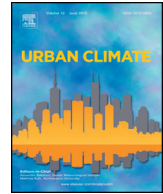




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Effects of urban sprawl on local climate: A case study, north central Iran

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ABSTRACT

Urban sprawl and urbanization as driving forces of land degradation have direct and indirect impacts on local climate dynamic. In this paper, the hypothesis that urban sprawl and unsustainable land use change cause local climate changes has been studied. Tehran as a megacity has been considered to show the urban sprawl and urbanization impacts on local climate. The methodology is divided into two main parts based on the primary datasets (satellite imagery and local climate data). The Landsat images and digital elevation model maps extracted from Shuttle Radar Topography Mission 1 Arc-Second Global data of Tehran acquired in every 5 years during June and July from 1975 to 2015 have been used for this study. The second dataset that has been used in this study contains daily mean temperature and precipitation (from 1990 to 2010) of eight meteorological synoptic stations in the study area. The results show that the rapid and unsustainable urban growth have significant effects on local climate. Moreover, it has been found that the urbanization and urban sprawl as well as unsustainable land use change caused significant change ($P = 0.005$) in evaporation rate in the study area (especially in east and center regions of the city with high population density).

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1. Introduction

The local climate in large cities is increasingly being varied by near surface changes of atmospheric parameters (Jingyong et al., 2005; Saadatabad and Bidokhti, 2011) which caused by unsustainable land use and land cover changes. Changes in land use in the last decades have resulted in a widening debate on the future impact of urban growth (Bhatta et al., 2010; Emadodin et al., 2012; Ramachandra et al., 2012; Arsanjani et al., 2013).

The rapid urban growth is becoming a serious problem in most developing countries (Tewolde and Cabral, 2011). According to the complex activities which take place in the urban area, the issue of urban sprawl and urbanization has been paid especial attention by local decision makers, urban planners, policy makers, climatologists, ecologists and sociologists. Moreover, the urban sprawl plays an important role in sustainable urban development (Tewolde and Cabral, 2011).

Aridity risk as a result of local climate change is one of the most crucial living environmental issues which greatly impacts the social and economic development of the world (Fu et al., 2008; Salvati et al., 2012). On the other hand, human use of degraded lands and land mismanagement (land over use) have led to a reduction in the environmental and economic productivity of terrestrial ecosystems and represent a serious threat to ecological, biogeochemical, and hydrological processes (Sivakumar, 2007; Hellden and Tottrup, 2008; Zhou and WANG, 2011; Salvati et al., 2012). The aridity trend has been further aggravated partly because of regional climate change related to global warming as well as the anthropogenic effects of the rapid development of social economy and the expansion of urban area (Qian et al., 2003; Zhai and Pan, 2003; Fu et al., 2008).

Urbanization and urban sprawl are two different concepts that use in the field of urban studies. Urbanization is a process that a society changes from a rural to an urban way of life and increasing population size that could growth via migration from rural area to the cities, urban sprawl refers to the rapid expansion of the geographic extent of urbanization (Sudhira et al., 2004; Bekele, H., 2005).

The impacts of urbanization and urban sprawl may also lead to environmental degradation damage for hundreds of kilometers outside the cities (Barrow, 1991). The search for economic opportunities draw farm labor from the suburban areas which upset efficient land use and create land degradation (Barrow, 1991). Rapid urban growth and unsustainable land use change not only cause land degradation but a change and variability in local climate that create some extreme natural events (e.g. flood and drought).

For instance, in Tehran province the intensive surface runoff on slopes and floods in valleys has been observed by researchers which is the result of heavy rainfall. These intensive surface runoffs have been caused by unsustainable land use change and land over use (Emadodin and Bork, 2012). Extreme flood events in Tehran province after rapid urban growth and land over use since the mid 1980s have caused economic, social, and ecological damages (Emadodin and Bork, 2012). According to UNISDR (2009) two extreme flood events were recorded in Tehran in 1986 and 1987, which led to 576 deaths, 668 injured, 590 destroyed and damaged buildings (UNISDR, 2009).

Unsustainable land use changes through the urban sprawl and population dynamics have dire consequences for land use and cause serious damage to the natural ecosystem (Arsanjani et al., 2013). Among all kind of impacts that rapid and unsustainable urban growth caused, local climate changes have not received enough attention. It is widely recognized that Land Use/Cover Changes (LUCC) at local, regional, and global scales are one of the crucial driving factors of global climate changes (Foley et al., 2005; Yao et al., 2015).

Several studies indicated that human-induced LUCC is one of the key factors which influence the regional climate (Kalnay and Cai, 2003; Paeth et al., 2009; Yao et al., 2015). LUCC also plays an important role in climatic systems by means of bio-geo-physical effects (Jingyong et al., 2005). The bio-geo-physical feedback mechanism basically manifests the changes of physical features of the earth's surface such as roughness, surface albedo, soil moisture, and vegetation coverage and structure (Pielke, 2005). The mentioned physical features influence the radiation, heat, and moisture exchange process between the surface and the atmosphere (Crutzen and Andreae, 1990). Beside LUCC factors; density of built-up area, urban geometry, city location, urbanization factors, the size of the city and population can affect the local and regional climate change as well (Shahmohamadi et al., 2009). These effects directly result in the changes of air temperature, humidity, precipitation, visibility, surface energy fluxes, anthropogenic heat emission, air pollution and wind speed (Deng et al., 2013, 2014; Yao et al., 2015). The information on LUCC produces great effect in the climate change assessment (e.g. land surface temperature and precipitation) (Wang and Ge, 2012; Woldemichael et al., 2014). As an important source of considerable human activities, urbanization causes LUCC over the urban areas (Singh et al., 2014; Yao et al., 2015).

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