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Tracking Regional Growth and Development: The Nairobi Case

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This chapter uses Nairobi City to show how spatial technologies, especially remote-sensing and geographic information system (GIS) technologies, can be effectively used in tracking urban growth and development. The first section provides background on Nairobi City, and the next section gives a description of the methods used in tracking Nairobi's urban growth and development. The last section discusses the results.

<A>Background on Nairobi

The city of Nairobi is located in the Republic of Kenya at the southern end of the rich agricultural edge of the Kenya Highlands (about 1.2 degrees S and 37 degrees E). The city was first established as a railway camp during the construction of the Kenya-Uganda Railway. The railhead reached the site in 1899. The railway headquarters and the central colonial administration were transferred from Mombasa to Nairobi at the beginning of the twentieth century. By 1910, the internal structure of the central business district (CBD) and the road network in the center had started to take shape. In 1934 Nairobi was upgraded into a municipality, and it acquired city status in 1950. Initially Nairobi covered an area of 18 km^2. However, there have been several boundary expansions since then. In 1927, the town area was extended to cover 78 km^2. In 1963, it was extended to cover an area of approximately 690 km^2 (UNDP 1997).

From the time it became a settlement in 1901, Nairobi has experienced sustained growth in both physical extent and population. During the period 1899–1905 there were approximately 10,000 people in Nairobi. In 1919 when Nairobi became a municipal council, it had a population of about 15,000 people, and in 1948 the population had increased to118, 976 (Matrix Development Consultants 1993). It continued to grow steadily: in 1962 it had a population of 343,500, which had risen to 1 million by 1983 (table 10.1). The 1999 census showed that the population of Nairobi was 2,143,254 people. This is despite the fact that the rate of growth had decreased from 7 percent to 5 percent. It is estimated that the current population (2007) of Nairobi is between 3 and 4 million.

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The daytime population in the city is higher than the resident population. This daytime population includes people from the surrounding areas who were not considered in the past and present censuses. This additional daytime population means that there is a higher population than the one officially accounted for. Moreover, because of a biased development pattern, rural-urban migration continues even alongside natural increase. This occasions administrative difficulties in planning and implementing local public services (Obudho 1999).

Nairobi can be divided into residential areas, the CBD, and industrial areas. The residential areas are made up of low-, middle-, and high-income areas. It is estimated that 80 percent of the population occupies less than 20 percent of the residential zones in the high-density settlements. In total, about 55 percent of the urban population is housed in unplanned areas. The main feature of these informal settlements is the lack of adequate infrastructure and services such as water, sewage, and solid waste disposal.

The original frame of the city was determined by the dictates of racial segregation, a colonial practice which prevailed as late as the early 1960s. Nairobi was systematically racially zoned in the major plans of 1905, 1927, and 1948. (Thanks to the nonimplementation of the 1973 Nairobi Metropolitan Growth Strategy, the 1948 Master Plan is still the only comprehensive plan for the city). The legal history of segregation argues against the colonialist claim that natural affinity would keep together different races in separate quarters (Enig and Ismail 1980). In 1902, the colonial government enacted the Crown Lands Ordinance, which stated that “natives” could only be issued with “licenses” on government land, which could only cover a plot of a maximum of five acres. It was not until 1954 that Africans were allowed to own leasehold property in Nairobi (Amis 1990). The predictable result of these racially segregated residential planning processes was an extremely unequal land distribution. Evidence of this inequality is evident in Nairobi today, where, even after independence, the availability of land remains severely restricted.

As for Nairobi’s socioeconomic role in Kenya, the city’s functions have expanded to such an extent that it has become the primate city in the country. It is the political, social, cultural, and economic capital of Kenya. In addition to being the capital city of Kenya, it serves as the regional and international headquarter for several commercial and public institutions, including many multinational companies and United Nations agencies.

The city of Nairobi has experienced tremendous growth in the last four decades. Rapid population increase has been both a cause and effect of this growth. In less than one hundred years Nairobi has burgeoned from an uninhabited vegetated plateau into a metropolis with over 3 million inhabitants. This rapid growth of the city has not been accompanied by systematic planning and development of physical infrastructure and social amenities, and adequate attention has not been paid to the conservation of natural resources and the environment. As a consequence, the city is currently faced with numerous problems. Among these problems are poor urban infrastructure; inadequate social amenities; haphazard and uncontrolled growth; inadequate and inappropriate housing; unprecedented growth and mushrooming of slum dwellings or urban sprawl; poor transport system; poor water and sewerage system; environmental deterioration; and personal insecurity.

The lack of accurate and up-to-date maps and information has rendered planning and management of urban areas in Africa a difficult task. For most urban areas, it is difficult to find maps that are less than ten years old. In the case of Nairobi City, most of the maps available are outdated (over ten years old), lack detail and accuracy, and are mostly in hard copy form, rendering them static and cumbersome to interpret and analyze.

There is no systematically developed and managed urban database. Therefore there is an urgent need to develop cost-effective, rapid mapping methodologies that yield timely data for planning and decision making. These methodologies should leverage the synergy of three main geographic information technologies: satellite remote sensing, geographic information system, and the Global Positioning System (GPS). Satellite remote sensing guarantees timely repetitive data acquisition for continuous map updating, while GIS enables spatial database creation and management. GPS facilitates the acquisition of higher geometric accuracy for both satellite imagery and GIS databases. Given that these datasets are in digital format, and that current technological developments ensure data access through the Internet, data sharing among stakeholders, however distant, has become a real possibility.

<A>Methods Used to Track Urban Growth and Development

The 2004 QuickBird high-resolution satellite data were used in the development of a multi-user digital spatial database of the city of Nairobi. The QuickBird satellite was launched in October 2001 by DigitalGlobe (DigitalGlobe 2003). The satellite currently has the highest spatial resolution (60 cm) of the commercially available satellites and competes directly with medium-scale aerial photograph. Due to its high resolution and its synoptic view (16.5 km x 16.5 km), the data are mainly applied in urban studies. Other areas of application include large-scale natural resources mapping, disaster management, utility mapping, hydrological studies, agriculture, real estate, insurance, etc. The applications of QuickBird imagery are further enhanced by the satellite's five-band multispectral characteristics—one panchromatic and four multispectral (blue, green, red, and infrared). The satellite imagery was used to map land-cover and land-use changes and updates to the city cadastre.

The land-use/land-cover map of Nairobi was developed by interpreting the QuickBird image digitally. First, road centerlines were digitized from the images and the roads were buffered according to their classes. From these road buffers, general land-use blocks were delineated and consequently interpreted using a predefined land-use classification system. A database of land-use classes and other associated data were finally produced in a GIS environment. Other features mapped in the QuickBird image are rivers, railways, schools, hospitals, and police stations. A field exercise was conducted where feature names (roads, rivers, estates) were recorded and positions confirmed using GPS. Stakeholder organizations also participated in the collection of data. For instance, the Kenya Police provided crime data, Ministry of Education staff provided schools data, and Kenya Telkom provided data on telephone infrastructure.

The mapping methodology entailed the used of high-resolution remote-sensing satellite data and GIS technology. The QuickBird satellite image of Nairobi was used to update the cadastral and land-use/land-cover maps of the City of Nairobi. The baseline cadastral data were acquired by digitizing existing cadastral maps of scale 1:10,000 acquired from the Survey of Kenya (Kenya 1981). These data were then overlaid on the QuickBird image and the changes mapped. Despite having a substantial nonlinear shift between the two datasets, near-perfect matching was achieved through individual block shifting.

Further, the cadastral data contained the following information: plot sizes, plot numbers, plot owners, postal addresses of owners, and plot status. Using this database a simple interface was then developed to enable data access and query to be undertaken by individuals not skilled in using GIS.

GIS was used to create an integrated and relational database for the city using data derived from the interpretation of the QuickBird satellite imagery (Maps Geosystems 2004).

<A>Results and Discussion

The following digital databases were developed:

<NL>1. Digital QuickBird image of Nairobi.

2. Updated digital cadastral maps of Nairobi (digitized from the 1:10,000 scale cadastral maps provided by the Survey of Kenya and updated by QuickBird satellite imagery).

3. Digital thematic maps of Nairobi that were digitized from the QuickBird image. These include roads, railways, rivers, academic institutions, health centers, police stations, buildings, and land use/land cover.

4. A water management database and application for the Nairobi City Council.<MC>

In addition, the following were developed:

1. Customized GIS software. Simplified GIS software called Promptinfo has been developed for users among the GIS community who may not necessarily be GIS experts. This software enables them to access and query the data (Maps Geosystems 2004).

2. Land parcel locator. A land parcel locator has been developed to enable quick access and identification of land parcel information (Maps Geosystems 2004).

3. Community GIS toolbox. The toolbox was developed by Maps Geosystems (2004) and basically comprises hardware, software, and data and can easily be installed in an organization's

local area network. The toolbox can be used by anybody within an organization with the right access authorization and therefore guarantees optimal data use and data security. It can be configured to prevent unauthorized data access.

The toolbox software can be easily customized for a wide range of applications. An essential element of the customization is an investigation into the needs of the end user that is made through consultation by a system engineer. This idea is to customize the software to perform what the user wants, rather than training the user to operate the software.

Remote-sensing and GIS technologies offer the practical possibility of resolving the shortcomings in the efficient, effective, and rapid generation of maps for resource and environmental information in Africa. The past two decades have witnessed dramatic advances in resource data collection by space satellites as result of major developments in cameras, sensors, and other remote sensing devices. Space platforms provide bird's-eye views of the earth's surface never available before, and the new sensors provide better resolutions and synoptic perspectives covering thousands of kilometers in single views. The satellite data are now readily available and the cost of acquiring data has drastically fallen in the last five years. Therefore satellite data and GIS can efficiently and cost-effectively be used to update the old maps and to generate new resource maps for sustainable development (Alexandrov et al. 2004).

QuickBird satellite data offer high planimetric detail nearly as good as aerial photographs, but the QuickBird image cannot be seen as a substitute to aerial photography. Whereas QuickBird imagery is good for thematic mapping, aerial photography is good in both thematic and topographic mapping. However, since QuickBird data are more readily available, QuickBird provides data for rapid mapping for planning purposes. In this study it has been demonstrated that high-resolution satellite data—particularly the QuickBird data—can be rapidly and repeatedly used to generate data and maps essential for urban planning and management. For example, the data and maps generated in this study are being used along with other available information (e.g., on population, crime) by the city authorities in a variety of applications (EIS-Africa 2002). Among the applications are updating of the cadastre; identification and demolition of illegal structures; planning for provision of more social amenities, including city beautification and environmental conservation; security planning based on crime incidences; and water and sewer management—particularly repair and maintenance work.

Although geographic information technologies can readily be used to acquire and manage data and maps that are essential for sustainable development, a number of factors militate against their application, particularly in Africa, where there is serious lack of updated large-scale topographic and thematic maps as well as integrated digital geospatial databases suitable for resource planning purposes. Among these detracting factors are inadequate awareness among decision makers on the importance of geo-information technologies in sustainable resource assessment, mapping, and management; lack of national policies on geo-information/spatial data infrastructure; inadequate capacity building (human resources and infrastructure, including hardware and software) in geo-information technologies at all levels; high cost and poor coverage of, and limited accessibility to, high-resolution satellite data; and poor internet connectivity due to internet bandwidth problems.

Based on the above, the use of geographic information technologies in sustainable development is recommended, particularly in urban planning and management. These technologies should be aggressively promoted in developing countries, specifically in African countries where the rate of urbanization is currently very high. These promotional efforts should focus on the importance of geo-information to decision making and capacity building.

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