Using Remote Sensing and GIS Techniques for Quick Estimation of the URBAN Growth in the North Region of Khartoum State

Dr. Fathi M.Mohammed Saied

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 urban growth taken place in the study area during the period 1984-2003. Remote sensing, digital image processing and GIS techniques were used to map this growth. Different procedures have been applied to the test data to achieve the objectives of this study. Image restoration as well as map projection and rectification operations were adopted to bring the test data at a common geo-reference coordinate system (UTM). Image enhancement and spatial topology processes have been applied and constructed to achieve the virtual representation of the real world. Analysis and overlay process were applied to the test data to model the urban growth in the study area between the year 1984 and the year 2003. The estimated amount of the urban growth was found to be approximately 3.249 Km^2. The experimental test, carried throughout this study, proved that integrated remote sensing and GIS techniques have great impact on detecting environmental changes and man-made features variations through time.

ملخص

هذه الورقة تسلط الضوء علي امكانيات نظم المعلومات الجغرافيةو نظم الاستشعار عن بعد واستخداماتهما في المجالات الهندسيةو تحديد حجم النمو العمراني في منطقة الدراسة واهم معطيات الاختبار تمثلت في صور الاقمار الصناعية العالية الدقة الماخوذة بنظام اكونس الامريكي بدقة واحد متر (2003) . ولعمل المطلوب من الاختبار تم تنفيذ عدة خطوات بتقنيات مختلفة نتج عنها تحديد حجم المنطقة المعمورة سكنيا في عام 1984م حيث كانت جملة المساحة 2.432 كلم مربع بينما بلغت جملة مساحة المنطقة المعمورة سكنيا في عام 2003م 5.561 كلم مربع بنمو عمراني قدره 3.249 كلم مربع (بنسبة 234%) وذلك خلال الفترة من (1984-2003)م . هذة النتائج التي خرجت بها الدراسة لها قدر عال من الاهمية في عمليات التخطيط العمراني وضع الخطط الاقتصادية والاستراتيجية والتي تعني بمنطقة الدراسة . قد وضحت هذه الدارسة ايضا الامكانيات الكبيرة التي يوفرها تكامل نظم الاستشعار عن بعد ونظم المعلومات الجغرافية وبالتحديد فيما يخص متابعة التغيرات البيئية والهندسيةفي منطقة الدراسة مما يساعد علي اتخاذ القرار .

* Asst.Prof. Omdurman Islamic University-Faculty of Engineering Sciences.

1. Introduction

The earlier integration process between geographical information and Database Management System (DBMS), were combined to form present day, GIS. In order to meet the different needs, a three-stage integration process between GIS and Remote Sensing are outlined (Ehlers *et al*, 1989).

1.1 Level One:

a) Simultaneous display of vector and raster data;
b) The raster-to-vector conversion process and vice versa.
c) A geometric registration capability.

1.2 Level Two:

a) Raster and vector advanced processing.
b) Entity-like control over remote sensing image components.
c) Capability to incorporate vector data directly into image processing.
d) Ability to handle time (irregular time intervals and interpolation between known times).
e) Ability to accommodate hierarchical entities.
f) Capability to analyze errors.
g) Ability to generate simulations combining cartographic data and image data (simulation, visualizations, etc.).

1.3 Level Three:

a) Spatial information system which accommodates both types of information at different hierarchical levels.
b) Automated image interpretation, integrated database structures, vector/raster operations and integrate knowledge-based processing of the data.
c) Incorporating information about data, equipment, procedures, and users in order to increase its usability within existing organizations.
d) The ability to be extended to access and handle the data.
e) The accommodation of different geographic/spatial models of the underlying reality.

2. 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.

3. Procedures, 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 digital 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 SPOT 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 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.

c) 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.

d) 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.

4. Conclusions

1. The study area, as tested, wittiness a great amount of change in urban area, where the rate increased from 2.432 Km^2 in 1984, to 5.681 Km^2 in 2003, equivalent to a growth of 233%.
2. It can be concluded that, remote sensing and GIS integration is a powerful tool for quick estimation of urban growth.

5.References

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[2] Ray Harris 1987: Satellite Remote Sensing.
[3] Jacobsen K. 2002. Mapping with IKONOS Images 2002.
[4] Wolf P.R. 6th. Principles of Surveying Edition 1997.
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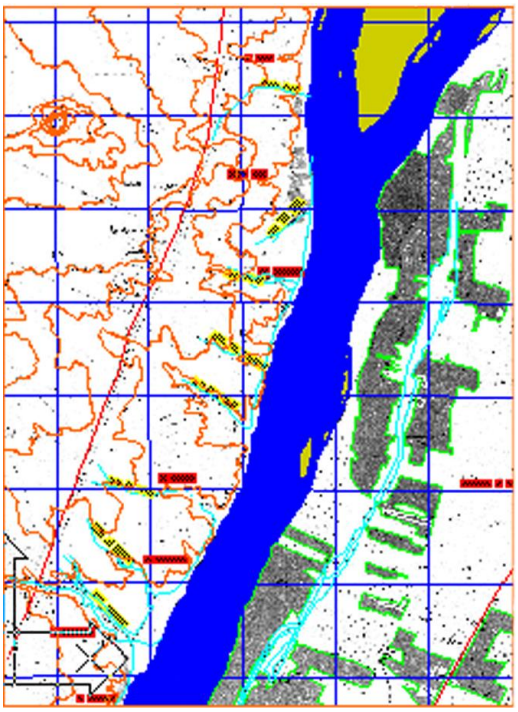
[6] Gerlach, F., 2000 Characteristics of Space Imaging One – Meter Resolution Satellite Imagery Products.



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

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

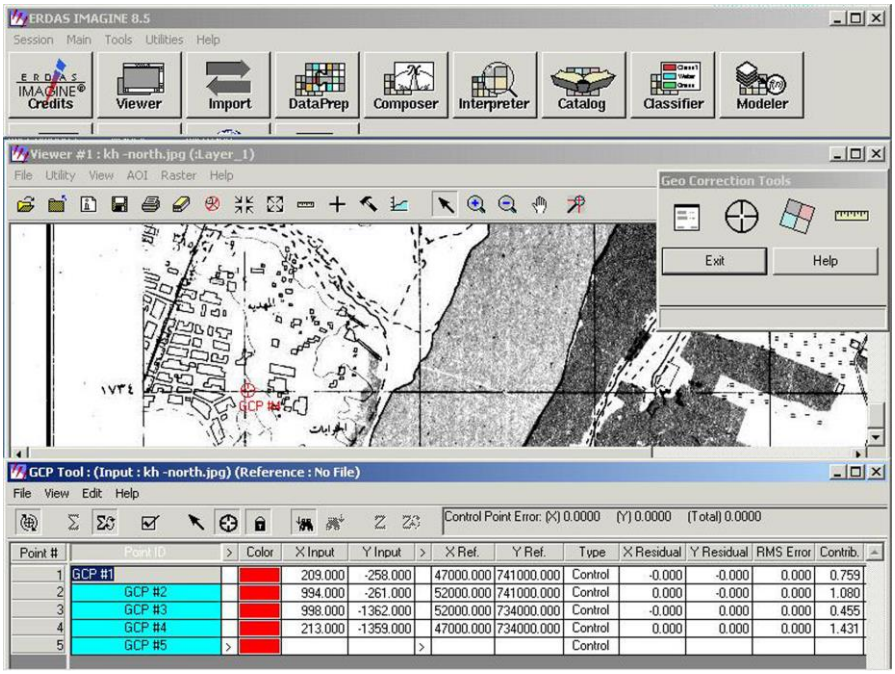
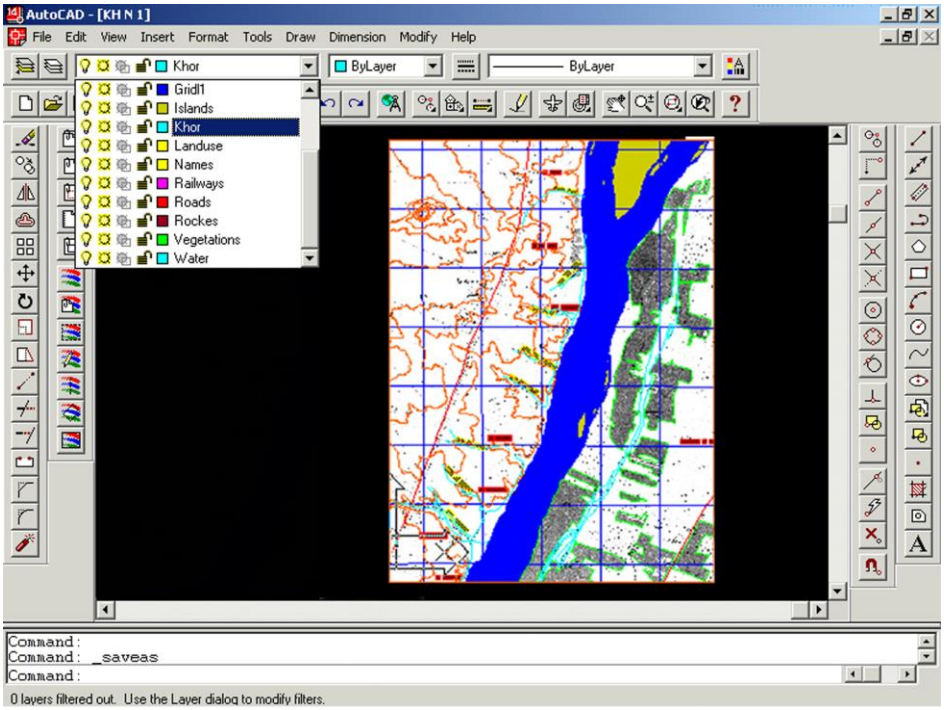
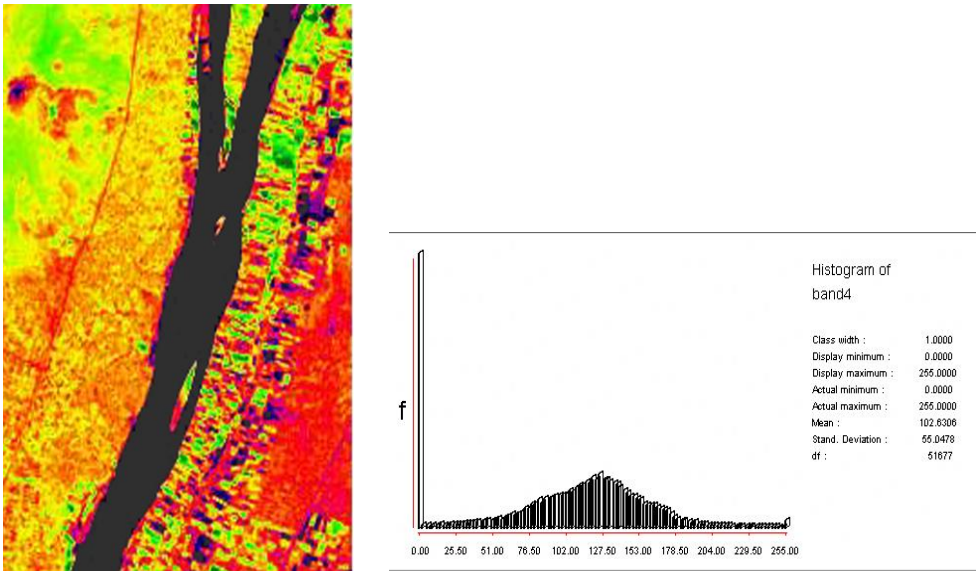


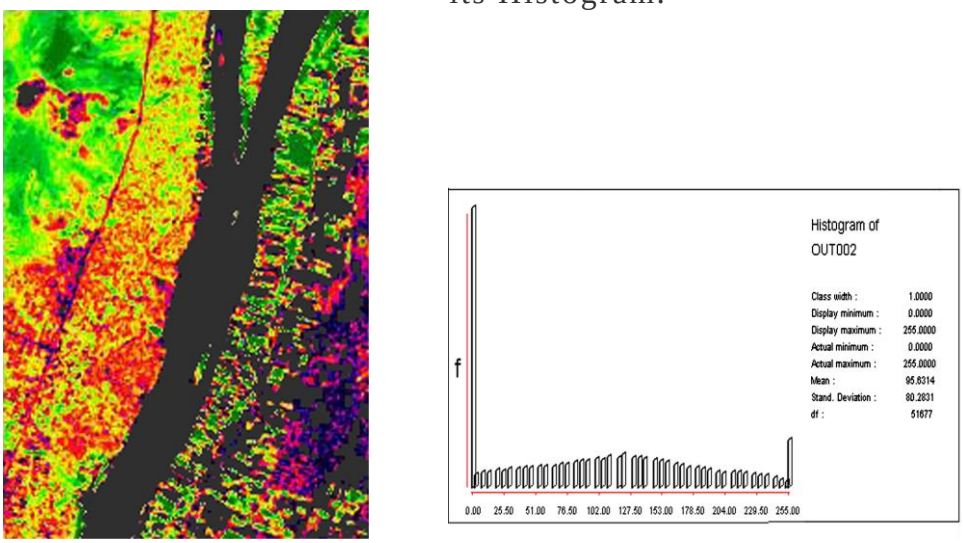
Figure (3) The Projection Process of the Map of Study Area using ERDAS software package.



Figure(4) Different Auto-Cad layers of the Study Area

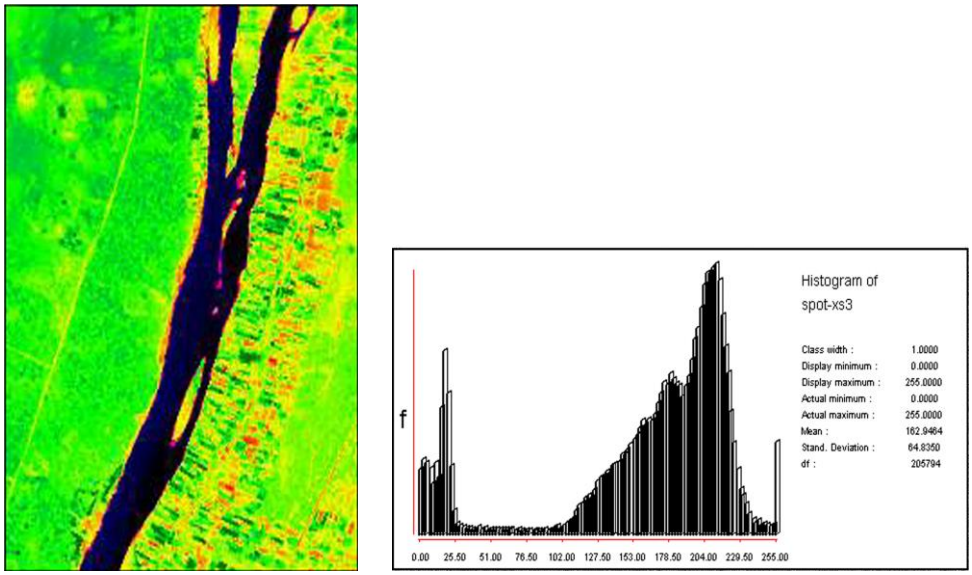


a) LanSat-7 Band 4 before Digital Image Enhancement With its Histogram.

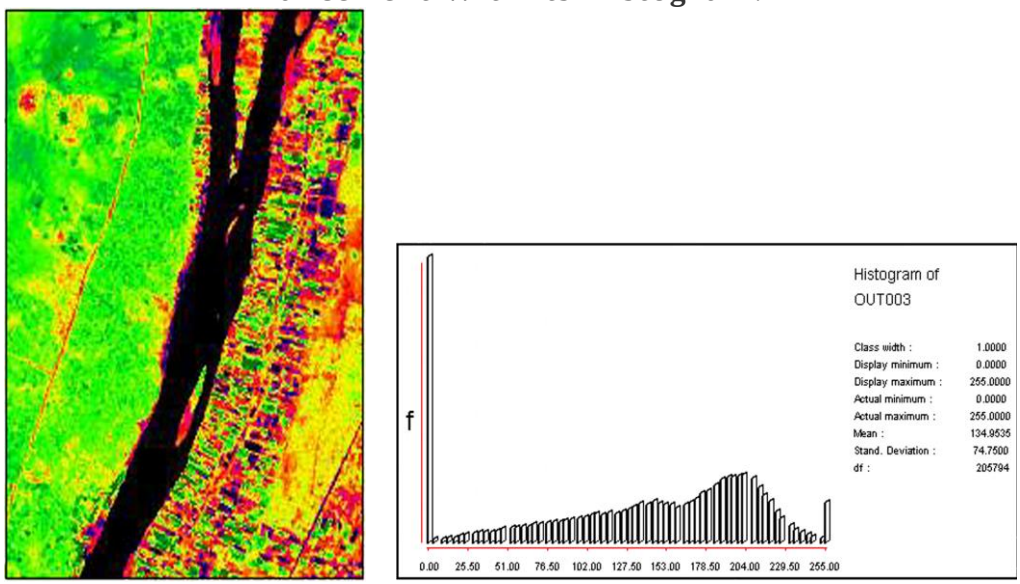


b) LanSat-7 Band 4 After Digital Image Enhancement With its Histogram.

Figure (5 (a, b)) The enhancement process of LAN Sat Band 4 (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(a),(b)) The enhancement process of Spot-4 Band XS-3(Study Area).

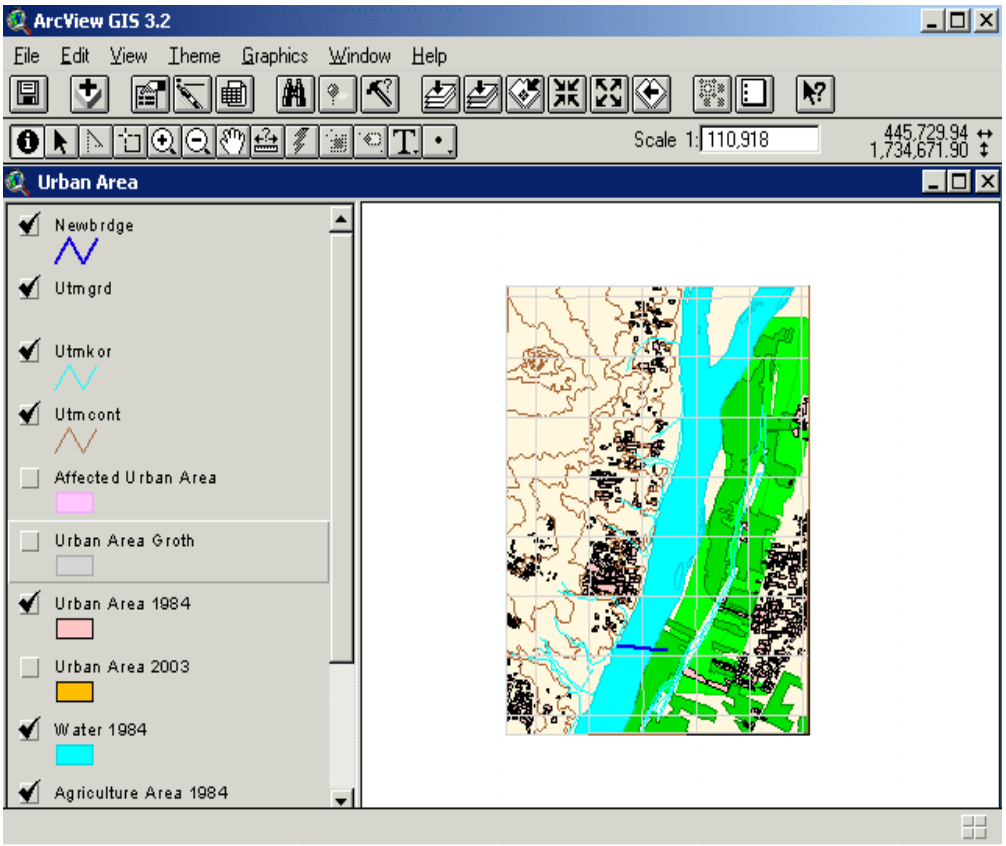


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Figure (7) Urban Area 1984

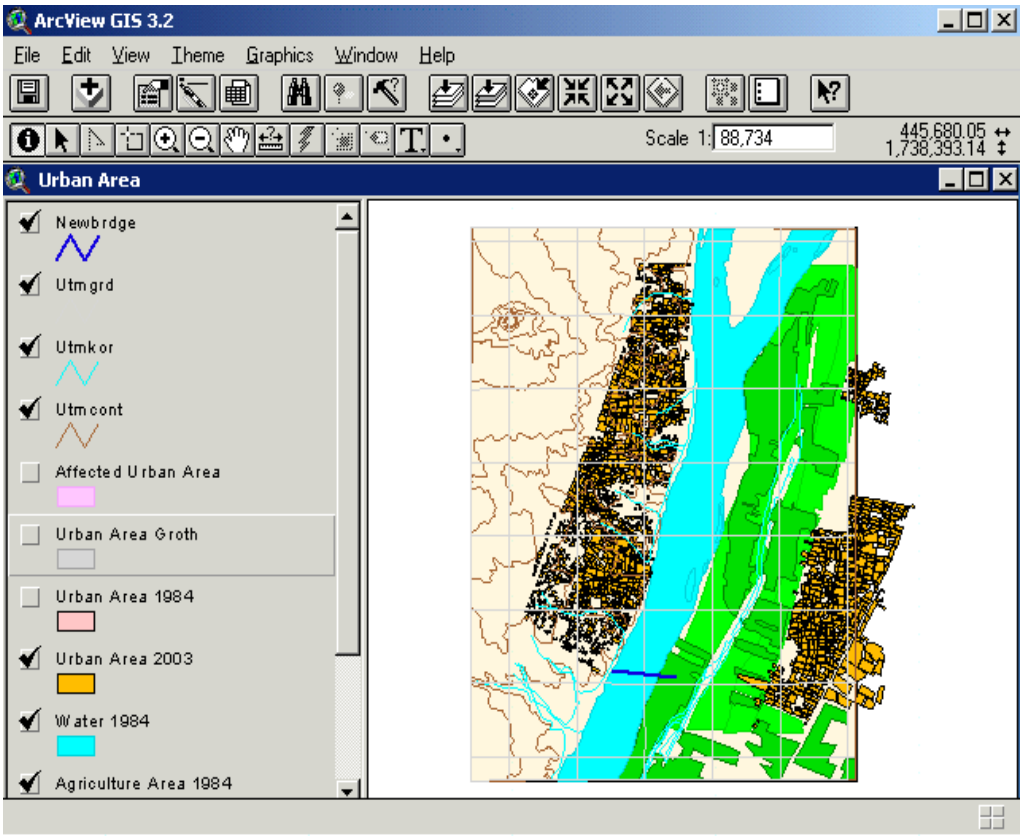

Figure (8) Urban Area 2003

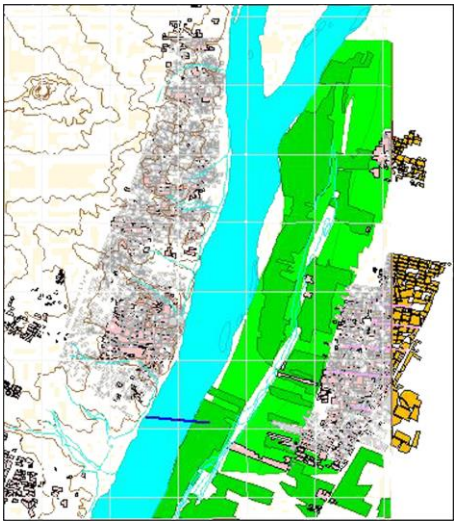

Figure (9) Urban Area Growth of the Study Area.

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