URBAN EXPANSION AND POPULATION GROWTH IN RAS SUDR CITY USING REMOTELY SENSED IMAGERY

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Abstract. Remote sensing and geographic information systems are considered as the most efficient techniques for detection and analysis of land use changes in the urban studies. Population growth is useful information necessary for management and development of any city. The main objective of this research is to predict and analyze the future urban growth, to define the boundaries of urban growth and to link urban growth with population of Ras Sudr city, Sinai, Egypt within the period of study using the satellite images. In this study, ETM+, aerial photos, QuickBird images and spot 4 images acquired in 2000, 2002, 2004 and 2012, 11 years time interval, were used to monitor urban growth in Ras Sudr city. The rectified images were classified into urban and non-urban using visual interpretation. Two land-use maps were produced for each date. The classified maps were compared to locate and quantify changes of urban land use during the selected period. The satellite images were rectified, classified, analyzed and compared using Envi4.8 and ARCGIS 10 software's. The obtained results from this application of aerial photos and satellite images indicate that use of this type of remotely sensed data are very useful for urban expansion and population growth analysis. The study has demonstrated potential as a means to detect, identify, map and monitor the changes. One can concluded that the expansion of Ras Sudr city is compared to the first date image; and the expansion is mainly due to the lands changed from bare land around the city to built-up areas. The increase in urban area or overall expansion of built-up land in the region may be considered as a good indicator for population growth.

Key words: Remotely Sensed Imagery, Urban expansion, Population growth

1. Introduction

Rapid urban development and increasing land use changes due to population and economic growth in selected landscapes is being witnessed of late in India and other developing countries. (Manish K. T., et al., 2012). In order to meet urban development challenges a planner needs to have fairly accurate and up-to-date information. (Pathana S. K., et al.1993; Pathak, et al., 2009; Kauditorium P. J and Tim V. V., 2011). Also, calls for the use of monitoring systems like remote sensing. Such systems along with spatial analysis techniques like digital image processing and geographical information system (Mahesh K., et al., 2008; Robert G. P. 2011). In the city of Urmia, Iran, urban growth and effective factors on them used population censuses data of the study area from the period between 1989 and 2007, and population censuses of Urmia (Jamal M., et al., 2012). The changes in the Egyptian government's housing and land policies over the last 40 years, including attempts to upgrade informal settlement and to combine upgrading with the development of settlements for middle-income households (El-Batran M. and Arandel C., 1998). High-resolution data from the HRV (High Resolution Visible) sensors onboard the SPOT satellite have been utilized for mapping semi-natural and agricultural land cover using automated digital image classification algorithms (Bakera J. R et al. 1991). Urban growth using multi-sensor satellite imageries and explored the potential benefits of combining data from optical sensors (Landsat, Worldview-2) with Radar sensor data from Advanced Land Observing Satellite (ALOS) Phased Array type L-band Synthetic Aperture Radar (PALSAR) data for urban land-use mapping (Kenneth M., Gunter M., 2012). Evaluates land use/cover changes and urban expansion in Greater Dhaka, Bangladesh, between 1975 and 2003 using satellite images and socio-economic data. Spatial and temporal dynamics of land use/cover changes were quantified using three Landsat images, a supervised classification algorithm and the post-classification change detection technique in GIS (Dewan A. et al., 2009).

2.0 Study Area and Data Set

The Sinai Peninsula or Sinai is a triangular peninsula in Egypt about 60,000 km2 (23,000 sq mi) in area. It is situated between the Mediterranean Sea to the north, and the Red Sea to the south, and it is the part of Egyptian territory located in Asia as opposed to Africa. The bulk of the peninsula is divided into two Governorates (with three more splitting the Suez Canal area). The main Governorates are North Sinai Governorate and South Sinai Governorate. South Sinai governorate occupies the

southern triangle of Sinai Peninsula, between Suez Gulf and Aqaba Gulf. The total area of the governorate is 31,272 km2, and it represents about 3% of the total area of Egypt. El Tor city is the capital city of South Sinai, the main cities are: Sharm El- Sheikh, Dahab, Nuweiba, Ras Sudr, Abo Zeneima, Abo-Reideis and Sainte Katherine. In this research Ras Sudr city has been selected to be the study area. Ras Sudr City is the capital city of Qism Ras Sudr located on the Gulf of Suez coast of the Red. The city is away from Cairo about 200 kilometers through Shahid Ahmed Hamdi tunnel. The region enjoys the coasts of sand a few herbs and sea salts, and calm waters. The city has a number of tourist resorts and hotels on the beaches. Ras Sudr is receiving increasing demand from Egyptians tourists and foreign tourism because it is near Cairo city and famous with safari. Figure 1 shows location map of Ras Sudr city, South Sinai Governorate, Egypt.

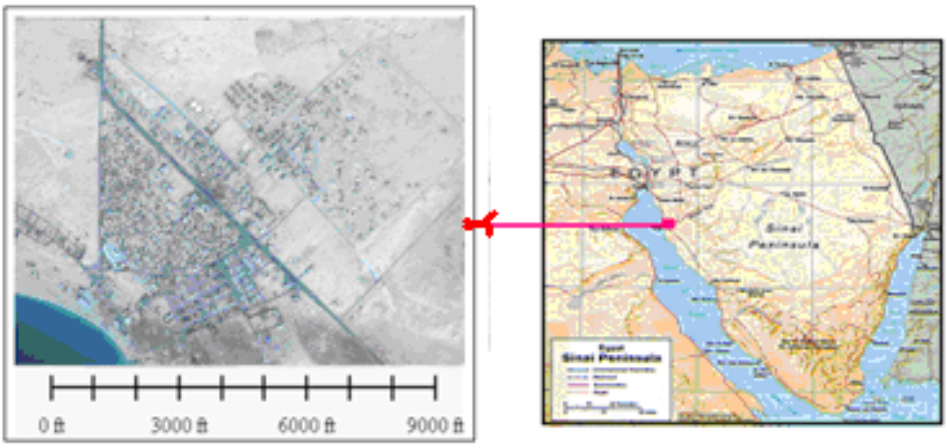

Figure 1. Location map of Ras Sudr city, South Sinai Governorate, Egypt.

3.0 Data Sets

Satellite Data of Ras Sudr city which has been used in this study were: (1) Land sat Enhanced Thematic Mapper plus (ETM+) imagery Dated 2000 - Free data from internet. (2) Aerial photos Dated 2002. (3) QuickBird images Dated 2004. (4) Spot 4 resolution 20m Multispectral and panchromatic 10m Dated 2011. Figure 2 shows Spot 4 satellite image of Ras Sudr City at 2011. Figure 3 shows produced map scale 1:2500 from Aerial photos at 2002. Demographic data or census data should be available for population forecasting, the most important source of information on Ras Sudr city is the Census of Egypt. The Census was conducted in Census books, 1986, 1996 and 2006 published by Central Agency for Public Mobilization and Statistics (CAPMAS). Also, population estimation of Ras

Sudr city according to local count of population dated 2012 has been used to evaluate predicted models. Also, GCps and CPs of well identified feature from produced map 1:2500 from Aerial photos has been used to rectified satellite images.

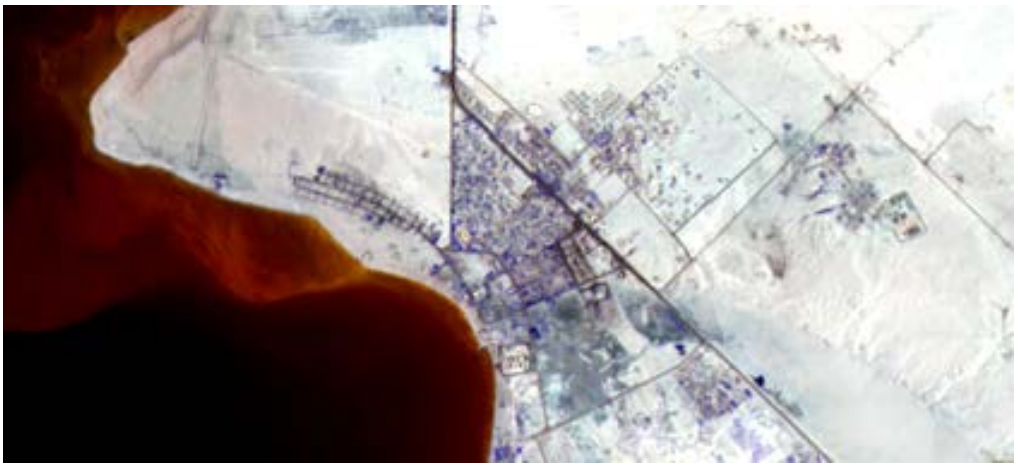

Figure 2. Spot 4 satellite image of Ras Sudr City at 2011.

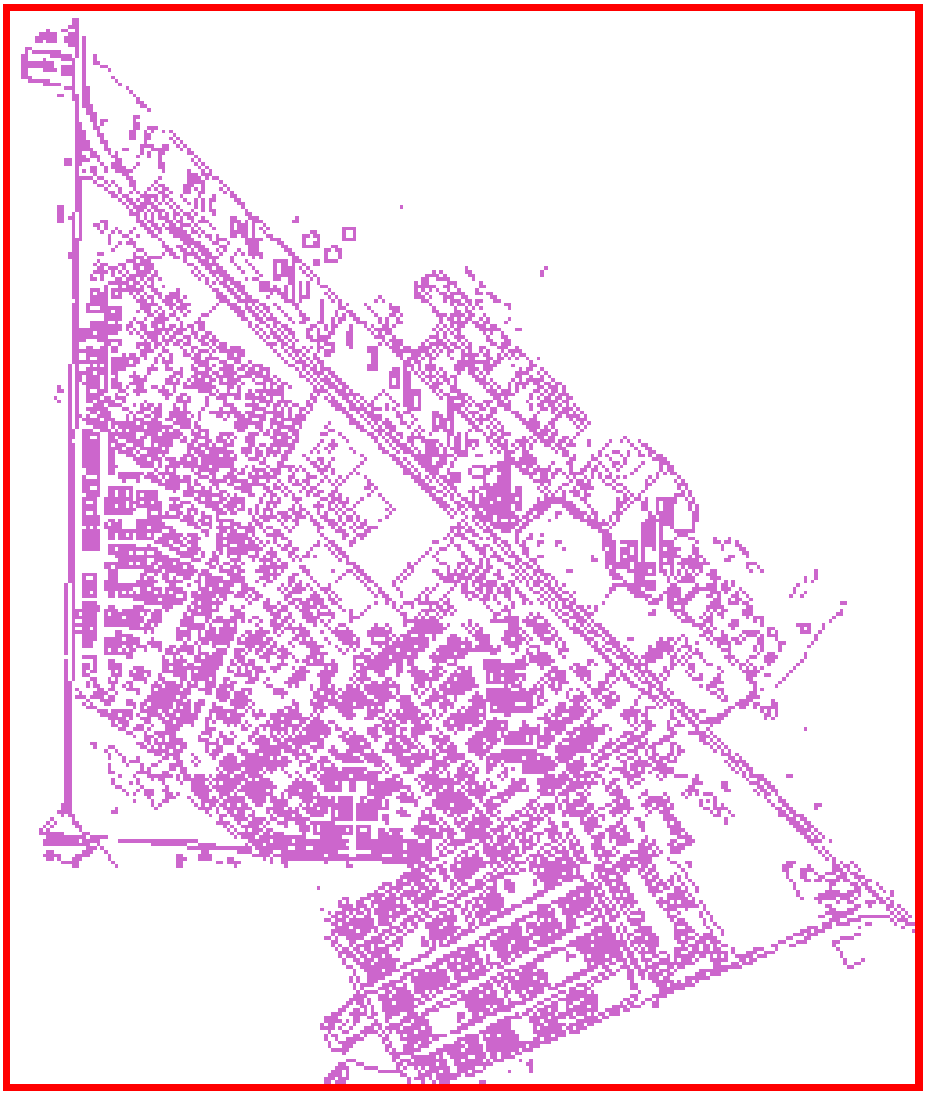

Figure 3. Produced map scale 1:2500 from Aerial photos at 2002.

4.0 Methodology

The proposed methodology based on using remote sensing images with different resolution to estimate population of South Sinai Governorate. The study area covered with Spot 4 multi-spectral images 20m resolution dated

2011, Land sat enhanced thematic mapper ETM+ panchromatic images 14.25m resolution dated 2000., Aerial photos Dated 2002 and QuickBird images Dated 2004

To study the issues arising from unplanned and rapid urban growth, developing countries could significantly gain from the information generated using advanced technologies such as remote sensing data, Geographical Information System (GIS), global positioning system (GPS) etc. for generating appropriate plans and strategies for urban growth and development. Areal interpolation method for population estimation based on uses available census population data as the input and applies the suitable predicted model to obtain the population as a function on time. Also, in this study population estimation method has been done from remotely sensed data based on the relationship or the correlation between populations and urban areas. Interpretation of urban areas has been performed visually from rectified images.

5.0 Results and Discussion

All images was rectified to Universal Transverse Mercator UTM projection, Datum WGS 84 using ground control points extracted from topographic maps scale 1:2500. Then urban area of the study area was extracted from rectified images from different sources as mentioned before. Used Coordinates System: Projection: UTM, Zone 36 North: Datum: WGS 84

Visually vectorization of urban areas has been performed using ARC GIS 10 software to produce vector maps. Each urban area identified as polygon. Four vector maps have been produced from each rectified images: (ETM+) imagery Dated 2000; Aerial photos Dated 2002; QuickBird images Dated 2004; Spot 4 resolution 20m Multispectral and panchromatic 10m Dated 2011.

The results of urban areas of Ras Sudr city were 1.345, 1.452, 1.704 and 2.207 km2 at 2000, 2002, 2004 and 2012 which represent 11 years time interval.

Two predicted models have been used to forecast urban areas as a function on time based on census data. Equation 3 represented prediction function based on second order model. and equation 4 represented prediction function based on regression line model.

$$A = 0.0181\,T^2 - 72.4827\,T + 72466.845 \quad \text{equation 3}$$

$$A = 0.0799T - 158.3899 \qquad \text{equation 4}$$

Where:
A= Urban area
T= Year

Urban area of Ras Sudr is 2.4488 km2 at 2013 using regression line model and 4.6323 km2 using second order model.

Urban area of Ras Sudr at 2000, 2002, 2004, 2011 and 2013 are ,1.345, 1.452, 1.704, 2.207 and 2.4488 km2 respectively. So, percentage of urban growth in 11 year is 64.08 % and in 13 year is 82.06%. Ras sudr city was surrounded by desert land, so the growth of the city during 11 year has caused some changes in some desert land and transformed it into residential areas.
Population estimation has been done based on the last three census data 1986, 1996 and 2006. After that a density maps has been produced for the study area. In this research population estimation has performed using correlation with urban areas method based on a functional relationship between urban areas and population size. Population has been estimated from censuses data. The relationship of the trend forecasting between a census population and time can be represented using linear equation or second degree equation. This is due to the limited number of census data which is the last three census of south Sinai Governorate.

$$Y = 8.03 X^2 - 31966.06 X + 31814030.28 \qquad \text{equation 2}$$

$$Y = 89.7 X - 177082.8667 \qquad \text{equation 1}$$

Where:
Y= Population
X= Year

Based on census population at 1986, 1996 and 2006 of Ras Sudr city which were 1329, 1423 and 3123 capita, predicted population using 2D model equation n 1 at 2000, 2002, 2004, 2011 and 2013 are 1910, 2250, 2654, 4575 and 5269 Capita respectively. So, percentage of population growth in 11 year is 139.53%and in 13 year is 175.86% using 2D model. Also, based on the last three census of Ras Sudr city, predicted population using regression line model equation number 2 at 2000, 2002, 2004, 2011 and 2013 are 2317, 2497, 2676, 3304 and 3483 Capita respectively. So, percentage of population growth in 11 year is 42.60% and in 13 year is 50.32% using regression line model. Figure 4 shows population and urban area of Ras Sudr city at 2000, 2002, 2004 and 2011.Local count of population dated

2012 has been used to evaluate the used models regression line model and second order model. According to the local count the population of Ras Sudr city was 4115 Capita at 2012, using regression line model population is 3393 Capita, So, the percentage of error in population estimation is -17.55%. Also, using second order model population is 4913 Capita. So, the percentage of error in population estimation is +19.39%. Urban area of Ras Sudr was 2.207 km2 at 2011 which have expanded about 1.64 times than urban area of Ras Sudr was 1.345 km2 at 2000 in 11 years time interval. Also, studying population growth rate showed that population is 1.43 times bigger in the same time interval. Reasons for this growth include immigration from villages to cities. Also, One can say that Ras Sudr had mainly horizontal growth during and vertical growth very limited. Ras sudr city has been extended mainly in three directions, North East, South and South East direction as seen in figure 5.

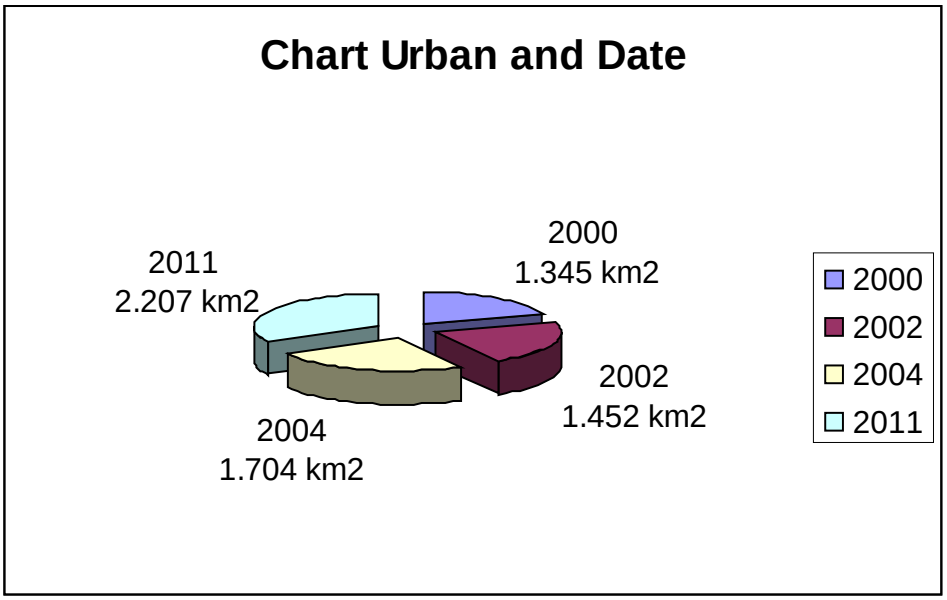

Figure 4. Population and urban area of Ras Sudr city at 2000, 2002, 2004 and 2011.

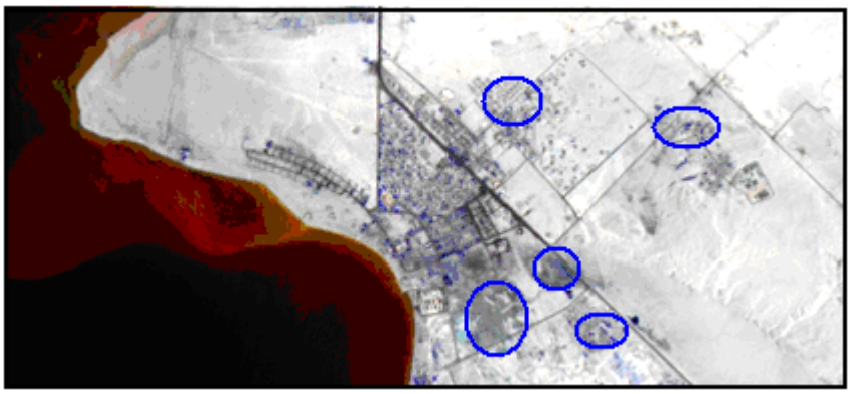

Figure 5. Expansion areas of Ras sudr city marked blue color.

Population density is a measurement of the number of people in an area. There are natural or Physical Factors and human factors affect population density. Density of population at predicted years 2000, 2002, 2004, 2011 and 2013 are 1722.7, 1719.7, 1570.4, 1497.1, and 1422.3 Capita/km2 respectively using (regression \line model). Figure 8 shows density chart of Ras sudr city at predicted years 2000, 2002, 2004, 2011 and 2013.

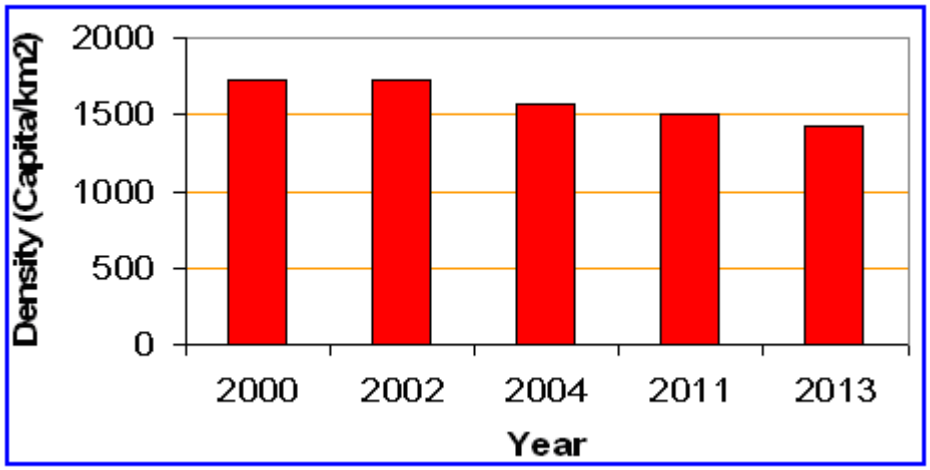

Figure 8. Density chart of Ras Sudr city at predicted years 2000, 2002, 2004, 2011 and 2013.

6.0 Conclusions

The study indicates that updating urban database and linking population with the location using Geographic information is essential for decision maker to know the location of urban areas and to use it in supporting planning processes. The major advantage of population estimation using remotely sensed data has is providing a timely update of a population database and its spatial distribution, which is difficult by conventional approaches. Also, population estimation based on the integration of satellite imagery and census data can be used to provide useful information on intra-census population, which is essential in many applications.

Urban area of Ras Sudr was 1.345 km2 at 2000 and 2.207 km2 at 2011 which have expanded about 1.64 times in 11 years time interval. Also, studying population growth rate showed that population is 1.43 times bigger in the same time interval in case of using regression line model and 1.40 times bigger in case of using second order model.

From the obtained results, the expected of urban growth of Ras Sudr city in 13 year is 82.06%. The expected of population growth of Ras Sudr city in 13 year are 50.32% using regression line model.and 175.86% using 2D model.

Based on local count of population dated 2011 the percentage of error in population estimation using regression line model is -17.55%. Also, using second order model the percentage of error in population estimation is +19.39%. Density of population at predicted years 2000, 2002, 2004, 2011 and 2013 are 1722.7, 1719.7, 1570.4, 1497.1, and 1422.3 Capita/km2 respectively using (regression \line model).

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