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Long term monitoring and assessment of desertification processes using medium & high resolution satellite data

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ABSTRACT

Desertification is one of the major environmental problems, affecting the living conditions of millions of people all across the world. Inventory and monitoring of the desertification status are the primary requirement in preparation of mitigation plans to combat desertification. The objective of the present paper is, therefore, to prepare spatial inventory of desertification status that provides information on the spatial extent of the area under desertification, its type and severity. Multi-season Landsat data of 30 m spatial resolution, pertaining to the years 1991, 2000 and 2016, have been analysed to prepare desertification status map (DSM) at 1: 25,000 scale for Jaitran Taluka, Pali district, Rajasthan state in western India. Monitoring and assessment of desertification has been carried out for a period of 25 years. Area under desertification in the Jaitran taluka has increased from 13080.22 ha to 15376.37 ha during the past 25 years. Preparation of desertification combating plans, which can be implemented in the field, requires DSM at cadastral scale. Therefore, DSM were also prepared on 1: 10,000 scale using very high spatial resolution data of Resourcesat-2 LISS-IV. Spatial information on land use, desertification status (extent, type and severity) extracted from the above DSM and the information on topography and morphology, inferred from Cartosat-1 images (2.5-m spatial resolution, panchromatic stereo) were used to suggest local specific actions for combating desertification.

1. Introduction

Desertification is one of the greatest environmental problem, affecting about one fifth of world population, 70% of drylands and one-quarter of the total land area of the world.

Every year, an additional 200,000 km^2 of productive land is lost due to desertification (Abahussain, Abdu, Al-Zubari, El-Deen, & Abdul-Raheem, 2002). Land degradation in drylands is called desertification (UNCCD, 1994, p. 58). . Arid, semiarid and dry sub-humid lands, put together are, called drylands. Areas for which the ratio of annual precipitations to potential evapotranspiration (called Aridity Index) falls within the range 0.05–0.65, are considered as drylands. Land degradation has a broad range of definitions that essentially describe circumstances of reduced biological productivity of the land (Reynolds & Stafford Smith, 2002; UNCCD, 1994, p. 58). Land degradation includes various processes such as physical (soil erosion by wind and water, water logging, soil compaction and crusting, mass wasting, etc.), chemical (acidification, salinization, alkalization), and biological (vegetal degradation, decline in bio-diversity). Land degradation is a process which may finally turn a “productive land” into ‘degraded’ or ‘waste land’

Desertification has a multidimensional interpretation. Some researchers consider desertification to be a process, while others view it as the end result of the process (Glantz & Orlovsky, 1983). The definition of desertification and the evolution of the desertification concept have been reviewed by many authors (Ajai et al., 2007; Ajai et al., 2009; Bai, Wang, & Xiong, 2013; Brabant, 2008; Brabant, 2019; Eswaran, Lal, & Reich, 2001; Puigdefabregas et al., 2009; Reynolds & Stafford Smith, 2002; Reynolds et al., 2007; Reynolds et al., 2011; Safriel, 2007; Thomas & Middleton, 1994). However, the most comprehensive and widely accepted definition is from the UNCCD which states that “ desertification is land degradation in arid, semi-arid and dry sub-humid areas resulting from factors including climatic variations and human activities” (UNCCD, 1994, p. 58). Impact of desertification on ecological processes are many and complex, including negative changes in vegetation properties (such as biomass, density, vegetation cover), loss of biodiversity and soil fertility and changes in landscape patterns over dry regions at different geographical scale (Thorns & Brandt, 1996; Xu, Kang, Qiu, Zhuang, & Pan, 2009). In broader sense, desertification may lead to complete failure of balance between

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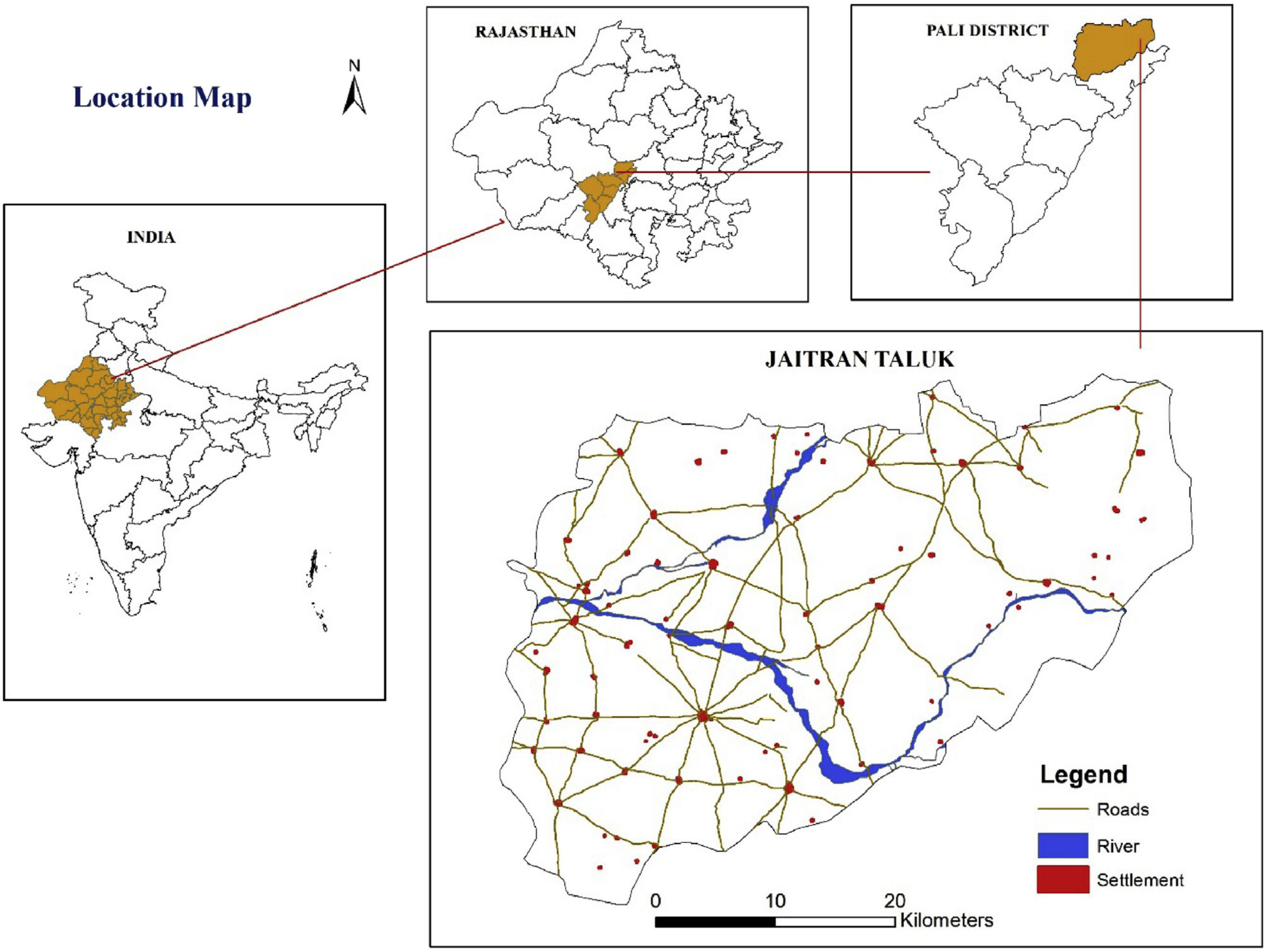

Fig. 1. Location map of the study area.

demand and supply of ecosystem services in drylands (Biro, Pradhan, Buchroithner, & Makeschin, 2013). Therefore, combating desertification is essential to ensure the long term productivity of inhabited drylands (UNCCD, 2001).

Spatial inventory, monitoring and assessment of land degradation/desertification extent along with its type and severity, are prerequisite in formulation of strategy to mitigate and rehabilitate the menace of land degradation. Field based surveys and orbital remote sensing are methods for studying and mapping and monitoring the status of land degradation and desertification as well as to identify the areas vulnerable to desertification. Advantages of using remote sensing technology include synoptic and repetitive coverage, real-time data acquisition, cost-effectiveness and faster than ground methods and facilitate long term monitoring (Albed & Kumar, 2013).). Extensive research using satellite imagery along with GIS have been conducted for mapping and monitoring land degradation/desertification, mostly with multispectral sensors, including Landsat, ASTER and the Indian Remote Sensing (IRS) series of satellites (Ajai et al., 2007, 2009; Bai et al., 2013; Brabant, 2019; Chikhaouim, Bonn, Bokoye, & Merzouk, 2005; Dhinwa, Dasgupta, & Ajai, 2016; Dube, Mutanga, Sibanda, Seutloali, & Shoko, 2017; Dwivedi, 2001; Kwanele & Njoya, 2017; Lanfredi et al., 2015; Sepuru & Dube, 2018; Shalaby & Tateishi, 2007; Verma, Saxena, Barthwal, & Deshmukh, 1994). There are indicators of desertification which can be derived from the satellite data and can be used for mapping and monitoring of desertification. These indicators include, vegetation cover, vegetation biomass, net primary production, and land use/land cover change. Satellite derived vegetation indices such as NDVI andSAVI (as surrogate to vegetation biomass) and Rain Use Efficiency (RUE) models have been used by researchers (Bai, Olsson & Schaepman, 2008; Dardel et al., 2014; Shoba and Ramakrishnan, 2016; Kundu, Patel, Saha, & Dutta, 2017; Varghese & Singh, 2016; Wessels et al., 2007) to study desertification. El-Kawy et al. (2011) have used multi-temporal satellite data to monitor long term land use/land cover change and identified land degradation in the western Nile delta of Egypt. Jiang and Lin (2017) have used MODIS derived NDVI, fraction of vegetation cover, land surface temperature and soil moisture to study the desertification status in the South Junggar basin, China. Ajaj, Pradhan, Noori, & Jebur, 2017 have used land cover changes, derived from Landsat data, to monitor desertification extent in western Iraq. Wijitkosum, 2016 has studied the impact of long term land use change on the desertification risk in Thailand.

The identification of suitable indicators for inventory and monitoring of desertification is critical (Reed et al., 2013). Moreover, the indicator based methods for land degradation/desertification inventory are unable to identify the process or type of land degradation and hence such inventory may not be useful in making action plans for combating desertification/land degradation. Combating strategies are different for different types of land degradation processes. Desertification-induced changes in land surface conditions are easily captured by satellite sensors, and hence satellite images can also be used to identify and map various processes/types of desertification/land degradation(Ajai et al., 2007, 2009; Brabant, 2019; Kharin, 1986).

The scale at which the spatial inventory on desertification needs to be generated depends on the purpose and the size of the geographic area to be covered (Ajai, 2004; Brabant, 2019). Mapping at block/taluka level, requires mapping and monitoring at 1:25,000/50,000 scale