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Analysis of The Driving Forces of Urban Expansion in Luxor City by Remote Sensing Monitoring

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Abstract: Luxor in Egypt is a city of great historical importance, rich in archaeological sites and natural resources. To ensure sustainable development in Luxor city, it is essential to understand the driving forces of its growth. Both Geographic Information Systems (GIS) and satellite Remote Sensing (RS) were successfully used to evaluate these overall driving forces. This paper is aimed at monitoring the growth dynamics of the urbanization process that occurred in Luxor city during a 20-year period from 1996 to 2017. The archived time series medium resolution Landsat ETM+ and TM satellite imagery are used to study and analyze spatial patterns of urban in order to improve understanding the impact of driving forces of urban expansion in Luxor. The GIS was not only used to identify the driving forces but also to provide an integrated monitoring of the study area. This offered a unique advantage to simultaneously store and manipulate spatial and attribute data of a large amount. A very significant increase in urban area has taken place in the last decade in Luxor city, which was revealed an important outcome. A net increase of 36.7 km^2 was witnessed in the last 20 years (especially in recent years), in the built-up urban area. The built-up urban area in 2017 saw an increase that was twice that in 1996, with an annual average increase of 1.75 km^2, and an annual change rate of 4.6%. The analysis of this dramatic change revealed that city infrastructure, economic growth, population growth, topographic elements, and city planning, and policies were the major driving forces for the rapid expansion of built-up urban area, albeit with different weights for these different forces. In this study, we explored a method of monitoring parameters related to the architectural heritage of Luxor governorate using "remote sensing big data" to provide data support for the city's urban planning and policy formulation.

Keywords: driving forces, urban expansion, urbanization, urban sprawl, remote sensing, Geographic Information system, GIS, Land Use and Land Cover, LULC, Luxor city, Egypt

1. Introduction

The current population of about 3.3 billion in the cities worldwide is expected to grow to 5 billion by 2030 [1]. Densely populated cities are major centers of production, consumption, and waste generation. The process of urbanization is inevitably linked to many worldwide problems related to natural resources and the environment, such as habitat loss, species extinction, land cover change, and alteration of hydrological systems [2]. Macro-guidelines and various strategies have been adopted by many national and regional governments in their attempts to decrease the negative impacts caused by poorly planned urban developments. However, there is considerable uncertainty as to whether these guidelines and strategies are actually effective [3].

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For many centuries, the Nile valley had been a magnet for settlers who carried out agricultural activities on its riverbanks. Today, the populated areas represent only 4% of the country's total area. There has been a dramatic increase in population density in the Nile Delta and valley during the last three decades, reaching 1200 persons/km^2[4]. Such unprecedented growth has resulted in poor provision for agricultural lands, especially in areas outside the formal urban (administrative) boundaries identified in 1985 [5]. The rapid urban sprawl has caused agricultural lands to decrease by 36% or about 1.5 million acres (6300 million m^2) in Egypt [6].

Urbanization and urban sprawl pose a serious challenge to sustainable development and the conservation of heritage sites. Resource utilization, natural resources allocation, infrastructure initiatives and effective urban planning are key concerns[7]. With Luxor being one of the most important heritage cities in the world, there should be more concerted effort to preserve ancient urban city centers and other historical landscapes as recommended by the Washington Charter on the conservation of historic towns and urban areas. The spatial layout and the entire monument environment should hence be given special attention. [8].

Urban sprawl is considered a serious hazard on two levels. Firstly, archeological sites located within the city boundary have to contend with exhaust fumes and air pollution and the construction of infrastructure in the vicinity [9]. Secondly, archeological sites near the boundary of the city face urban sprawl heading towards them; such urban expansion may cause fragmentation and deterioration of the historical landscape [10]. These realities underline why it is such a priority to study historical cities in order investigate the negative impacts of rapidly expanding urbanization [11].

In reference to Valletta Principles [12], the built environment and natural changes are not considered a threat instinctively. With controlled and appropriate management, such a change can be seen as an opportunity for enhancing the quality of architectural and cultural features of historical cities. These principles can provide useful guidance for ensuring a positive relationship between heritage conservation and urban development. Therefore, it is crucial not to delay the monitoring and characterizing of the urban sprawl of historical cities in Egypt such as Luxor.

Both research and heritage management use aerial photographs and other Satellite remote sensing (RS) techniques for the enhancement of archaeological and landscape studies [13]. Land Use and Land Cover (LULC) patterns should be investigated to have an in-depth understanding of the effects of urbanization. These patterns are shaped by the interactions of environmental and socio-economic forces. In this study, therefore, LULC was monitored and characterized, while focusing on the spatiotemporal differences of the driving forces with the objective to develop a comprehensive understanding of the urbanization process in terms of causes and effects along with the negative impacts on archeological sites. Merging the study results with other socioeconomic statistics and historical documents will facilitate policymakers to approach urban planning and heritage preservation with better informed decisions. Accordingly, a sustainable development strategy for the Luxor governorate can be realized.

The Geographic Information System (GIS) is one of the best tools to process a large quantity of data for accurate analysis. The main topics in the application of GIS and RS in urban analysis are as follows; Modeling and monitoring the urban environment, Classification of built-up urban areas, Measuring physical properties of built-up urban areas (vegetation, air quality, etc.), Analyzing the physical characteristics, demographic and socioeconomic patterns of the urban environment, and Monitoring land cover changes and urban growth in an exact period of time [14].

Hence, GIS is considered the most appropriate tool for this study of the processes of urban sprawl of Luxor City in the recent decades. The technique reveals the expansion processes of the built-up area in Luxor by identifying both the influencing factors and driving forces. This paper presents a time series, dynamic monitoring, and analytical study of the processes of urban expansion and urbanization of Luxor City over a 20-year period, from 1996 to 2017, based on multiple-sourced RS data. A meaningful analysis of the spatiotemporal processes and influencing factors in the expansion of built-up urban areas would be beneficial to urban development and planning to narrow or close the gap between city planning needs and the required policies to conserve archeological sites [15].

2. Study Area

Pharaonic monuments are the most important representations of ancient Egypt civilization. From 3000 to 300 B.C. Luxor (Thebes) was the old capital of ancient Egypt, and Karnak and Luxor temples on the east bank are among the most important monuments in Ancient Egypt. They are the records of the Middle Kingdom until the reign of the Ptolemies [16].

Luxor Governorate is located in South Egypt (Fig. 1), adjoining QENA Governorate in the north, ASWAN Governorate in the south, Western desert in the west and Eastern Desert in the east. Luxor Governorate is divided into seven districts, namely Luxor city, El Byadya, El Qorna, El Zanya, El Tod, Armant, and Esna [11]. The total land area of Luxor governorate is 2955.34 km^2 and the total population is 1,200,839 [15]. Owing to its location at the south of Egypt, it is predicted to have a rapid population growth as 48% of urban population is found in this sector [17]. The topography of Luxor Governorate consists of the Nile River in the middle and plains on its banks leading to the hills of the Western and Eastern deserts. The center of Luxor Governorate is Luxor city which contains more than 800 archeological sites. These locations show the long history of the area, and many of them are listed as UNESCO World

Cultural Heritage sites, thus emphasizing the cultural importance of the area. With such an advantage, Luxor governorate continues to grow rapidly, thanks to whole industries related to Egyptian culture and heritage.

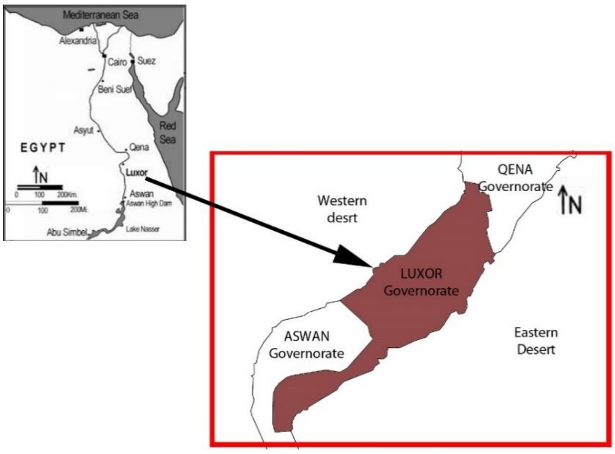


Fig. 1 – Location of Luxor governorate in Egypt.

3. Methods and Data collection

The RS technique is popular among researchers as it enables them to obtain accurate results for urban sprawl and land use land change (LULC) detection [18], [9], [10], [19]. For this study, it is important to obtain quantitative results for urban expansion for comparison with potential driving forces statistics. This numerical comparison would indicate the degree of influence each driving force imposes on urban sprawl.

Multi-temporal RS data were used as the main spatial data source to analyze the urbanization process. Satellite images from 1996, 2007, 2017 (Resolution 30*30 m), and the Digital Elevation Model (DEM) for the study area were obtained from the The U.S. geological survey website [20]. Good quality satellite RS data of the two different temporal phases (1996-2007 and 2007-2017) were used: Thematic Mapper (TM) data acquired on October 15, 1996; Enhanced Thematic Mapper (ETM) data acquired on December 11, 2006; and Thematic Mapper (ETM) data acquired on October 10, 2016. The types and sources of data for the study area are shown in Table 1.

All statistical guides from 1996 to 2017 were obtained from the Luxor governorate information center agency for the analysis of the driving forces of urbanization. The comparison between the data from the statistical guides (economic growth, population growth and City infrastructure construction) and the processed satellite images helped to explain the driving forces of urban expansion in the study area.

Table 1 - Types and sources of data for the study area.

Data	Source of Data
Land Sat Image, November 2017	Landsat Archive, L8 OLI/TIRS, The United States Geological Survey “USGS” (USGS, 2016)
Land Sat Image, November 2007	Landsat Archive, L7 ETM+ SLC (USGS, 2016)
Land Sat Image, December 1996	Landsat Archive, L4-5 TM (USGS, 2016)
Digital Elevation Model	Aster Global DEM (USGS, 2016)
Detailed Land Use Map	Urban Planning Agency, Egypt
Statistical guides from 1996 to 2017	Luxor governorate information center agency

4. Framework of Driving Forces Analysis of Urban Expansion Using RS Monitoring and GIS

The processes and procedures used for conducting the driving forces analysis of urban expansion of Luxor city using RS and GIS are depicted in Fig.2.

4.1 Pre-Treatment of Image Data

To analyze changes in urban expansion, radiation level normalization for multi temporal RS images and geometric calibration were performed. The Luxor city area and its surroundings were the focus of this study. RS data for the selected two different temporal phases (1996-2007 and 2007-2017) were acquired in relation to the scope of this study. Table 2 refers to the reference points which were used to determine the RS images boundary. The administrative boundaries could not be adapted because it did not contain any desert land crucial to urban expansion. Four reference points were selected and fixed in positions that performed a rectangular shape to contain the whole study area and the desert that surrounded it. Coordinate calibration was performed by selecting specific control points in fixed locations near to identifiable features to compare the geographical coordinates with RS images coordinates. Coordinate conversion was performed in GIS and resampling of pixels was carried out at a resolution of 30 m.

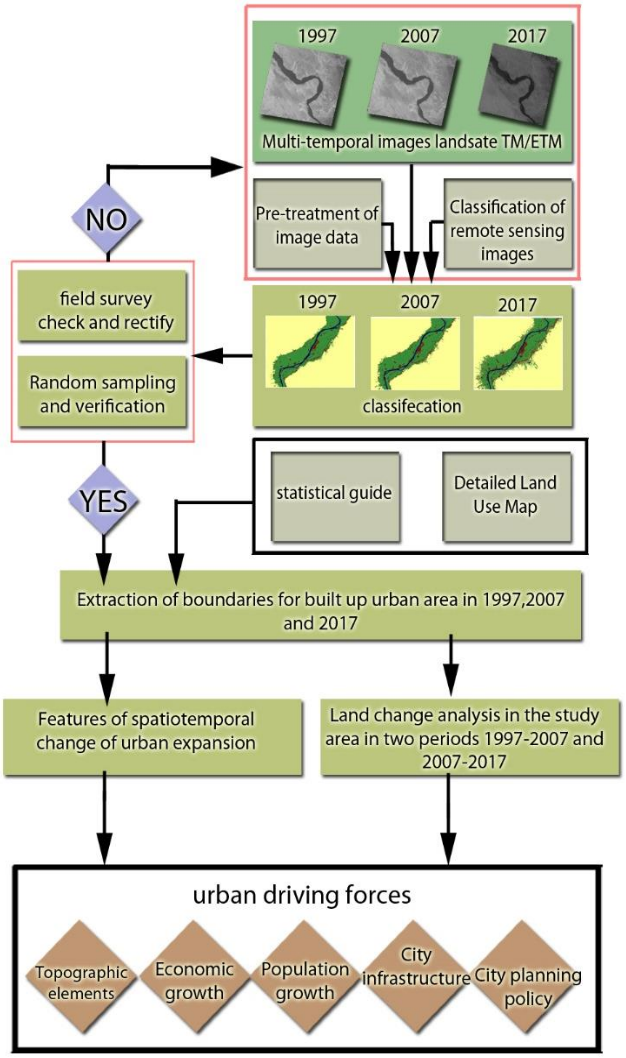


Fig. 2 – Framework of driving forces analysis of urban expansion of Luxor city using RS and GIS.

Table 2 - Reference points of the study area.

min x	439545.0000000
max x	484575.0000000
min y	2821785.0000000
max y	2858025.0000000

4.2 Classification of RS Images

There are several ways to process RS images. In this study, unsupervised classification of the IDRISI SELVA 17.0 software was used to obtain four classes: desert, urban, vegetation, and water bodies. In this context, "urban" refers to built-environment, such as residential blocks, public utilities, public buildings and other special facilities. Using the IDRISI SELVA 17.0 software, the CHIAN CLUSTER Classification module was performed for the processing of three RS images, and the diagram for classified multi-temporal RS images was created as shown in Fig. 3.

As it is very important to ensure the accuracy of classification[18], an accuracy test was conducted to compare image classifications with the actual situation. To assess the results, a file of one hundred-point locations was selected according to a random sampling scheme. The vector file was then exported to the GOOGLE EARTH PRO software to compare each point class to the real situation. The accuracy of the system classification compared to the real LULC was 89% for the 1996 data, 94% for the 2006 data, and 91% for the 2016 data.

4.3 Built-Up Urban Area Boundaries Specification

Urbanization level refers to the city development level. Major developments, especially economic and social development, need land for growth. Hence, urban expansion could be considered an indication of the growth and development of the city. The downtown and its suburbs represent the built-up urban area, i.e. the scattered urban blocks all around the downtown and suburban areas. The built-up areas in different temporal phases could be considered an archive for the scale and the dimension of urban development [21]. We examined and compared the built-up urban areas in different temporal phases and extracted the development process phases. As a result, two main classes were created to allow for the binary process, *viz.* the first class refers to urban land and the second class, non-urban land, that included water bodies, desert and agriculture land. Fig.4 illustrates the binary process which was carried out for the reclassified RS images.

The false-color RS images were digitized to create a manual visual version. Next, the boundaries of built-up urban areas were extracted for 1996, 2007 and 2017. In this study, we were not only interested in urban sprawl but also the urban expansion process. Hence the water bodies and vegetation inside the built-up urban area were not taken into account when calculating urban expansion boundaries[22]. For the clarification of the built-up urban area expansion process, binary reclassified RS images of the three temporal periods were superimposed on each other. This superimposing analysis enabled us to identify the qualitative and quantitative growth process of urban expansion, and to visualize the scale and dimensions of that growth, as shown in Fig. 5.

5. Urban Expansion Analysis

5.1 Analysis of Urban Expansion Rate

To show the dynamic characteristics of urban expansion of Luxor, we used the urban expansion intensity index [19]. The rate of urban expansion and the dynamic change of the spatial structure of a city differ in a temporal range. As the dynamism of land use class shows change in the quantity of a certain land use class in a unit of time, it is a key index for evaluating spatial change of urban expansion. By analyzing the dynamism of urban expansion, the quantitative comparison can be conducted according to the following formula:

$$LUDI = \frac{Ua - Ub}{Ua} \times \frac{1}{T} \times 100\% \qquad (1)$$

where *Ua* and *Ub* indicate areas of a certain land use class at time a and time b respectively. *T* indicates the duration from time *a* to time *b*. *T* is a unit of year. Land use density index is the annual change rate of a land in a specific class. In this study, the formula was used for the urban class of the reclassified binary RS images in Fig. 4. Table 3 shows the built-up urban area in Luxor city in the three different periods by digitizing the RS images. Finally, the change in built-up urban area was clarified by using the formula for urban expansion in Luxor City for 1996–2017 (Table 4).

Tables 3 and 4 show that the built-up urban area of Luxor City had increased dramatically. The total built-up area of Luxor City was about 37.7km^2 in 1996, and it increased to 74.4 km^2 in 2017, thus showing that the built-up urban area had doubled. A rapid urbanization of annual average expansion 1.7 km^2 resulted in a net increase of 36.7 km^2 during 21-years period (1996 – 2017) showed an annual change rate of 4.6%.

Table 3 - Three different periods of the built-up area in Luxor City.

Year	1996	2007	2017
Area in km^2	37.7	47.7	74.4
Area in acres	9336.4	11790.6	18390.9

Table 4 - Urban expansion in terms of area, rate and change rate of Luxor City in two different periods.

Item	1996-2007	2007-2017
Expansion area (km^2)	10.0	26.7
Expansion percentage (%)	26.5	55.9
Expansion rate (km^2 a^{-1})	2.6	5.6
Annual change rate (%)	2.4	5.6

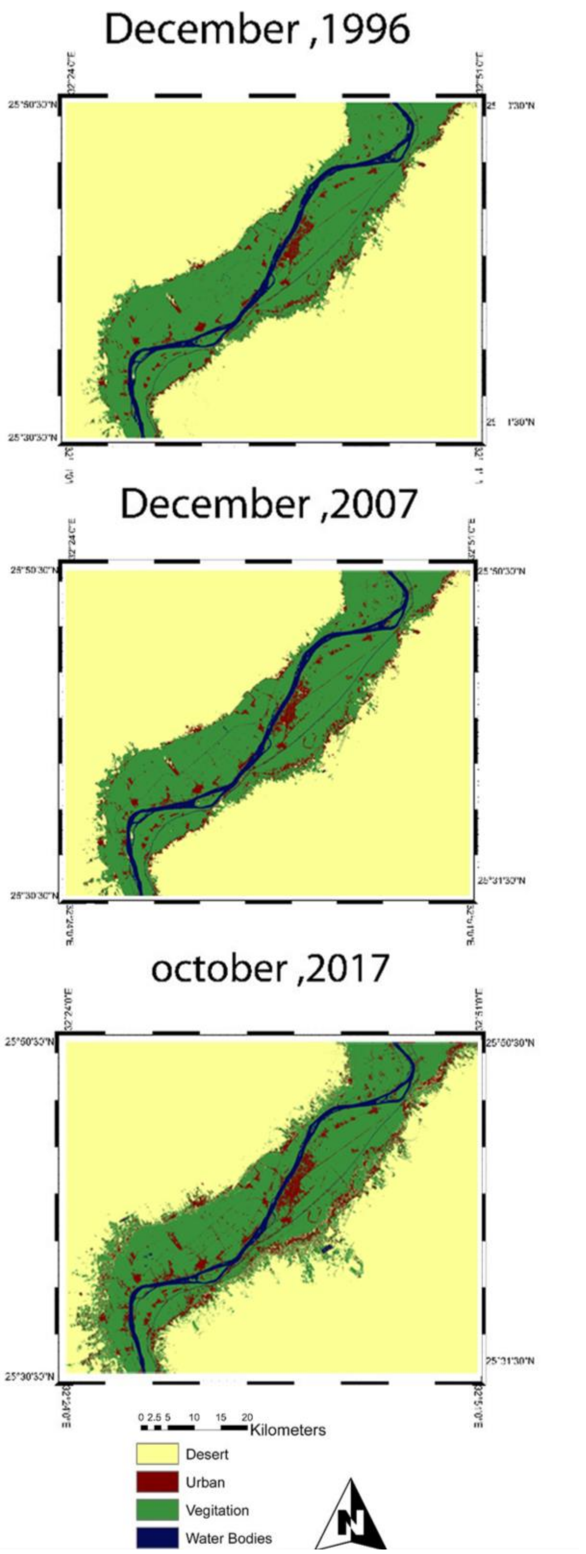


Fig. 3 - Diagram for the classified multi-temporal RS images of Luxor City, Egypt.

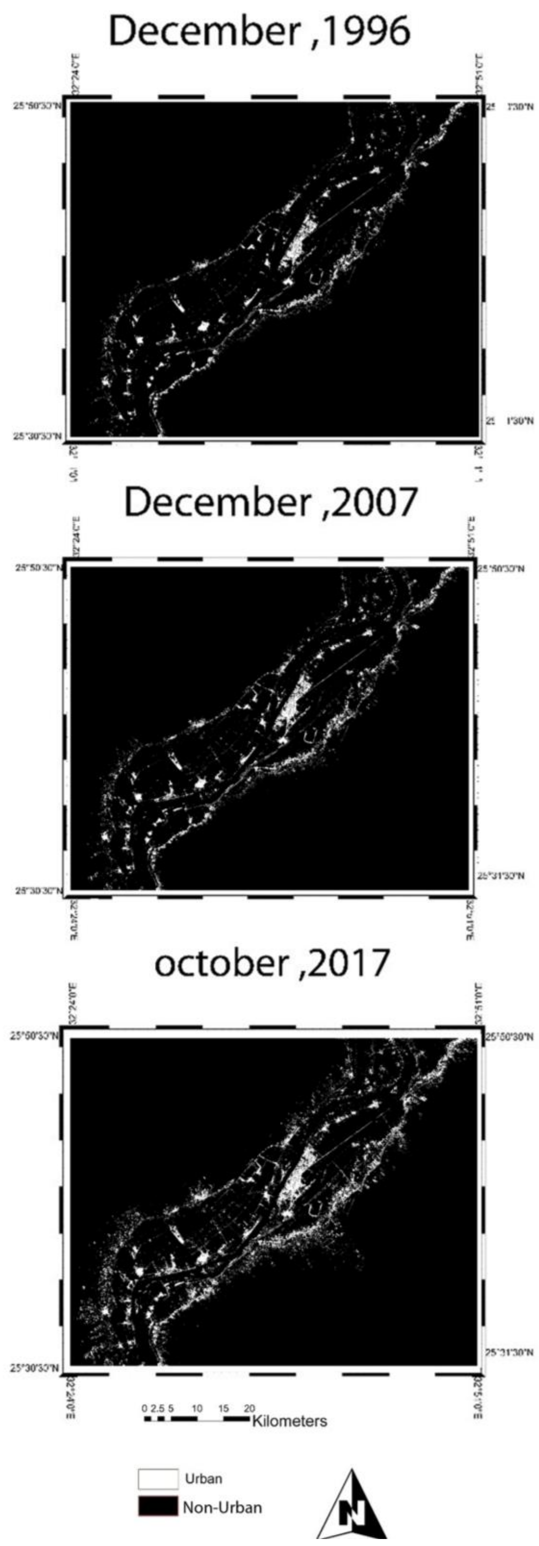


Fig. 4 - Binary images of both urban and non-urban lands in Luxor City, Egypt.

5.2 Urban Expansion Spatiotemporal Change Features

There are many methods of detecting change of urban expansion using satellite images[23]. Urban expansion statistics is insufficient to understand the urbanization process in Luxor city in the last 20 years. There is a need for a spatiotemporal analysis so that we can extract reasons for the slow urbanization of Luxor before 2006 and the accelerated rate of urbanization in the years that followed, resulting in an urban sprawl, especially towards the east. The built-up area expansion of Luxor city can be summarized as follows:

From 1996 to 2007, the built-up urban area of Luxor city expanded by 10 km^2, at an annual average rate of 2.4 km^2. The areas of urban built-up were scattered all around the case study area, making it very difficult to detect the area with the most increase. Spatial urban expansion in Luxor city during this period proceeded layer by layer because of the absence of development policy and the slow economic growth. The most noticeable urban expansion was on former agricultural land.

From 2007 to 2017, the built-up urban area of Luxor city expanded by 26.7 km^2, at an annual average rate of 5.6 km^2. The major expansion was in a radiating pattern, especially eastwards in the direction of the new city of Teba, El Zanqta and Khozam zones, and northward in the Armant District. The rest of the expansion was scattered all around the case study area. The spatial urban expansion in Luxor city in this period proceeded by the layer by layer pattern in some areas and assumed the axial form in total towards the desert. Essentially, the government had directed the growth towards the desert area. Unfortunately, because of the absence of scientific studies of urbanization in Luxor, reclamation development continued to take place in the surrounding urban and suburban land, thus allowing the urban sprawl to inevitably encroach onto agricultural land.

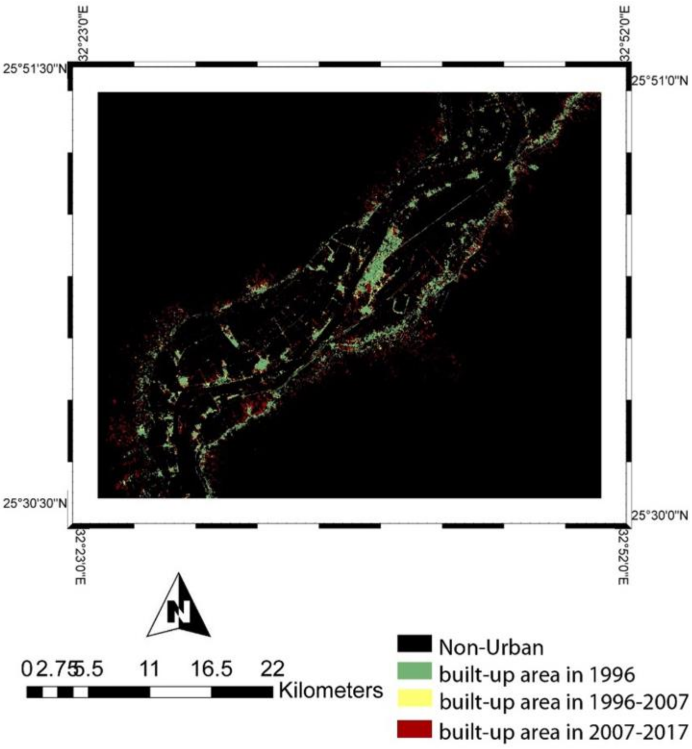


Fig. 5 - Expansion of the built-up urban area is presented in a Binary image of Luxor City, Egypt (1996-2017).

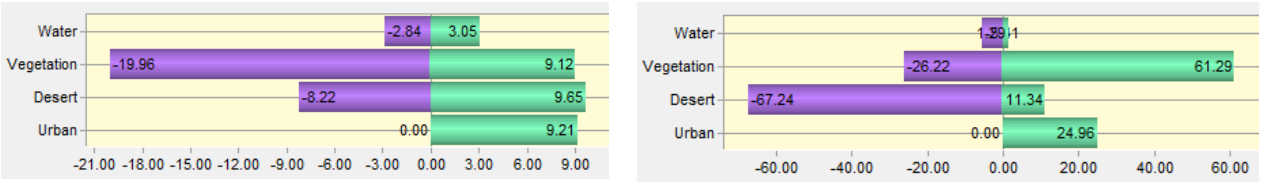
5.3 Land Use and Land Cover Change Analysis

It is important to study the land use and land cover changes for the study area during this period in order to understand the behavior of the urban expansion and its effects on the surrounding environment [18]. Land Use and Land Cover (LULC) patterns are crucial for the evaluation of the gain and loss for each classification class. In this study, the LULC categories included four classes, namely urban areas, deserts, water, and vegetation. The model in Fig.6 shows the gain and loss for each class during two periods.

From 1996 to 2006, desertification was a matter of concern as desert gained more areas more than the other classes. The vegetation class lost huge areas to desertification and urbanization. The change in the area of the water class was often because of the change in water level from one year to another. From 2006 to 2016, there was considerable change in the areas lost or gained for the same classes due to the government's new policies. Desert reclamation works, and vegetation saw a rapid increase, with urbanization doubling the size of the built-up area. Fig. 7 shows the main contributors to net change in the urban areas.

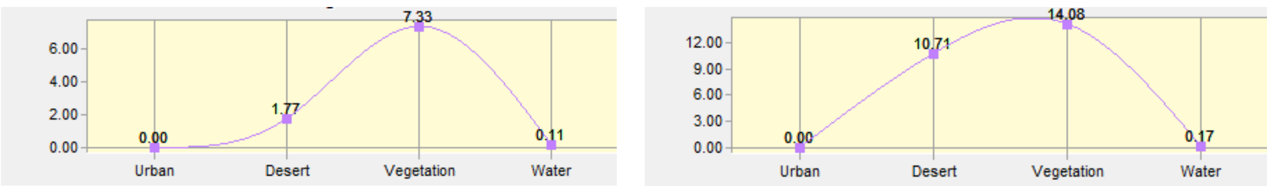
Despite new policies put in place by the government to control urban sprawl and to limit its encroachment onto agricultural land, we found that the vegetation class accounted for the largest net change in the last 25 years. This was because the agricultural land surrounded the urban areas as shown in Fig. 3, making it easier for it to be encroached upon. However, from 2006 to 2016, new towns sprang up in the desert, e.g. Teba town. These new towns helped to absorb the population from the valley.

Fig. 8 shows the percentage gain and loss for each LULC class. Comparing the first period to the second, we can see that urban expansion and vegetation saw big changes in terms of gain and loss. Urban areas made the highest gains, reflecting the need of the city to expand. The gain by Vegetation was twice thus reflecting the success of rapid desert reclamation.



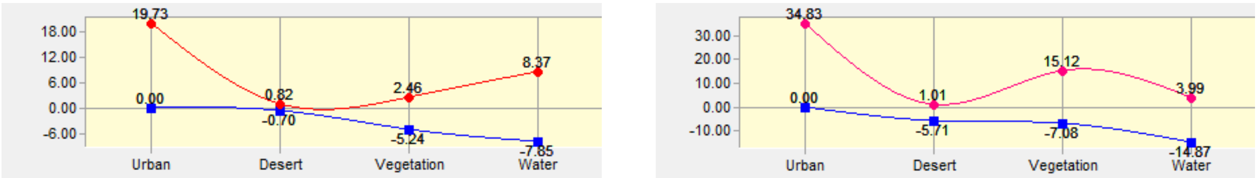
a) b)

Fig.6 - Gains and losses in each classification class in the two periods a) from1996 to 2006, and b) from 2006 to 2016 (km^2).



a) b)

Fig.7 - Contributions to net change in urban areas by LULC classes a) from1996 to 2006, and b) from 2006 to 2017 (km^2).



a) b)

Fig. 8 - Gains (red) and losses (blue) in each LULC class in the two periods a) from1996 to 2006, and b) from 2006 to 2017 (Percentage %).

6. Analysis of the Driving Forces of Urban Expansion

At the level of the regional landscape, there are many environmental variables that lead to landscape changes. Human and natural factors have a considerable influence on these variables. Urban driving forces form a complicated system of actions, interactions, consequences and feedback loops, causing spatiotemporal alterations. It must be acknowledged that it is difficult to analyze, represent and predict them effectively [24]. Nevertheless, in this study, we compared the urban sprawl with each possible driving force to examine its impact.

6.1 Topography

The topographic environment has a great effect on Luxor city urban structure. Luxor city is located on the banks of the Nile River and around an irrigation system. The land on the west bank is almost flat and thus attracted considerable development. The desert offered cheap land and the sandy soil made it easy to build infrastructure and roads. On the other bank, there is a nearby chain of mountains which makes it unconducive to development. This region has difficulty constructing infrastructure and roads because of the high cost of building on the hard and rocky soil.

6.2 Economic Growth

Economic development is one of the most important driving forces because there is no development without financial fundamentals [25]. Economic development fluctuates from time to time and is easily affected by many factors such as political situation and natural disasters. Tourism and other kinds of development have helped Luxor enjoy a rapid increase in economic development, especially after 2006 when the government declared Luxor an open museum. Because tourism is a very important industry in Luxor [26], the city grew rapidly .

6.3 Population Growth

Population growth in urban areas increases the demand for residential blocks, commercial blocks, economic clusters, roads and public facilities, thus resulting in urban expansion. Luxor governorate has a reasonable rate of population growth, but with a high rate of migration from rural areas to the city, the demand for built up areas is increasing.

Luxor Governorate contains seven districts, Luxor city, El Bayadia, El Qornah, El Zanya, El Tod, Armant and Esna as shown in Fig. 9 [11]. Luxor governorate population of each district and the total is shown in Table 5. The population of Luxor was 657.3 thousand in 1996, 888.6 thousand in 2005 and 1.2 million in 2017 [28], reflecting an increase factor of 3.5 on average. By comparing the relationship between the population numbers and the built-up urban area, as shown in Fig. 10, the influence of population growth on urban land expansion in the city is clear.

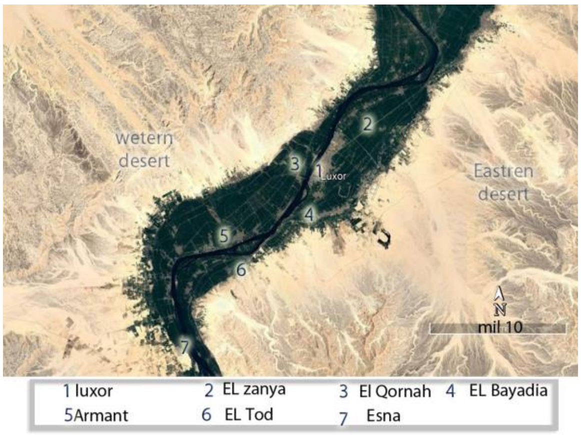


Fig. 9 - Luxor satellite image [27].

Table 5 - Population in Luxor governorate (thousands)[28].

Name	1996	2006	2016
Luxor city	123.4	160.6	210.9
El Byadya	34.1	46.4	65.9
El Qorna	79.7	105.9	144.7
El Zanya	38.9	53.4	67.3
El Tod	55.7	76.4	105.5
Armant	95.3	130.8	170.7
Esna	230.2	315.1	435.5
Total	657.3	888.6	1200.5

6.4 Traffic Infrastructure

Roads have a great influence on determining the pattern of urban expansion [25] as the built-up urban area geometry is mainly shaped by them. As urban development requires transport facilities, total road length becomes an important index of urban expansion. Two main regional roads pass through Luxor governorate, both running parallel to the Nile River, with one on the east bank and the other on the west bank. Owing to the mountains on the west bank, the regional road ends in Armant region and continues again from El Qorna region. Luxor governorate had 1140 km in total road length in 2007, and 2145 km in 2017 [28]. The relationship between total road length and the built-up urban area is shown in Fig. 11. The increase in roads in tandem with urban expansion suggests that the former has a role in the latter.

6.5 City Planning and Policy

Government policies have a vital role in guiding the development process by controlling urban expansion and supporting it with the provision of urban facilities and infrastructure construction. The government also needs to implement policies to avoid uncontrolled urban expansion [29]. In the 1980s, clear developmental policy was lacking because of the low population. However, in the 1990s Luxor government saw the need for effective policies and guidelines to monitor urban expansion. There was great concern about conserving agricultural lands from the desertification phenomenon. While such developmental policies were deemed beneficial, a drastic change of policies in 2006 was brought about by the political situation. A set of new policies were adopted with the main objectives of converting Luxor city to an open museum, guiding the urban sprawl towards the desert, and increasing agricultural lands. Those policies were the key driving force of urban expansion and the development process in Luxor. New towns were developed especially in the flat desert areas in the east, around ancient cities such as Thebas and El Tod.

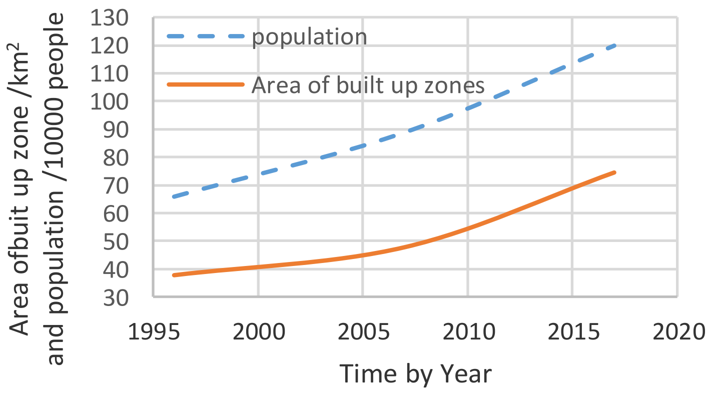


Fig.10 - Relationship between population and built-up urban area in Luxor city from 1996 to 2017.

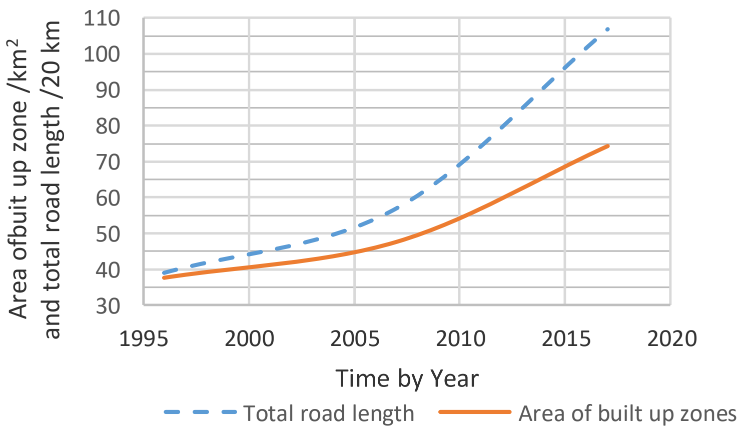


Fig. 11 - Relationship between total road length and built-up urban area for Luxor city from 1996 to 2017.

7. Discussion

The Egyptian government is trying to implement an efficient development policy on a macro-scale level. There are many challenges ahead because most of the Egyptian cities are old settlements with a complicated urban context. As such, policies for urban development have to take into consideration the need to conserve heritage urban areas. The Driving Forces Analysis (DFA) concept is a very helpful method to understand the whole urban expansion process. It has been used in many countries which seek rapid socio-economic development [30]. DFA integrates the spatiotemporal analysis with statistical data to easily identify urban expansion scale and dimensions. This method shows clearly the effects of development policies. Landsat TM and ETM images are enough data resources for spatiotemporal analysis. Such data are easy to use and easily validated, and their outcomes can be compared with other data sourced from elsewhere. This 40-year free data archive provides researchers in the scientific community with programs and simulation models over wide areas [31]. This study is an example of an RS application and shows the effectiveness and accuracy of this method.

8. Conclusions

The effect of urban growth on heritage cities is a complicated issue requiring urgent resolution. These cities have changed over the years at an alarming rate. If decision-makers view these changes from the perspective of urban development, they can control them and transform them into opportunities to conserve the heritage cities. The first step towards regulating future urban growth is to monitor and characterize previous land use and land cover changes, focusing on the spatiotemporal differences and analyzing the driving forces that push them.

Because of the urban driving forces, the built-up urban area in Luxor city has expanded rapidly, reaching 36.7 km^2 net increase in the 21 years period from 1996 to 2017. This means that the built-up urban areas in 2017 had doubled compared to 1996. The annual average increase was 1.75 km^2 and the annual change rate was 4.6%. indicating rapid urban growth. This growth took the form of an axial pattern proceeding towards the desert owing to the government's new cities policy that favored development in the desert areas. The urban sprawl towards the east is very considerable because of its topography.

Population growth is the most dynamic driving force of built-up urban area expansion. City planning policies can, to a large extent, control the degree of urban expansion by orienting the infrastructure and developmental process towards the east, while topography and natural geographic environment constrain, to a certain degree, the spatial development in the western part of the city. Despite governmental effort, it is difficult to prevent rural-urban migration from exacerbating the urban sprawl. When people move to the city in search of better jobs and living conditions [32], the problems of urban sprawl are more serious than those in the districts as it is difficult to control the rate and orientation of urbanization.

The use of multi-temporal RS images is an efficient and functional approach to dynamic monitoring in terms of expansion, area, rate, and orientation. This technique provides scientific criteria for decision-makers to formulate a suitable and effective development planning policies. The problem of desertification should also be looked into as and its consequences have destroyed about 10 km^2 of agricultural land. At the same time, agricultural land has lost about 14 km^2 to urban expansion.

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