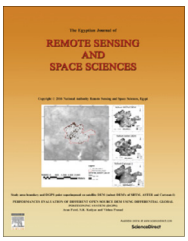
The Egyptian Journal of Remote Sensing and Space Sciences (2016) xxx, xxx–xxx

HOSTED BY

National Authority for Remote Sensing and Space Sciences

The Egyptian Journal of Remote Sensing and Space Sciences

www.elsevier.com/locate/ejrs
www.sciencedirect.com



RESEARCH PAPER

Monitoring land use change and measuring urban sprawl based on its spatial forms The case of Qom city

Hassan Mohammadian Mosammam [a,*], Jamileh Tavakoli Nia [a], Hadi Khani [b], Asghar Teymouri [a], Mohammad Kazemi [a]

[a] *Department of Geography and Urban Planning, Shahid Beheshti University, Tehran, Iran*
[b] *Department of Geography and Urban Planning, Kharazmi University, Tehran, Iran*

Received 8 February 2016; revised 13 July 2016; accepted 3 August 2016

KEYWORDS

Land use/cover change;
CA-Markov model;
Shannon's entropy;
Spatial forms of urban sprawl;
Qom city

Abstract As a response to the challenge of rapid pace of urbanization and lack of reliable data for environmental and urban planning, especially in the developing countries, this paper evaluates land use/cover change (LCLU) and urban spatial expansion, from 1987 to 2013, in the Qom, Iran, using satellite images, field observations, and socio-economic data. The supervised classification technique by maximum likelihood classifier has been employed to create a classified image and has been assessed based on Kappa index. The urban sprawl was also measured using Shannon's entropy based on its primary spatial forms. To our knowledge, measuring urban sprawl based on its spatial forms would contribute to prioritizing policies and specific regulations in dealing with its dominant form. Finally, LCLU change and urban growth were simulated for 2022, using CA-Markov model. The results revealed that dramatic growth of built-up areas has led to a significant decrease in the area of agriculture, gardens and wasteland, from 1987 to 2013. The obtained relative entropy values have indicated that the Qom city has experienced increasing urban sprawling over the last three decades. The continuous linear and non-continuous linear developments along the major roads and highways are the dominant forms of sprawl in Qom city. The CA-Markov model estimated that this unsustainable trend will continue in the future and built-up areas will be increased by 10% by 2022 resulting in potential loss of 438.03 ha agriculture land, 638.37 ha wasteland, and 17.01 ha gardens. Those results indicated the necessity of appropriate policies and regulations particularly for limiting linear sprawl along the main roads.

* Corresponding author.
E-mail addresses: Mosammam2@yahoo.com (H.M. Mosammam), Jaytavakoli@yahoo.com (J.T. Nia), hadi.khani73@gmail.com (H. Khani), teymouri024@gmail.com (A. Teymouri), titan122002@yahoo.com (M. Kazemi).

Peer review under responsibility of National Authority for Remote Sensing and Space Sciences.

http://dx.doi.org/10.1016/j.ejrs.2016.08.002

Please cite this article in press as: Mosammam, H.M. et al., Monitoring land use change and measuring urban sprawl based on its spatial forms, Egypt. J. Remote Sensing Space Sci. (2016), http://dx.doi.org/10.1016/j.ejrs.2016.08.002

1. Introduction

The rapid pace of world's urban population growth, especially in developing countries, is one of the major challenges for governments and planning agencies. Today, 3.9 billion people—54 percent of the world's population—reside in urban areas and is expected to reach 6.3 billion in 2050, with nearly 90 percent of the future urban population increase being in developing world cities (United Nations, 2015). Without any doubt, this trend has been the considerable spatial manifestation and will continue in future. The inevitable outcomes from this process are the spatial expansion of towns and cities beyond their juridical limits and into their hinterlands and peripheries in order to accommodate the growing urban population. In this condition, we will need to adapt to this process. Therefore, effective governance and planning to achieve a more sustainable urban form are crucial for urban planners and policy makers. In other words, urban areas and their spatial extension are needed to minimize wasteful use of non-renewable resources, to avoid the disruption of the ecosystem equilibrium, to reduce social inequities, and to promote inclusive and sustainable development (Burgess and Jenks, 2002; UN-Habitat, 2008). However, since World War II, urban sprawl has gradually become one of the dominant urban spatial expansion patterns throughout the world, with the differences in dates, causes, and consequences (Ewing et al., 2003a; Gill, 2008; EEA, 2006; Gómez-Antonio et al., 2014). The literature review indicated that there is no clear-cut consensus on the definition of urban sprawl which is strongly dependent on the cultural, geographic and political context' (see Torrens, 2008; Besussi et al., 2010). In general, urban sprawl refers to certain forms of city spatial expansion toward suburbs and peripheral areas with, low density, single-use, extensive road and highway networks, car-dependent, open up vast space of territory, scattered and ribbon development in an mono-centric urban structure. (Ewing, 1997; Galster et al., 2001; Hasse and Lathrop, 2003; Zhang, 2001; Tewolde and Cabral, 2011; Gómez-Antonio et al., 2014). In developed countries, it has been fueled by globalization, market economy and dominance of capitalism ideology, particularly in automobile industry and fuel market, as well as reduced livability of inner-city, (Ewing, 1997; Snyder and Bird, 1998; Galster et al., 2001; Besussi et al., 2010); in developing countries, it is often the result of overtaking of urbanization from urban planning, inappropriate government's land and housing policies, urban–rural migrations and low and middle-income household's efforts to find an affordable housing in the urban fringe (see Deng and Huang, 2004; Menon, 2004a,b). However, a major concern with the urban sprawl and LULC change is associated with negative environmental, social and economic impacts (Buiton, 1994; EEA, 2006; Hasse and Lathrop, 2003). The environmental dimension impacts include the loss of fertile lands, open space and biodiversity (Harris, 1984; Benfield et al., 1999; McKinney, 2002; Atu et al., 2013) spoiling water quality (Allen and Lu, 2003; Wilson et al., 2003; Tu et al., 2007), higher GHG emissions and pollutions levels (Glaeser and Kahn, 2004) and increasing runoff and flood potential, and increase of energy consumption. (EEA, 2006; Sung et al., 2013) In the socio-economic dimension urban sprawl leads to excessive infrastructure and public service costs (Lee et al., 1998; Burchell and Listokin, 1995; Batty, 2008) the decline of downtown and public space, reducing social cohesion, loss of a sense of community, reducing public health, safety and security, loss of cultural values (Freeman, 2001; Nechyba and Walsh, 2004; EEA, 2006; Resnik, 2010; Jaeger et al., 2010; Pereira et al., 2014), increase of income inequality and polarization (Carruthers and Ulfarsson, 2003; Brueckner and Helsley, 2011) traffic congestion (Ewing et al., 2003b; Hathout, 2002) longer travel distance and limited access, especially for non-driver people. (Ewing, 1997; Kain, 1992; Bento et al., 2003).

Over the last few decades, the exacerbation of these issues not only has led to rising new approaches to achieving a more sustainable urban form such as smart growth and compact city (Ewing, 1997; Kushner, 2002; Shaw, 2000; Jenks and Dempsey, 2005), but also new methods and techniques have been developed to monitor and analyze urban sprawl phenomenon and its consequences. In an effort to monitor and analyze urban sprawl, some research organizations and researchers (Peiser, 1989; Sierra Club, 1998; El Nasser and Overberg, 2001; Galster et al., 2001; Ewing et al., 2003a) measure urban sprawl by their indicators, while other scholars emphasize the spatial and temporal technologies such as GIS and remote sensing in combination with statistical techniques (Clarke and Gaydos, 1998; Galster et al., 2001; Yeh and Xia, 2001; Hasse and Lathrop, 2003; Thomas et al., 2003; Ji et al., 2006; Jat et al., 2008a; Dewan and Yamaguchi, 2009; Tewolde and Cabral, 2011; Rawat et al., 2013; Deep and Saklani, 2014; Alexakis et al., 2014; Liu and Yang, 2015). However, the mapping and monitoring of urban sprawl and LULC changes using GIS and remote sensing techniques has attracted more interests and has largely proved to be effective and valuable tools for monitoring and estimating urban sprawl over a time period (Yeh and Li, 1997; Masser, 2001; Jat et al., 2008b; Belal and Moghanm, 2011; Butt et al., 2015; Dadras et al., 2015). Those tools are also effective in cost and time related barriers (Epsteln et al., 2002; Haack and Rafter, 2006).

Beyond methods, investigation and monitoring of urban growth and LULC change are necessary to examine the impacts and identifying the points of intervention and to direct growth away from sensitive ecological areas, especially in developing countries. Like most of the developing countries, Iran has experienced high urban population growth in the last five decades. The number of cities has increased substantially from 199 in 1956 to 1139 in 2011, and the urban population has grown about nine times in the same period (Statistical Center of Iran, 2011). According to Statistical Center of Iran, more than 71.4 percent of the Iran's population – 53.646.661 people – living in towns and cities in 2011. In Iran, urbanization growth has been fueled by governments' incentives and policies particularly after Islamic Revolution and disparity in regional development which resulted in urban–rural migrations. One

Please cite this article in press as: Mosammam, H.M. et al., Monitoring land use change and measuring urban sprawl based on its spatial forms, Egypt. J. Remote Sensing Space Sci. (2016), http://dx.doi.org/10.1016/j.ejrs.2016.08.002