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Land Use Land Cover Change and Urban Growth in Khoms District, Libya, 1976–2015

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ABSTRACT

Rapid and unplanned urbanization presents a formidable challenge to sustainable urban growth in most developing countries. This study applies Geographic Information System (GIS) and remote sensing tools to quantify land use and land cover change in the coastal, economically important district of Khoms, Libya. The study revealed a 16% per year long-term historic urban growth rate, leading to an urbanization increase of 658% from just 800 ha in 1976 to 6,067 ha in 2015 over the 40-year analysis period. Qualitative evaluation of satellite images showed devastating impacts on both terrestrial and marine ecosystems through broad scale clearing of forests and other native areas for agriculture and urban development, and through reclamation of the Mediterranean Sea during the construction of a naval base and port at Khoms City. An integrated approach that explores of a range of innovative approaches to address sustainable development issues faced by Khoms District and other similar fast growing but environmentally fragile developing country locations is recommended.

KEYWORDS

Environmental Impacts, GIS, Image Classification, Land Cover, Land Use, Libya, Remote Sensing, Urbanization

INTRODUCTION

Urbanization is one of the most important land conversion processes around the world (Haase et al., 2018). Conventional wisdom has it that high population growth rate is the major underlying driver behind the rapid growth of cities (Jat et al., 2008; UNEP 2010). The standard way of thinking about urbanization is that people will drift from rural to urban areas in search of better economic opportunities, access to infrastructure and improved social services (Adepoju, 2018). As this drift occurs, the consumption of resources in cities is expected to more than double from 40 billion tons in 2010 to an unsustainable level of 90 billion tons in 2050, according to a recent study by the IRP (2018). Today, urban areas are home to 55% of the world's total population, with Africa contributing 13% of the 4.2 billion global urban population (UN-DESA, 2018).

There is an undeniable close correlation between urbanization and the three dimensions of sustainable development: economic, social and environmental (Cobbinah and Erdiaw-Kwasie, 2018; UN-DESA, 2018; Yan et al., 2018; Lawrence, 2019). On the one hand, well-planned urbanization can improve living conditions of city dwellers, create an enabling environment for socio-economic development, and enable growth of the middle class (Kayizzi-Mugerwa, 2014; Zhou et al., 2015). Numerous case studies exist where cities have improved sustainability and enhanced the positive

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impacts of urban development through strategic planning tools and green plans that focus on key sustainability target areas such climate change and energy, land and water conservation, public spaces, air quality management, waste management, and mobility (see for example, Yigitcanlar, 2008; Shen et al., 2011). On the other hand, negative consequences of rapid and unplanned urbanization are widespread and well documented in both developed and developing countries. For example, early urbanization experiences in the 1930s and 1940s in developed countries such as the United Kingdom and the United States saw the widespread destruction and conversion of farmlands to urban areas (Firman, 1997). Similarly, recent studies have documented unplanned land conversion and urban development challenges experienced in many developing country cities, including the deterioration of public services, propagation of slums and the informal sector, saltwater intrusion of coastal aquifers, environmental impacts on riparian and coastal habitats, and widespread urban poverty (UNEP, 2010; Kayizzi-Mugerwa, 2014).

Other widely cited problems resulting from uncontrolled urbanization and unsustainable land use change practices include decaying of urban infrastructure, uncontrollable growth of informal settlements, climate change, loss of agricultural land, air pollution, traffic congestion, and the destruction of ecosystems (Huang et al., 2009; Youssef et al., 2011; Zhou et al., 2015; Shen et al., 2017). In fact, the study by Verburg et al. (2006) identifies urbanization as one of the leading threats to the elimination and eventual extinction of large numbers of native species of living organisms. In Steyl and Dennis (2010), a significant drop in the water table and consequent seawater intrusion experienced in the North African coastal countries of Libya, Tunisia, Algeria, Morocco and Egypt has been attributed to land conversion factors that include rapid urbanization, agricultural water consumption, and periodic droughts. Given this multiplicity of impacts, there is growing interest in using geospatial technologies in research to help map and monitor both spatial and temporal land conversion trends, especially in urban areas.

Geographic Information System (GIS) and remote sensing tools have been widely used to map and monitor land cover change and analyze urban growth (Epstein et al., 2002; Yang and Liu, 2005; Haack and Rafter, 2006; Mallupattu and Reddy, 2013; Rawat and Kumar, 2015; Lv et al., 2018). The National Aeronautics and Space Administration (NASA) Landsat satellite data series is a popular choice for such change detection studies because of efficiency in providing a synoptic view of an area of interest, repeated coverage over large areas, lower costs in comparison to higher resolution multispectral sensors, and public availability of historical archive imagery (Zhang et al., 2014). There is need for comprehensive understanding of both temporal and spatial dynamics of land use change and human activities, in addition to land use change drivers (Zhao and Murayama, 2011; Dadras et al., 2014). Well-established techniques that have been applied to analyze urban change include image-to-image, map-to-map, and post-classification comparison (Green et al., 1994; Yang and Lo, 2003; Haack and Rafter, 2006; Zhang et al., 2014; Mahboob et al., 2015; Joshi et al., 2016). Built-up area indices have also been estimated using time consuming, expensive, but accurate techniques such as heads up digitizing, point sampling, and pattern recognition approaches such as supervised and unsupervised classification, and knowledge-based expert system approaches (Epstein et al., 2002; Sugumaran et al., 2003; Lu and Weng, 2005; Mundia and Aniya, 2005).

Controlling urbanization and land change to achieve sustainable development requires accurate and reliable information about urban growth patterns and trends; however, attaining this goal is still a formidable challenge in most developing countries (Jiang and Yao, 2010; Arsanjani, 2011). Urban expansion in developing countries tends to follow growth patterns that are different from developed countries, (Gillham, 2002; Helbich and Leitner, 2010). Consequently, the location and quantification of land use change is the main issue that needs addressing for better understanding of urban growth in developing and rapidly changing environments (Alsharif and Pradhan, 2014). This is especially true for the North African nation of Libya, where the myriad of issues associated with rapidly urbanizing coastal areas include: overexploitation of natural resources; unplanned housing