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Effect of environmental policies in combating aeolian desertification over Sejzy Plain of Iran

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ABSTRACT

Wind erosion in arid and semi-arid regions is a serious concern because it can cause land degradation and consequently affect the land use pattern. The aim of this study was to assess the variations of aeolian sediments and gypsum sediment surfaces (ASGSS) during 1992–2017 in Sejzy Plain and to analyze the impact of plans against desertification, as well as human and environmental activities on the variations of these surfaces. In the current study, Landsat satellite images were classified using the multiple layer perceptron (MLP) neural network. Finally, the logistic regression model has been used to study the impact and role of plans against desertification, human and environmental activities on the ASGSS variations in the studied area. The ASGSS decreased from 37.9% in 1992 to 24.3% in 2017 in the study area. Investigation of the effect of aeolian desertification in the region showed that planting stabilizing species and preventive measures taken in controlling gypsum-mining activities and grill areas, especially in the northern parts of the region has prevented further variation in the gypsum sediment cover. The results indicate that the planting of stabilizing species in lands outside the ASGSS has a greater effect on reducing ASGSS, in comparison with the planting of stabilizing species in the interior lands of the and ASGSS. Also, the results show that policies related to plans against desertification have been useful in reducing lands with ASGSS.

1. Introduction

Natural environments are influenced by changes caused by natural and human factors; thus, planning and management of these environments is needed to monitor such changes. In addition, identifying and assessing trends over time and the effects of constructive and destructive activity on the environment can be used as a basis of planning for sustainable development.

Wind erosion in arid and semi-arid regions is a serious concern because it can cause land degradation and consequently affect the land use pattern (Santra et al., 2017; Webb et al., 2006). Wind erosion typically causes problems such as soil fertility degradation (Goudie, 1999), crops production loss and associated economic loss (Hagen et al., 2007), visibility reduction (Blackburn, 2006), and air pollution (Webb et al., 2017). Some studies have shown that most aeolian sediments carried with wind are deposited near the source area (Hagen et al., 2007). The emission and transport of Aeolian sediment causes significant problems for human settlements, transportation networks, vegetation cover, adjacent agricultural land and irrigation networks (Holmes et al., 2012; Webb et al., 2017).

In recent years, remote sensing (RS) and the geographic information system (GIS) technologies have been used to monitor changes in natural environments (Amin and Fazal, 2017; Frohn and Lopez, 2017; Kennedy et al., 2009; Tarolli et al., 2009; Yang and Shi, 2018). Satellite image processing algorithms were used to understand current situation or past trends of surface process (Firozjaei et al., 2018; Milan et al., 2007; Moghaddam et al., 2015; Panah et al., 2017; Telfer et al., 2015; Weng et al., 2018; Willis, 2015; Yao et al., 2011). The use of spatial analysis of the effects of different factors was examined and spatial relationships discussed.

Remote Sensing technology is used to monitor changes in natural environments to decrease time and cost spent. Satellite data offers unique multi-temporal and multi-spectral properties and expands the coverage area providing good facilities with which to study dynamic

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phenomena. It provides valuable information for understanding and monitoring patterns and land development in addition to creation of land cover and land use maps (Hu et al., 2016; Were et al., 2013). The use of GIS technology allows comprehensive assessment of the environment accompanied by the risk factors associated with it (Merrett and Chen, 2013; Satapathy et al., 2008).

In recent years, considerable interest has been created in the application of tools related to GIS technology and remote Sensing data to study land cover and land use changes (Butt et al., 2015; Guo et al., 2017; Latifovic et al., 2005). (Anderson et al., 2010; Pacifici et al., 2009; Weng et al., 2017) used neural networks to classify different surfaces. Studies that used remote sensing data to assess desertification include (Symeonakis and Drake, 2004; Tao, 2014; Wang et al., 2017; Weng et al., 2017; Xu et al., 2017). Logistic regression is a statistical model belonging to a group of generalized linear statistic models that provides a powerful device for organizing data analysis. In many environmental studies such as desertification, land degradation and human-caused events, this model has been used to identify influential factors on environmental changes (Djeddaoui et al., 2017; Dubovyk et al., 2013; Huang et al., 2007; Zhang et al., 2010).

Sejzy Plain is located 20 km east of the city of Isfahan in central Iran. In recent years, it has become the source of first-grade wind erosion. Natural and human factors are involved in the development of aeolian desertification in the region. Aeolian desertification is a type of land degradation because of wind erosion resulted from the extreme human activities in arid and semi-arid regions (Tao, 2014). Low rainfall, high evaporation and severe wind are among the natural factors. Uncontrolled exploitation of groundwater and surface water leading to groundwater salinization, unprincipled exploitation of gypsum mines, loss of protective soil surfaces (crusts) caused by mining activity, the movement of heavy vehicles, expansion of gypsum furnaces and intensification of land degradation are human factors. Only more than 5000 ha of Sejzy Plain lands have been destroyed because intensive exploitation of gypsum and other building materials (Department of Natural Resources and Watershed of Isfahan Province, 1995).

Eastern Isfahan, with its industrial, logistical and military facilities, enjoys a strategic location. However, aeolian desertification and land degradation, followed by sandstorms and the suspension of dust in the air has damaged the ecological, economic and social aspects of the environment. An example of this includes damage to the facilities of Shahid Beheshti International Airport and Shahid Babaee air base, industrial and economic damage to factories and railways in the region, accidents leading to loss of life and property on the Isfahan-Bandar Abbas route, damage to agricultural land and orchards in the region and creation of dust and air pollution in Isfahan and its environs. On some occasions, relatively dense dust covers the city of Isfahan (Department of Natural Resources and Watershed of Isfahan Province, 2015). Studies on fine particulates in Isfahan confirm that dust mainly originates from deposits east of Isfahan (Mahmoudi and Khademi, 2014; Norozi, 2015).

The Iranian government signed the United Nations Convention on Combating Desertification (UNCCD) (UN, 1995), and based on the national action plan against desertification promulgated in 1996. The national action plan to combat desertification is programs for the Convention implementation at country level (Wang et al., 2013). The basic objectives of the national action plan on combating desertification are prevention of land degradation, rehabilitation of degraded land and reclamation of desertified land (UN, 1995). The Iranian national action plan includes sub-regional and regional action plans to combat desertification in different part of country (Range, 2005). The Combat to Desertification department of Natural Resources and Watershed organization has taken action against aeolian desertification in Sejzy Plain by planting *Haloxylon ammodendron* (C.A.Mey.) in different periods, prevention of mining, shutting down 38 furnaces and, in recent years, implementing a 10-thousand ha action plan to plant stabilizing species against desertification. These include planting stabilizing species (such *Tamarix*, *Nitraria* and *Calotropis procera*), irrigation and protection (Department of Natural Resources and Watershed of Isfahan Province, 2015).

The present study was undertaken to monitor variations in the aeolian sediments and gypsum sediment surfaces (ASGSS) to discover the effects of action plans against desertification implemented in eastern Isfahan. The modelling of spatial patterns of variation in ASGSS gives valuable information for better understanding of the process of change and to determine the effect of the plans. The importance of recognizing environmental changes can be understood when integration of data revealed the availability of the objectives envisaged by the plans implemented against desertification. Also, the impact and success rate of policies and plans against desertification implemented by the local government is to be assessed. The results of this study could be a useful for making optimal decisions by planners and decision-makers. This study has prepared some references for the plans and projects implemented by local governments and for researchers who studied about aeolian variations that affect cities.

2. Study area

Sejzy Plain east of the city of Isfahan in central Iran is located between 51°57′ and 52°9′ E longitude and 32°34′ and 32°50′ N latitude (Fig. 1). This region is an area of approximately 433 km^2 and is divided by the Isfahan-Nain road into two parts (north and south). A major feature of the Sejzy Plain is the fine-grained material of the region. The prevailing wind direction in Sejzy Plain transports the fine-grained colloidal material from the fields and meadows surrounding the plain towards the plain. Gypsum and sand mining in the area has severely damaged the surrounding plains and the chalky sediment has been spread by the wind, burying fertile soil and natural vegetation (Fig. 2). There are about 220 furnaces in this area which produce bricks and gypsum (Department of Natural Resources and Watershed of Isfahan Province, 2015).

3. Methods

The methods applied in this study consist of four steps (Fig. 3). The first step is to apply atmospheric correction on satellite images. The second step is to classify satellite images. The training data set and the neural network classification algorithm are used in this step. In the third step carried out the assessment of ASGSS variations using the Cross-Tab model. Finally, the logistic regression model was considered to assess the effect of environmental policies on ASGSS variations and in combating desertification.

3.1. Data and preprocessing

The three satellite images used in this study were acquired by the thematic mapper (TM), enhanced thematic mapper plus (ETM+) and operational land imager (OLI) sensors from Landsat satellites for January 1992, 2002 and 2017 (path/row 164/37). The image from 1992 reflects the situation in the region before implementation of the plan against desertification, the image from 2002 reflects the situation 7 years after implementation and image from 2017 represents the situation after implementation of major plans against desertification. These satellite images were used to examine changes in the area over time. The accuracy of the classification results and extraction land surface variations are directly related to the spectral properties of the various surfaces. In addition to the effect of surface biophysical properties on spectral properties, the climatic factors and seasonal changes also affect the spectral properties of land surfaces. This study uses images for 1992, 2002 and 2017 correspond to the same month of the year (January) so that changes in climate and seasonal conditions do not affect the results of the study. Also, for selected dates, climate conditions such as air temperature, relative humidity and precipitation