# Using Remote Sensing and GIS Techniques for Quick Estimation of the Population Growth in Khartoum State

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## Abstract

*Satellite imagery acquired by IKONOS imaging system in 2003 and the analog map of the study area at scale 1:25000 (1984) have been used to estimate the population growth taken place in Halfaya Town. Remote sensing, digital image processing and GIS techniques were used to achieve the objectives of this study. Different procedures such as, image restoration, image enhancement, topology, spatial analysis and overlay have been applied to model the urban growth in the study area between the year 1984 and the year 2003 .Based on the developed GIS model of the study area the estimated population growth rate was found to be 233%. The study proved that integrated remote sensing and GIS techniques have great impact on detecting environmental changes and man-made features variations through time.*

## ملخص

*ان صور الاقمار الاصطناعية الماخوذة في عام 2003م بنظام IKONOS عالية الدقة علاوة على الخريطة الطبوغرافية بمقياس 1:25000 لمنطقة مدينة حلفاية الملوك لشمال ولاية الخرطوم قد استخدمت لغرض عمل احصاء سكاني للمدينة. وقد استخدمت التقنيات اللازمة لتكامل نظام الاستشعار عن بعد ونظام المعلومات الجغرافي ( GIS) في بناء نموذج (GIS) مكننا من الحصول على نتائج ايجابية في امكانية عمل احصاء سكاني لاي منطقة الامر الذي وفر الدقة والسرعة وكذلك الامكانيات المادية المطلوبة لعمليات الاحصاء السكاني في السودان.*

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## 1. The Study Area

The rural region of Khartoum North was selected as a test area for the present experiment. The study area lies between latitudes 15° 41′ 00″, 15°45′00″N and longitudes 32° 30′ 00″, 32° 34′00″ E. It is one of the regions witnesses a rapid changes and development. Until 1984 the area was covered with few human activities and different types of land cover such as water bodies (the River Nile), vegetations, cultivated areas, drainage and other natural features.

## 2. Procedure, Results and Analysis

a) An analog line map at scale 1:25000 (Figure 1) produced by the Topographic and Aerial Photography Administration (1984) as well as the spectral bands of the IKONOS system2003, (Figure 2), covering the study area, were used as the primary data for this test. The analog map was digitized and transformed to UTM grid (Adindan-Sudan datum) based on well-distributed control points. ILWIS and ERDAS programs were used to transform the IKONOS data coordinate system to a UTM coordinate system based on control points derived from the analog map grid Figure3. RMS error of $\pm$0.02 m and a maximum contribution error for GCPs of $\pm$ 1.431m were achieved.

b) The line analog map of the study area was scanned as a raster image, which has been attached to AutoCAD environment. Nine layers define the land-use features in the study area were created and exported as a DXF file Figure 4. As a result of this process secondary data was imported and managed within a GIS environment (Arc/Info) where a corresponding coverage for each layer has been created. Topology was constructed and attributes for all coverage were added as database items.

c) Remotely sensed data, acquired by the Landsat-7 and Spot4 imaging systems, have been subjected to digital enhancement techniques; all spectral bands have been linearly stretched to remove useless information. Figure 5 shows the enhanced

spectral bands of the Landsat-7 system, while Figure 6 shows the same process applied to the Spot 4 data (bands) covering the study area.

d) False Color Composites (FCC) were produced based on bands 1, 2 and 3 of IKONOS system as well as bands 1, 2 and 3 of the Spot system. A re-sampling process was applied to the Landsat data based on the sampling rate of the IKONOS system. As a result a FCC was generated. This FCC was used, as a raster-map, for extracting land use features.
Different land use and thematic information have been extracted by on screen digitizing based on the FCC of the study area.

e) The digitized data were exported as GIS coverage where topology was again constructed for all coverage. The same data management and geometric correction process carried out on the previous session were again applied to all coverage generated from the remotely sensed data.

f) Overlay processes were carried out to estimate the urban growth during the period from 1984 to 2003 (Table 1). Figure 7 shows the urban area in 1984, while Figure 8 shows the same phenomena in 2003. Figure 9 shows the urban growth taken place in the study area during the period 1984 - 2003.

g) As it has been discussed before, many Sudanese towns meet a rapid natural increase and rural urban migration, which has resulted in annual growth rates of up to %10. This means that population census may well give false indications of the real situation almost as soon as it has been completed. Perhaps %20 - %30 of towns' population may be living in new urban areas not represented in the population statistics. City planners and administrators need some basic information on population housing and living standards. Such new urban areas are often over looked by planners, and because of the difficulties of obtaining reliable information, provisioning of basic needs (i.e., water, roads, schools, electricity, health clinics, markets, etc.) can be very difficult and slow without providing the required up-to-date figures on population. The problem of these new urban areas will continue to grow.

It is clear that a quick solution of estimating population in Halfaya town enable local planners to keep on top of the town's rapid and haphazard growth.

Using the developed GIS model from remotely sensed data in this research study, I suggest the use of a methodology that seeks to estimate population in Halfaya town (Figure 10) within tolerable limits of accuracy. This is clarified as follows:

- The mathematical model used in the estimation of the population of Halfaya town is as follows:

  $P = H \times S \times I$ , $H = A/a$
  P = is the total population
  A = is the total residential area of Halfaya town obtained from the query of the GIS model in $m^2$.
  a = Average area of one house in Halfaya town = 500 $m^2$.
  H = Total number of houses in Halfaya town
  S = Average number of stories in Halfaya town = 1.
  I = Average number of inhabitants = 5 persons.

- The computations and results are as follows:
  $P = H \times S \times I$
  $P = (2339886.18 / 500) \times 1 \times 5 = 23400$ persons

- The 1993 population census in Sudan was carried out by direct enumeration by the Central Buerue of statistics of Sudan's Government. The total population derived from that census for Halfaya town was 24500 persons.

- Comparing this figure with the result obtained from the GIS model, the error obtained is equal to: 1100 / 24500 approx. equals %5

## 3. Conclusion

1. The study area, as tested, wittiness a great amount of change in urban area, where the area increased from 2.432

$Km^2$ in 1984, to 5.681 $Km^2$ in 2003, equivalent to a population growth of 233%.

2. The study showed that it is indeed possible to derive population data from remote sensing and GIS techniques. Such data are suitable for use by many administrators, planners, and population scientists. The method is easy to execute and relatively cheap compared to traditional ground methods.
3. It can be concluded that, remote sensing and GIS integration is a powerful tool for quick estimation of the population and urban growth.

## 4. References

[1] Lilles and Kiefer Third Edition 1994: Remote Sensing and Image Interpretation

[2] Ray Harris 1987: Satellite Remote Sensing.

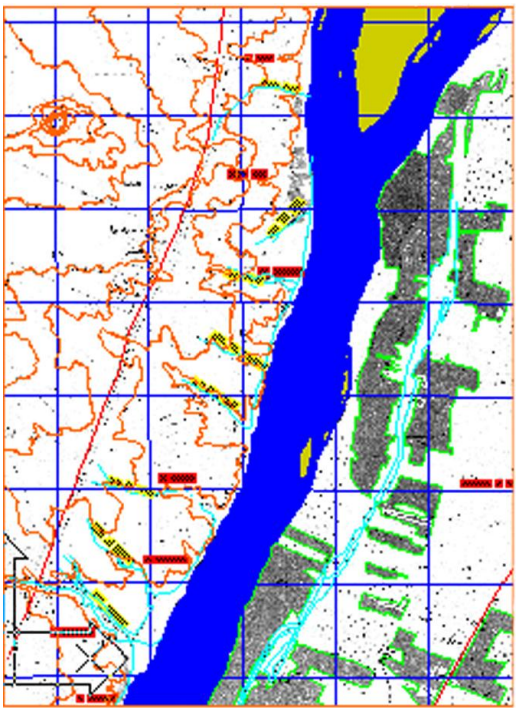
[3] Jacobsen K. 2002. Mapping with IKONOS Images 2002.

[4] Wolf P.R. $6^{th}$. Principles of Surveying Edition 1997.

[5] Carter –1996: Fundamentals of Geographical Information System (GIS).

[6] Gerlach, F., 2000 Characteristics of Space Imaging One – Meter Resolution Satellite Imagery Products.

[7] Abdalla Elsadig Ali 1988: Population Estimation from Aerial Photographs.



**Figure(1) Analog Line Map of the Study Area**

**Figure (2) IKONOS imaging system data (2003) - Bands RGB (1, 2, 3) for the Study Area**

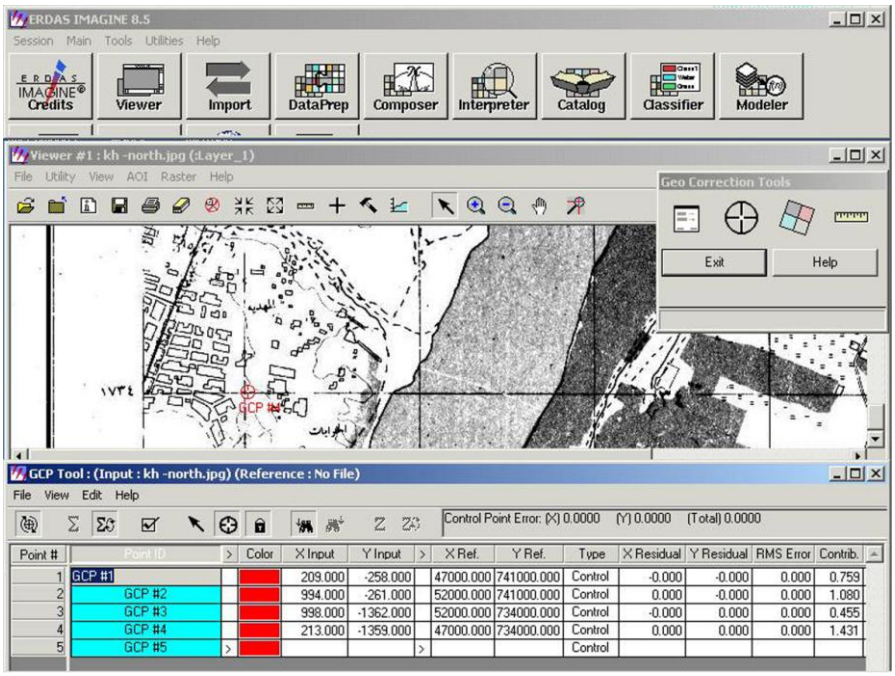



**Figure (3) The Projection Process of the Map of the Study Area using ERDAS software package.**

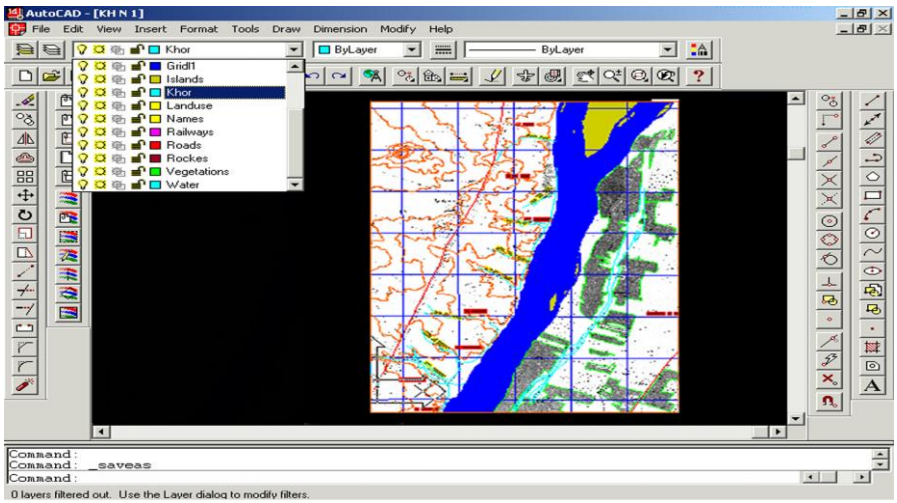
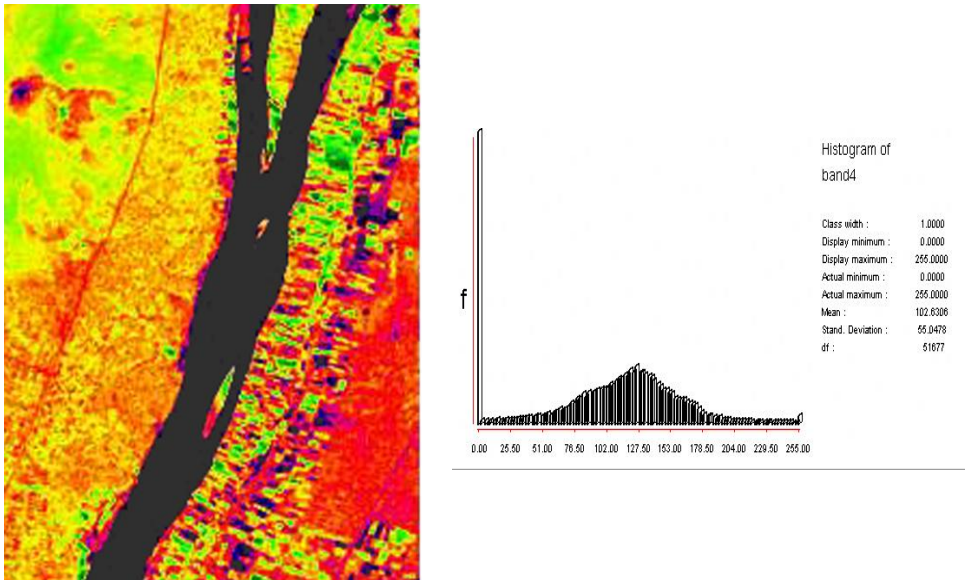
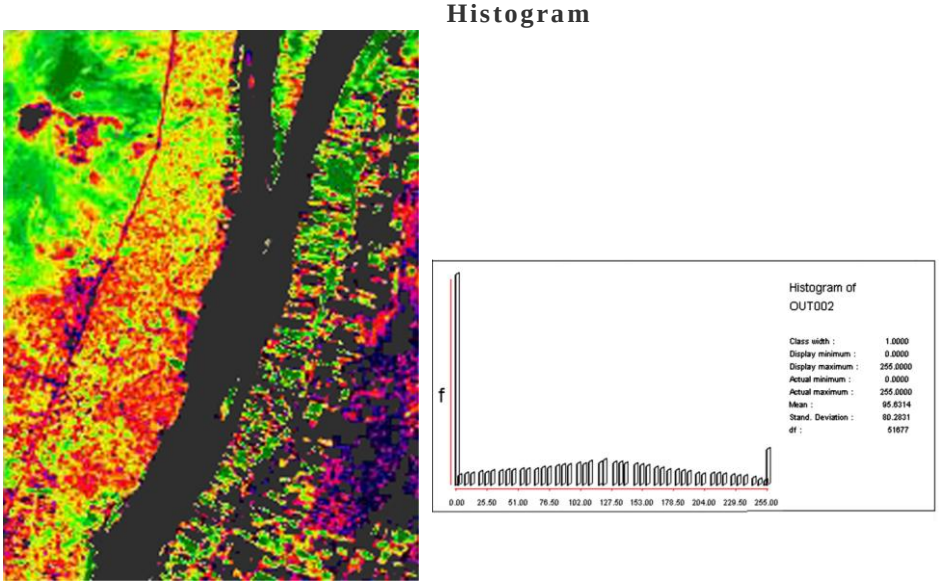



**Figure (4) Different layers of The Study Area**

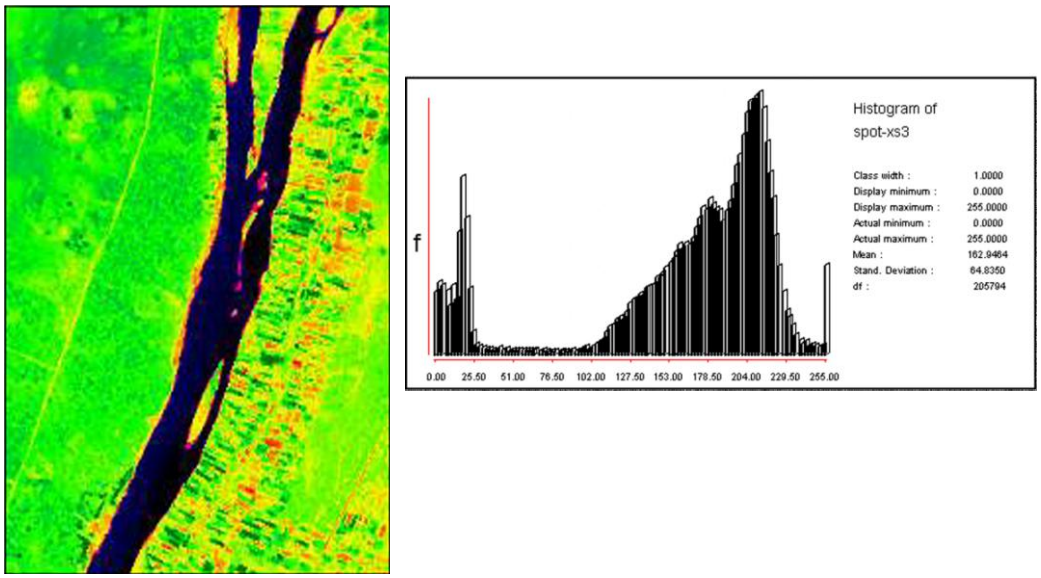



**a) LanSat-7 Band 4 Before Digital Image Enhancement With its Histogram**

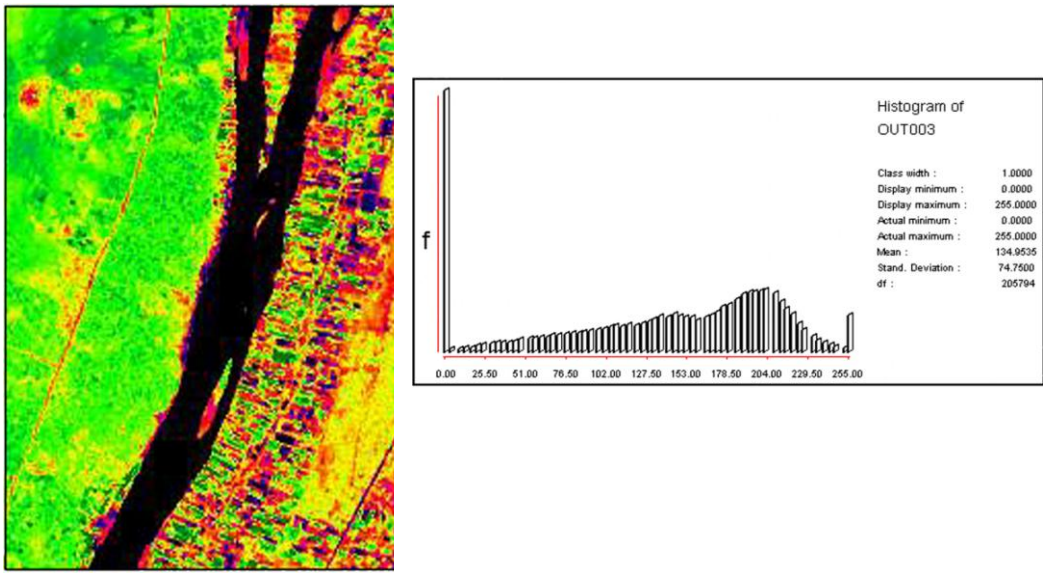



**b) LanSat-7 Band 4 After Digital Image Enhancements With its Histogram.**

**Figure (5): The Enhancement Process of the Landsat Data (band 4) of the Study Area.**




**a) Spot-4 Band XS-3 Before Digital Image Enhancement With its Histogram.**




**b) Spot-4 Band XS-3 After Digital Image Enhancement With its Histogram.**

**Figure 6: The Enhancement Process of Spot-4 data (XS-3) of the Study Area.**

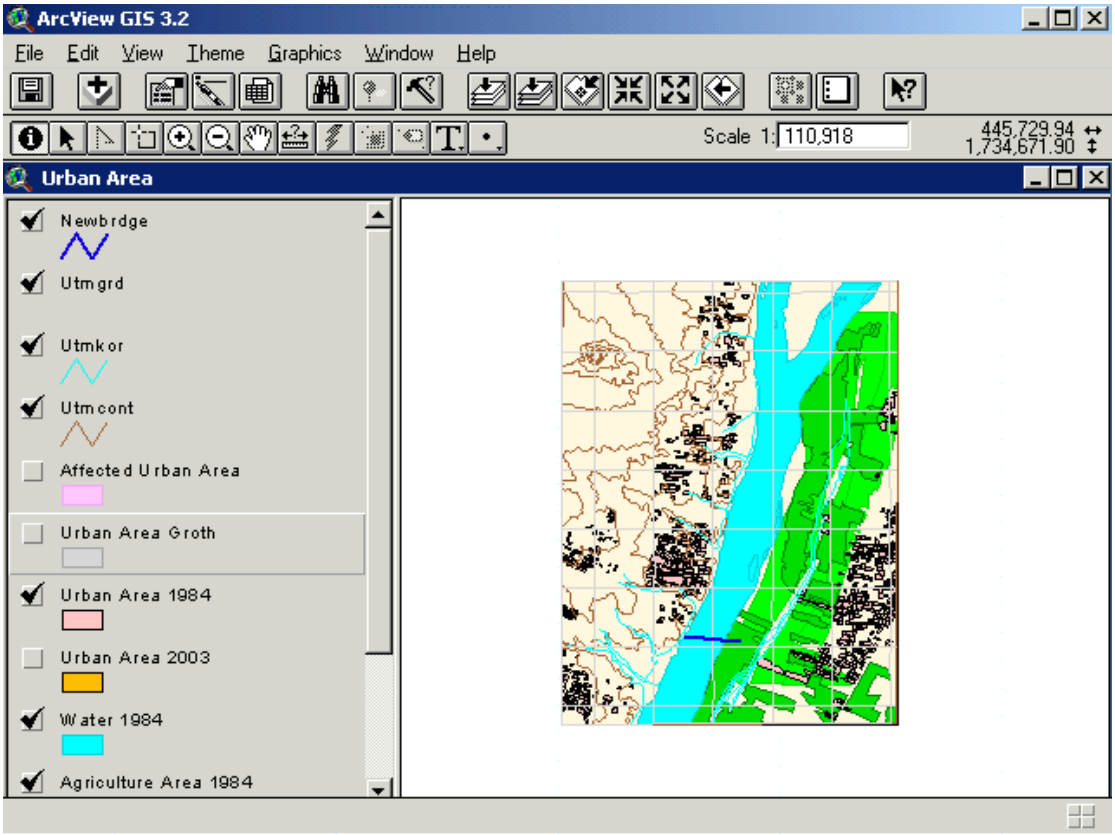



**Figure (7): Urban Area 1984**

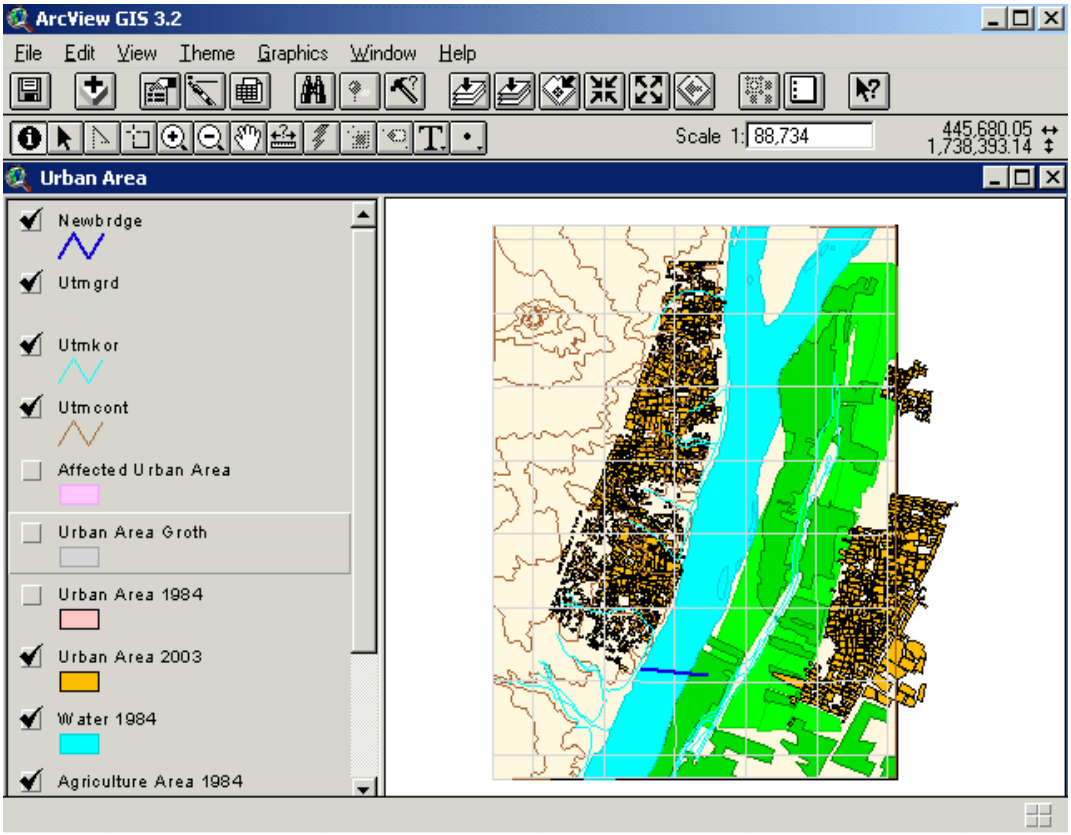



**Figure (8): Urban Area 2003**

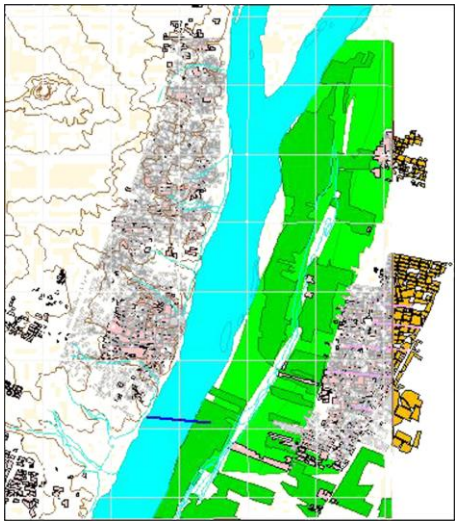


**Figure (9): Urban Area Growth of the Study Area.**

**Table (1) Urban Area Growth Analysis (1984-2003)**

| Year 1984 (sq.km) | Year 2003 (sq.km) | Growth (sq.km.) | % |
|---|---|---|---|
| 2.432 | 5.681 | 3.249 | 233.62 |
| | | Per Year | 12.30 |

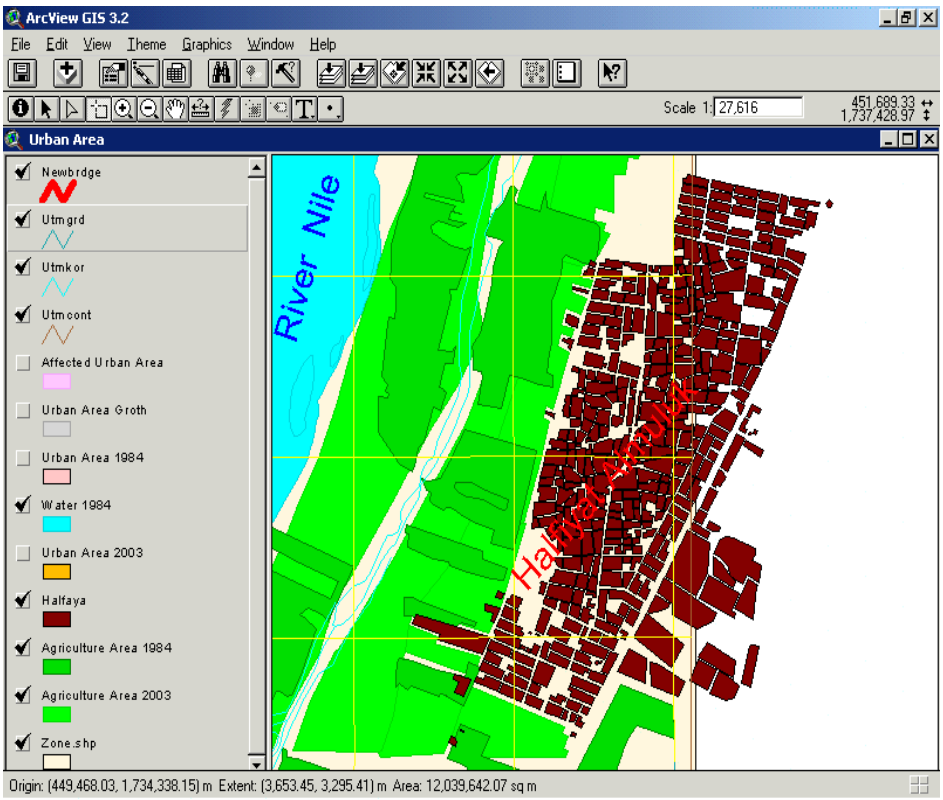



**Figure (10): Map of Halfaya Town from GIS**