economic activities with 8.3% is incompatible with those found by previous studies in [55, 67,68,66,69,70], this is due to the uniqueness of the study type, many of these studies are related to the US driving forces in relation to agricultural land or LULCs change, none of these studies was focusing on the driving forces in the vicinity of cultural heritage sites.

The high demand for residential units' rentals ranking 6.04% is coherent with [26] as this factor according to Egyptian context are "neither available nor reliable". In Egypt, there is a huge lack of reliable socio-economic studies, therefore, these forces are often not highly ranked. Local government policies enforcement regarding implementing building requirements result is 6.04%. this is considered the most important outcome of the study according to [71]. The regulatory framework, political issues and lack of adequate reliable data can be a DF behind the US, but also a factor opposing US. A lot of forces function as driving forces, but in the end it is the public authorities who decide how land development should be governed. Inadequate management may therefore be a key driver of US, whereas planning and political control can play a critical role in preventing or restricting such development.

While, Osman, Divigalpitiya, & Arima, in [55] and [41] stated that, existing centralised administrative structure in Egypt has been formed throughout the second part of the 19th century. The transition from kingdom to republic in the 1950s changes d in the leading members but kept the whole body of Egyptian bureaucratic organization until now. Moreover, shifts in the Egyptian market economy from capitalism to socialism and back again to capitalism throughout the 1970s following Nasser's death didn't bring considerable improvements to this system. Therefore, the land-use and urban planning strategies remained basically the same since the primarily plan for GCMR in 1956 until the final one in 2006. The bureaucratic culture in Egypt has a particular set of pillars, which secured its structure and performance from the late of the 19th century. This system has kept precise defined links among the key authorities of Egypt (Legislative, Executive, Judiciary) concerning urban planning.

Additionally, the fragmentation of agricultural land ownership is the ninth in this study 5.66%, unlike [58] rapid population growth and the inheritance system, which includes fixed portions of agricultural land and leads to consecutive division of the land, generating agricultural land fragmentation. Therefore, in this study, it can be understood that there are multiple factors more significant in driving US towards CHS. The depreciation of agricultural land value is the tenth with 4.15%, unlike previously stated by [72], depreciation of agricultural land is significant in all Egypt, therefore in this case study, there are more affecting driving forces than this one. Unlike flat land nature, free of topographic variations driving force according to experts is flat land nature, according to [38], it is also identified as the last driving force.

This study can be used to determine the most affecting DFs of US in the vicinity of CHS. On the selected three case studies, (Giza, Sakkara, and Thebes), multiple future possible scenarios are possible, including historical growth trends (HGT), officially planned growth (OPG), and selective growth scenarios (SGS) [73]. The HGT

scenario predicts the future forms of sprawl and maintains a permanent context of historic growth patterns, whereas the GPO scenario illustrates the growth patterns along with the sprawl limitation strategies employed in the authoritative development plans. AHP analysis is used to calculate SGS scenarios, from which the researcher can determine many possible scenarios, aiming to achieve the best scenario to protect the CHS in the future.

Providing similar case studies worldwide can benefit from this research, particularly in countries where CHS is a problem, such as Nepal [74], Mexico [23], Cyprus [30], ...etc. In addition to economic problems, rapid urbanization and ineffective policies, these countries face other challenges. It is crucial to the success of urban development strategies that the government of the regional and the local levels work together to develop them, and that these levels of government communicate effectively with stakeholders so they can mitigate these hazards.

5. Conclusion

The most significant result of this research is that unlike the expected, local government policies enforcement regarding implementing building requirements are of low significance with 6.04% as high demand of residential units' rentals. The questionnaire results highlighted the most significant DF is the availability of basic services in the vicinity of US areas as the most affecting driving force of US in the vicinity of cultural heritage site.

Results also revealed a significant growth of US (Figure 7) in Giza zone in the first period from 2003-2013 by 59.46% and 5.95% annually (Table 12) (Table 13). This percentage is higher than the amount of US in the middle section. Increased amount of growth can be related to the high accessibility of the study zone as it is highly connected to major roads, adding to the availability of agricultural land. These two factors contributed significantly to the amount of growth in this period.

The lack of socio-economic data in Egypt is a multidimensional problem affecting preparing reliable development plans, conducting research and it proliferates the local problems significantly; because the proposed addressed solutions do not match the actual local situation. Therefore, the only way to collect socio-economic information in this research was conducting a questionnaire. Researchers should find other sources to collect accurate socio-economic data such as the field survey, which requires bigger budgets to assure more depth and more exposure to local societies.

This study results highlighted the insignificant role of local government policies enforcement regarding implementing building requirements. Regulatory framework, political issues and lack of adequate reliable data can be a DF behind US, but also a factor opposing

US. A lot of forces function as driving forces, but in the end, it is the public authorities who decide how land development should be governed. Inadequate management may therefore be a key driver for US, whereas planning and political control can play a critical role in preventing or restricting such development. The bureaucratic culture in Egypt has a particular set of pillars which maintain its structure and performance since the late 19th century. This system has kept particular defined links among the primary authorities of Egypt (legislative, Executive, Judiciary) regarding urban planning. There are certain steps for growth plans: the national development vision which should be provided by politicians to express their strategy for the future, the executive authorities construct the comprehensive plans to shape the strategic program in physical scientific plans by urban experts.

This study can be used to determine the most affecting DFs of US in the vicinity of CHS. By applying this on the selected three case studies, (Giza, Sakkara and, Thebes), multiple future possible scenarios can be implemented, historical growth trend (HGT), officially planned growth (OPG) and, selective growth scenarios (SGS). This research will affect future urban expansions in Egypt, which can be managed in a similar manner. By using the findings of this study, decision-makers may be able to identify that traditional urban planning plans are not significant anymore, and that a local community-driven approach to planning would be more efficient. In addition, the local authorities must be empowered to enforce the law. In order to ensure the implementation of a government plan, the decision support system needs to be tailored to address the local area needs. The development of spatial indices using the data identified in this study could serve as a practical planning tool that could be utilized in the vicinity of CHS to enforce future growth in urban areas.

The result of this study is significant in similar case studies that suffer from US on CHS worldwide. In order to mitigate the hazards of these problems and achieve successful urban developmental strategies, regional as well as local levels of government have to work together to develop them and for better communication between these levels of government and stakeholders to be effective in contrary to this research outcome which highlighted the insignificant role of local government policies enforcement regarding implementing building requirements in Egypt. This research can be used as a prominent primary management tool that can help to manage future urban expansions in similar cases in Egypt. Adding to that, it is the foundation of many upcoming researches.

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