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# Environmental monitoring of spatiotemporal change in land use/land cover and its impact on land surface temperature in El-Fayoum governorate, Egypt

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ABSTRACT

Present study aims at monitoring and mapping spatiotemporal changes in Land Use/Land Cover (LULC) and Land Surface Temperature (LST) in El-Fayoum governorate and its districts using Landsat data and GIS. Four multi-temporal Landsat images provided the necessary spectral data to this study. Multispectral and thermal bands were processed, using ENVI 5.1, to produce LULC and LST, respectively. Accuracy assessment was calculated for LULC maps using ground observation points and Google Earth imagery. ArcGIS 10.1 was used to assess LULC changes in nine sectors/districts in the past 26 years in three different periods; 1990–2003, 2003–2013 and 2013–2016. LST of each LULC class was mapped to assess temporal changes of LST responding to LULC changes in the whole governorate. Results showed that the annual rate of land reclamation in the governorate exceeds the annual land loss, as a result urban sprawl, which is explained by the continuous increase in the agricultural lands during the whole period of study. Urbanization and reclamation projects were carried out on expense of the desert bare lands in the desert extension, El-Fayoum El-Gedida and Yousef El-Sediq while in Snorus, El-Fayoum City and District, the urban areas expanded on expense of the agricultural lands during the whole period of study. Desert bare lands exhibited the highest mean LST (> 42 °C) followed by urban, vegetation and finally water bodies for the four studied years. Maximum levels of LST were recorded in 2016; 47.62 °C for bare land, 41.73 °C for urban areas, 39.12 °C for vegetation and 33.41 °C for water bodies. It can be concluded that remote sensing and GIS techniques could successfully be used to assess spatiotemporal environmental impacts of planned developmental projects and uncontrolled human activities on LULC and relationship with LST.

## 1. Introduction

The earth's surface is continuously changing due to natural or human activities; for example, pests, agro-forestry, lightning strikes, wildfires, storms, agricultural expansion, economic, technological, social, historical factors and urban expansion (Borak et al., 2000). Usually, the changes in earth's surface are categorized into land cover and land use (Barnsley et al., 2001). Initially, land cover defines the physical state of the land surface such as wetlands forests/cropland and broadened in consequent usage to include human structures such as pavements, constructions and other structures of the natural environment which include soil category, biodiversity, ground/surface water (Cheng et al., 2008; Jaiswal et al., 1999). Reversely, land use indicates the way in which human beings utilize the land and its resources such as mining urban development, grazing, logging and agriculture. On the other hand, land cover and land use are commonly used interchangeably because two terms are interdependent and closely related (Verburg et al., 2003, 2009).

On the other hand, land use/land cover change (LULCC) could be well-defined as the replacement of one land cover class on the earth's surface or the change of the land (Meyer and Turner, 1992). LULCC is the influence of various related practices operating over space and time (Foody, 2002). Lambin and Ehrlich (1997) recommend that there are three main reasons of LULCC with differing scales and rates; technological and economic considerations, institutional and political arrangements and biophysical factors. To be able to maintain and carry out meaningful and effective policies to sustain territorial development, there is a critical need to identify the LULC forms in the region (Lillesand and Keifer, 1994; Lillesand et al., 2003; Lu et al., 2004).

Fortunately, there is now available documentation of the

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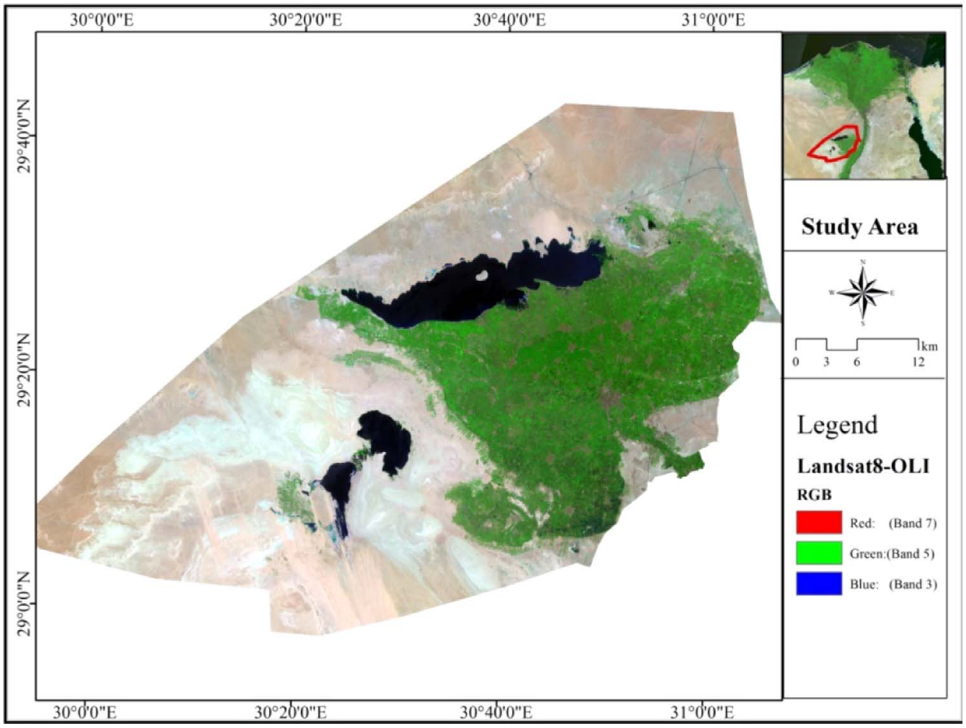


**Fig. 1.** Location map for El-Fayoum Governorate.

spatiotemporal forms of LULC using satellite images which gives the capability to assess the reasons and consequences of change in relation to human activity forms (Cardille and Foley, 2003). Therefore, studying LULCC has been considered an essential research topic in the spatial analysis of remote sensing (RS) since the 1970s (Lo and Shipman, 1990). RS and spatial analyses technology have become accessible to scientists such a potent equipment to identify and map LULCC (Macleod and Congalton, 1998), in vegetation mapping (Müllerova, 2005), in assessment of deforestation (Binh et al., 2005), in coastal zone management (Xie et al., 2011; Kesgin and Nurlu, 2009; El-Zeiny et al., 2016), in detection of land degradation (Fadhil, 2009), in yield evaluation and estimation (Rao et al., 2002), in detection of urban changes (Martinez et al., 2007), in assessing landscape changes (Huiliang et al., 2009) and other applications. RS presents a valuable tool for managing and understanding earth resources and assessing LULCC. Great efforts were made so as to delineate LULC on global and local scales by processing multi-spatiotemporal data from both space borne and airborne sensors (Matinfar et al., 2007).

Medium spatial resolution satellite imagery such as Landsat data are the most broadly frequently used data of observing and assessing land cover changes (Williams et al., 2006). These images were employed for monitoring and evaluating LULCC particularly in the land which are greatly influenced by human activities to various degrees. For instance, Junfeng et al. (2011) exploited multi-sensor Landsat data (i.e. MSS, TM and ETM) images for studying LULCC. Fan et al. (2007) utilized Landsat images (TM and ETM) for identifying LULC in the China Pearl River Delta. Zaki et al. (2011) applied TM images for monitoring changes in land cover in Northeast Cairo of Egypt (Al-doski et al., 2013). Arveti et al. (2016) used geospatial techniques for evaluating LULC in Tirupati Area at South India. Gad and El-Zeiny (2016) assessed and mapped LULCC in El-Fayoum and Wadi El-Natrun Egyptian desert depressions using Landsat ETM images and GIS.

Up-to-date precise information on LULCC is necessary to recognize and analyze the environmental influences of such changes (Giri et al., 2005). Digital change detection is the process of determining and describing land cover changes and land-use characteristics based on co-registered multi-temporal remotely sensed data. The basic principle in utilizing remote sensing images for change detection studies is that the process can recognize change between two or more periods that is uncharacteristic of normal variation. Several scientists have addressed the problem of accurate monitoring of LULCC in wide variety of environments (Singh, 1989; Muchoney and Haack, 1994; Chan et al., 2001; Shalaby and Tateishi, 2007). There are various methods accessible to assess spatiotemporal changes (e.g. image differencing, ratios or correlation, spectral indices, supervised classification) which might be attributable to change (Singh, 1989; Stow et al., 1996; Yuan et al., 1999; Khorram et al., 1999; Gad and El-Zeiny, 2016).

Environmental and urban researches utilize emissivity data and LST for various purposes particularly to investigate LST patterns and relationships with surface properties and UHI forecasts. Further, it is utilized to study the relationship between LSTs and surface energy fluxes so landscape properties, procedures, and patterns can be described and characterized (Weng, 2009). LST can also be used to control the physical, biological and chemical processes of earth systems and is considered a good indicator of the earth's surface energy (Feizizadeh et al., 2013). Studying LST supports the knowledge of spatiotemporal changes on the state of surface stability and therefore is essential in many applications (Kerr et al., 2000). Several research studies depend on LST derived from satellite images such as urban heat island researches, Land use classification, thermal environment, and hydrological investigation in urban growth (Ibrahim, 2017). LST derived from thermal infrared bands of space-borne remotely sensed data, which investigate the relation between urban thermal behaviors, spatial structure and surface properties, is a basic remote sensing application in urban climate studies, as it supports occupation planning (Chen et al., 2006). LST on regional and global scales obtained TIR remote sensing is a distinguished approach because sensors in this spectral region measure the energy that is emitted directly from the land surface (Rose and Devadas, 2009).

Present study aims to assess and map LULC changes in El-Fayoum Governorate using Landsat data and GIS techniques in the past 26 years. Further, the effect of developmental projects and interrupting human activities on LULC is also discussed in districts of the governorate. It also investigates the impact of LULC on LST in the whole governorate.

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