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Assessment of land degradation and desertification due to migration of sand and sand dunes in Beluguppa Mandal of Anantapur district (AP, India), using remote sensing and GIS techniques

B. Pradeep Kumar, K. Raghu Babu*, M. Rajasekhar and M. Ramachandra

Department of Geology, Yogi Vemana University, Kadapa, Andhra Pradesh, India.
*Corresponding author: dr.kraghu@gmail.com

ABSTRACT

Land degradation and desertification by means of sand migration, is one of the major problems facing the world today. Degradation is the process of conversion of productive land into waste land or degraded to desertified land. Degradation is influenced by the natural and anthropological causes in arid and semi-arid regions. According to a report by the Indian Space Research Organization (ISRO), 96 million hectors or 30 percent of India's agricultural land, is affected by the land degradation. The present study deals with identification, mapping and assessment of desertified areas in Beluguppa Mandal of Anantapur district, using geospatial techniques, aided by Landsat satellite images. The main reason for land degradation and desertification of this area is the migration of sand and sand dunes by aeolian process. Present study is focused to define the desertification in the study area during 18 years period beginning 2000 and onwards. Hence, temporal data of Landsat satellite image of past 18 years (i.e., 2000-2018), were collected and processed, to know how much of land is covered by migrated sand dunes and get desertified. By using geospatial technologies like satellite remote sensing (RS) and geographical information system (GIS), identification and mapping of desertified areas and progress of desertification were made in the present study. The results of the present study clearly reveal that 26 hectares of agriculture land is desertified in Srirangapuram village, and an area of 14 hectares of agriculture land is desertified in Narinjagundlapalle village in Beluguppa mandal of Anantapur district, A.P.

Key Words: Desertification, waste land, Semi-Arid, Landsat, Geospatial techniques, Anantapur district

INTRODUCTION

Land degradation and Desertification is one of the major environmental problem facing the world today. Nearly one fifth of the world population suffocates from desertification conditions. In fact, 33 percent of earth surface is degraded and exhibits desert like conditions. Arid, semi-arid and sub-humid regions all together form part of drylands. In the United Nations conference at Nairobi during 1977, the issue of Desertification (UNCOD) was described as the desertification happening because of destruction of biological potential of the land. Subsequently, the evolution of the desertification and its definition have been revised by many researchers (Thomas and Meddleton, 1994; Eswaran et al., 2001; Reynolds and Stafford-Smith, 2002; Anonymous, 2005; Budihal et al., 2006; Reynolds et al., 2007; Safriel, 2007; Ajai et al., 2009; Bai, et al., 2011; Arya et al., 2014; Amal Kar, 2016).

However most comprehensive and widely accepted definition of "Desertification" refers to land degradation happening in arid, semi-arid and sub-humid areas, resulting from the factors including climatic changes and human activities (UNEP 1992).The fact is that the ecosystem is seriously affected by the desertification (Lam et al., 2011). Many of the anthropogenic process, shifting of cultivation and deforestation, non-sustainable land use practices, mining, urbanization, road construction and other activities that sternly disturb the natural ecosystem. Therefore, combating desertification is essential to ensure the long term productivity of inhabited drylands (UNEP 1992). There are five types of indicators, (i) physical, (ii) climatic, (iii) biological, (iv) hydrological, and (v) socio-economic, which are used for monitoring and assessment of desertification or land degradation and their prediction (Dhinwa et al., 2016). In India, states like Rajasthan, Delhi, Gujarat, Goa, Maharashtra, Jammu and Kashmir, Odisha, Madhya Pradesh, Karnataka, Telangana and Andhra Pradesh are facing such problems like land degradation and desertification conditions.

The present study in Beluguppa Mandal of Anantapur district, situated in the south central part of Andhra Pradesh, falls under the semi-arid climatic regions. Drought and desertification are known as the common features of the arid and semi-arid regions, as mentioned before. The main reason of desertification in the study area is shifting of sand and sand dunes by the aeolian process. RS along with GIS have been used for desertification mapping the study area (Ajai et al., 2007, 2009). This mapping will help to take action plans and mitigation of desertification of the study area.

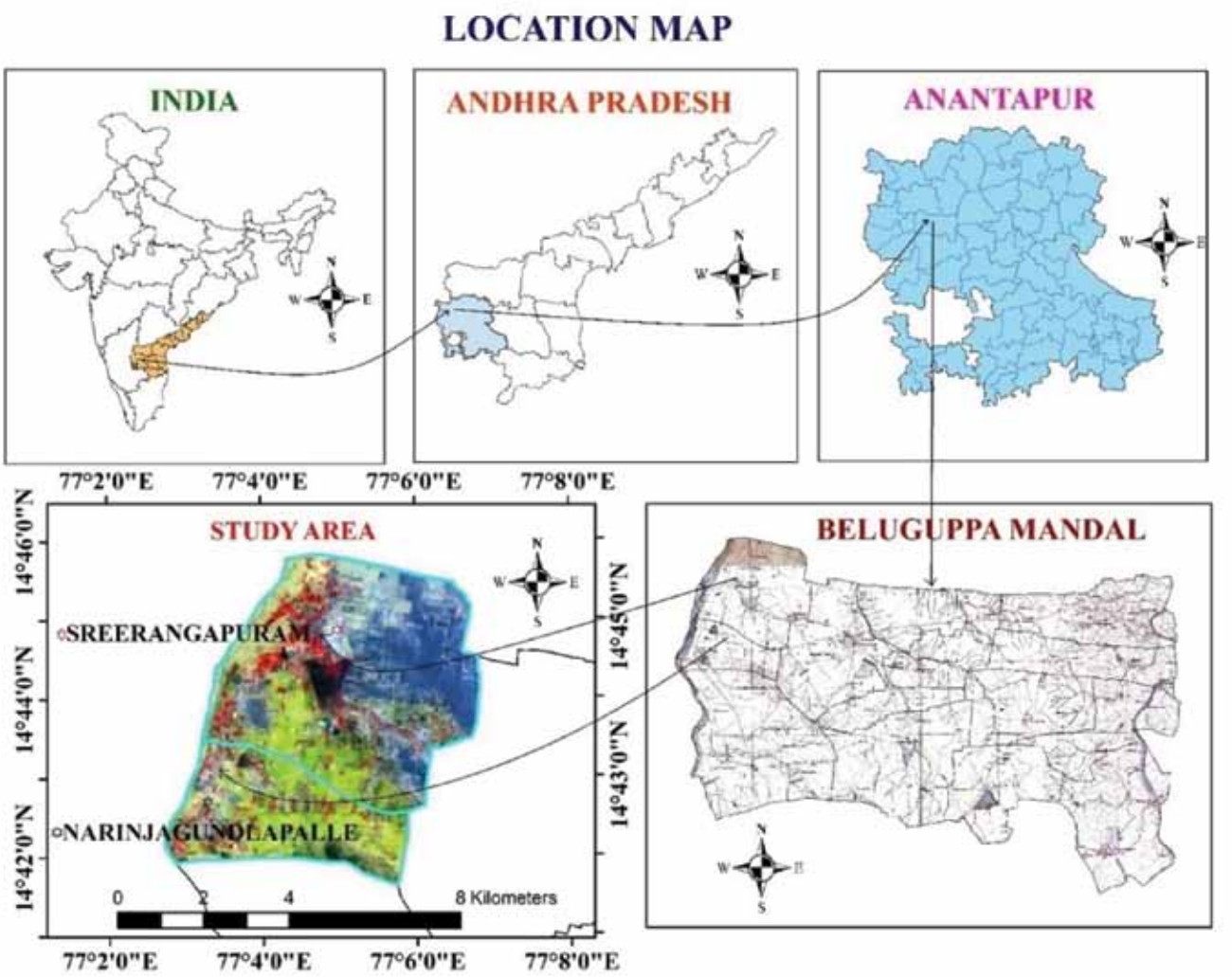

Figure 1. Location map of the study area.

STUDY AREA

Anantapur district which falls in the rain shadow area of Western Ghats and in the interior of Deccan Plateau, is the one of the chronically drought affected district in the country. The district is bounded by Kadapa District in the north-east, Kurnool District in the North, Chittoor District in the south-east, and Karnataka State on the West. Being located in the rain-shadow region of Andhra Pradesh, the district is drought-prone. It has geographical area of 19,130 Sq. Km. The district with an average annual rainfall of about 520 mm is lowest in the state and is identified as the second driest part of the country, next to Jaisalmer. Anantapur experience tropical climate with temperature ranging from 24 to 46° C in summer seasons which continuous from March to May. In Anantapur, most of the people depend on agriculture for their livelihood. In this district, there are two main cropping seasons: Kharif crop season (Monsoon) during July to September or October and Rabi season (winter) during November to April. The villages Sreerangapuram and Narinjagundlapalle of Beluguppa Mandal in the Anantapur district are the foci of the present study. The Mandal Beluguppa is bounded by Kanekal Mandal towards north, Kudair Mandal towards East, Kalyandurgam Mandal towards South, and Rayadurgam Mandal towards west. The study area Beluguppa Mandal is located in the Survey of India (SOI) topographical maps of 57 F/1, 57 F/2 and 57 F/6. (figure1). It has geographical area of 341 sq.km. There are two major rivers that flow through this Mandal; one is Hagari or Vedavathi and another one, Penna River. Hagari or Vedavathi River which flows on western part and Penna River is in eastern part, both are seasonal or ephemeral rivers and thus, they get dry during most of the year. Hagari River flows through Mandal's of Bommanahal, D-Herehal, Kanekal, Beluguppa, Gummaghatta and Brahmasamudram in Anantapur District and then enters in Karnataka state. Most of the Soil types in Beluguppa Mandal are Black Soils and Red soils.

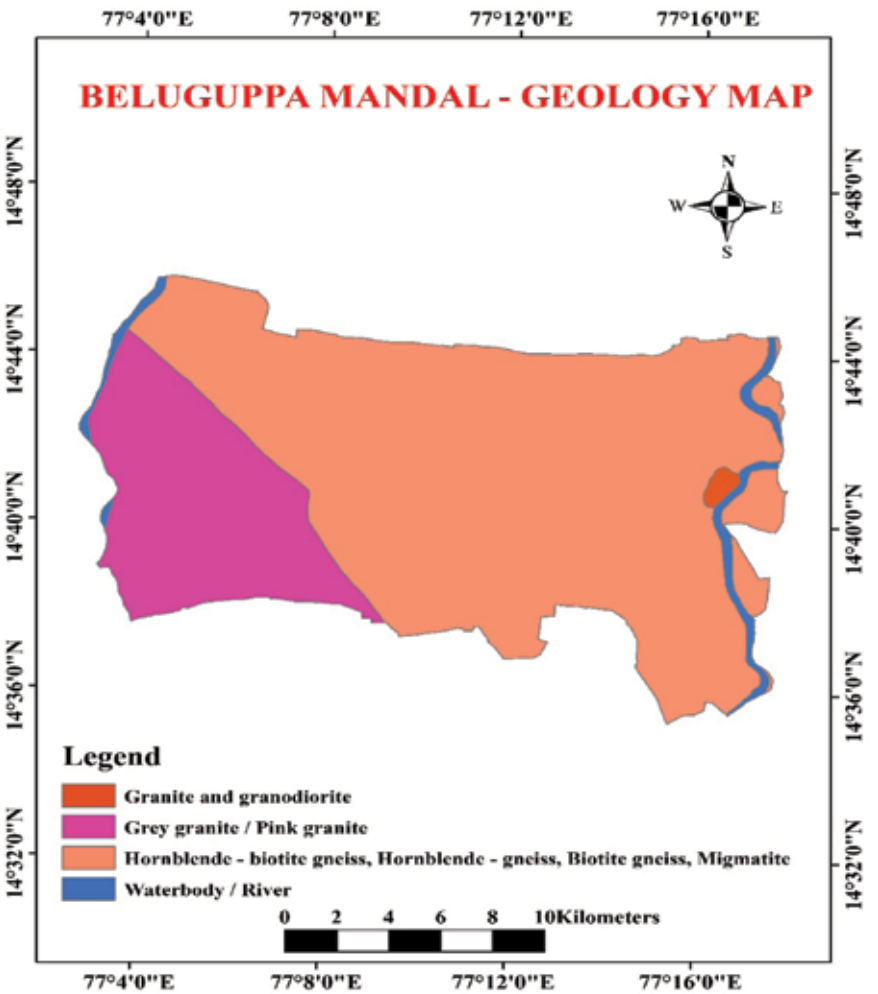

Figure 2. Geological map of the study area.

GEOLOGY OF THE STUDY AREA

Geological formations in Anantapur district are mainly divided into two distinct and well-marked groups: younger groups of sedimentary rocks belonging to the Proterozoic age and the older groups of metamorphic rocks that belong to the Archean age. Figure 2 shows the Geological map of the study area. The major rock types present in the study area are Peninsular Gneissic Complex consisting granite, granodiorite, felsic hornblende-biotite gneiss, hornblende gneiss, biotite gneiss and migmatites, which are present in eastern part of the study area and belong to Archean age. Grey granite/pink granite is present in the south western part of the study area.

GEOMORPHOLOGY

The villages of Beluguppa Mandal under the present study, are associated with active geomorphic changes by the aeolian processes. Sandy soils and alluvium is seen along the Hagari or the Vedavathi River areas. Here, the sand and sand dunes are spreaded by the action of wind. Sand and sand sheets or sand dunes are developed here under a range of environmental and climatic conditions. Sand dunes play very important role in the change of environmental ecosystems, which may be classified in many ways, like size and shape of the dunes, occurrence of environment, degree of internal complexity and the direction of wind. There are five main types of dunes, transverse, oblique, barchans, longitudinal and parabolic. Transverse and linear dunes are found in the area of the present study. Because of low rain fall in the area, the soil type is sandy soil. The low moisture also means that silt and sand-sized particles are easily blown away, while the remaining particles eventually form a tightly packed layer, known as desert pavement (Pradeep Kumar et al., 2018). The geomorphology of the study region shown in Figure 3.

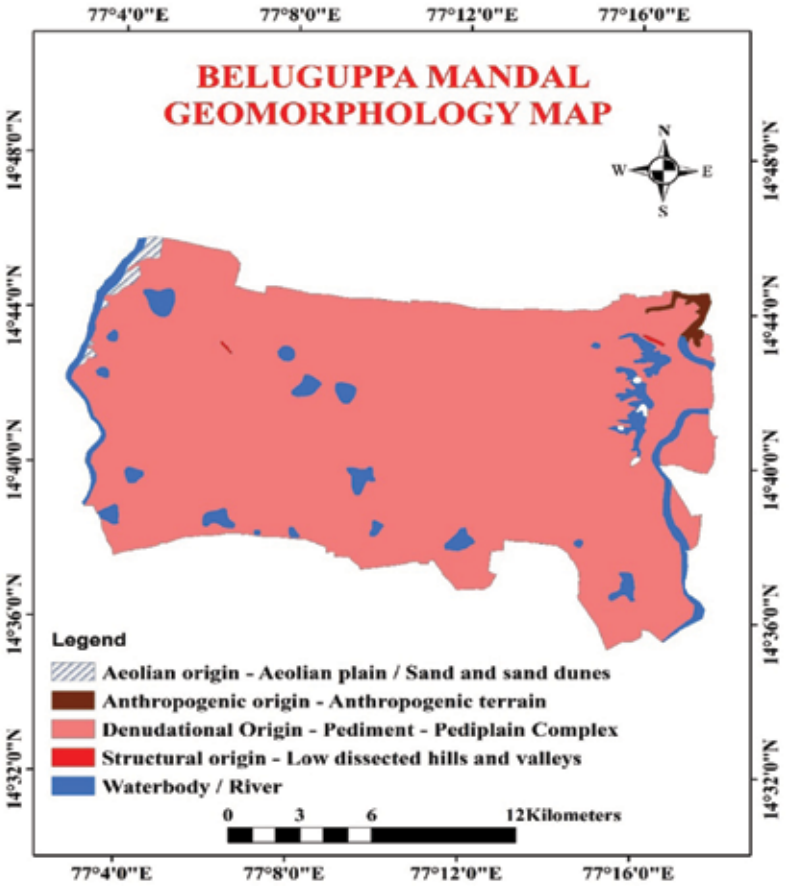

Figure 3. Geomorphology of the study area.

Table 1. Data used

	Data used	Spatial resolution	Year of acquisition	source
Satellite Data	Landsat 4-5	30m	2000	http://www.usgs.glovis.gov
	Landsat 7	30m	2010	
	Landsat 8	30m	2018	
Ancillary Data	SOI maps- 57F/1, 57F/2, 57F/6	1: 50, 000	1962	Survey of India
Collateral Data	Soils, Climate etc.			Groundwater Department, Anantapur District, Andhra Pradesh.

DATA

To prepare desertification status map of Sreerangapuram village of Beluguppa Mandal of Anantapur district (Andhra Pradesh, India), ancillary data like Survey of India (SOI) topo sheets, with 1: 50,000 scale and Landsat data, freely downloaded from (http://www.usgs.glovis.gov) is used. For the preparation of Geology and geomorphology map of the study area, required data has been downloaded from NRSC (National Remote Sensing Center) (http://www.nrsc.gov.in) website (Sources: Table 1).

METHODOLOGY

The present study aims to identify the land degradation or desertification areas of Sreerangapuram and Narinjagundlapalle villages of Beluguppa Mandal. Ancillary data of SOI (Survey of India) topographic maps with 1:50000 scales were used to demarcate the mandal boundary as the base map. Required remote sensing satellite data has been collected from USGS website. Landsat data (ETM+, TM and OLI) of eighteen years has been collected from 2000 to 2018 and layer stacking is done by using ERDAS Imagine

Table 2. Details of the Sreerangapuram and Narinjagundlapalle villages.

Name of the Village	Longitude	Latitude	Total areal extent
Sreerangapuram	77° 04' 02.36"	14° 44' 44.89"	27.06 Sq.km (2706 Hectares)
Narinjagundlapalle	77° 03' 08.10"	14° 42' 37.61"	11.35 Sq.km (1135 Hectares)

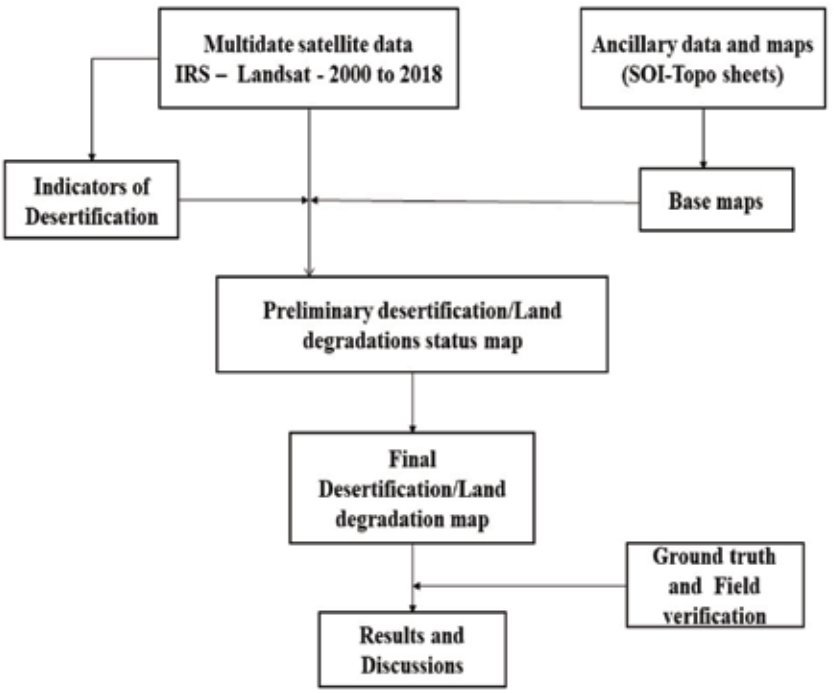

Figure 4. Methodology for preparing DSM (Desertification Status Map).

2014. Before processing the satellite images, the detailed field survey is carried out in the Beluguppa Mandal and GPS (Global Positioning System) points were collected for getting the exact locations of sand dunes or sand migrated areas (Table 2). The downloaded satellite imageries are layer stacked process through ERDAS Imagine 2014 software and given natural color compound 4, 3, 2, and 7, 6, 4. Using this high resolution data in Geographical Information System (GIS), shape files are created and the images were geo-referenced with coordinate system WGS1984. In the Landsat image, the Hagari or Vedavathi River is focused, where the sand is originated and migrated from the river banks to the adjoining villages. The red tone in the image, specifies the vegetation. Usually water absorbs light, so it appears black or dark blue, mud is in brown and suspended sand and sand dunes appears in white color. The detailed methodology is given in Figure 4.

Data has been processed for the preparation of DSM (Desertification Status Maps). Geometry calculation technique is used for knowing the rate of migration of sand/sand dunes. By using the ArcGIS 10.4, and Landsat imagery (layer stacked by using ERDAS), the study areas was demarcated and a polygon line was drawn through the edge of sand migrated areas.

RESULTS AND DISCUSSION

The study area of Sreerangapuram and Narinjagundlapalle villages in Beluguppa mandal with the land extent of 27.06 Sq. km and 11.35 Sq. km in area, desertified to the extent of about 2.73 Sq.km and 0.85 Sq. Km respectively. These areas are faced with migration of sand and sand dunes because land degradation and desertification. Hagari or Vedavathi River is the place of origination of the sands for this migration, which flows through the western side of the study region. During the months June to august strong surface winds flows west to eastern side, because of this strong surface winds, the sand has been migrated to the agricultural fields which reduced the soil fertility and caused desertification conditions. The satellite image (Figure 5) and Plate 1 give the clear picture of migration of sand and sand dunes in the study area. Different size and

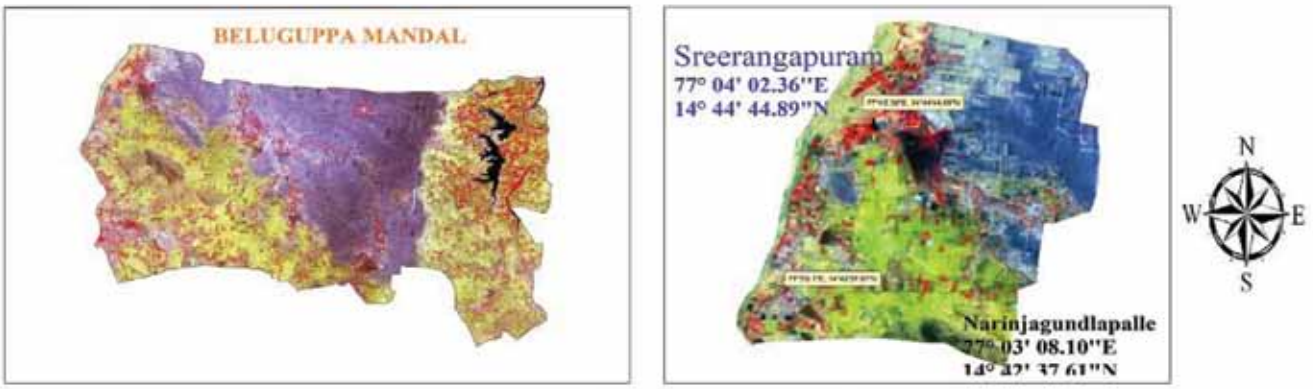

Figure 5. Satellite image of Beluguppa Mandal showing the sand migration/desertification.

Plate 1. Field photos collected in the sand migrated/desertified villages of Sreerangapuram and Narinjagundlapalle villages of Beluguppa Mandal

shapes of the sand dunes present in these villages, where linear and transverse type of dunes are very common. In the Landsat images, different colour indicates various things like: different shades of red and green colour indicates agricultural or vegetation, water absorbs light so it shows in blue or black in colour, brown or tan colour represent light vegetated ground and the sand is in yellow to white in colour (Ajai et al., 2009). Plate 1 shows the location of the study area and the intensity of sand migration in the field.

Changes in 18 years span are calculated through geometry calculation technique used in this study, which clearly reveal (Table 3) that the sand and sand dunes were migrated continuously and desertification process is very active in this areas. For example, the Sreerangapuram village has a total extent of 27.06 Sq.km area, in which the sand migrated area is about 2.44 Sq.km that means 244 hectares of land is desertified in the 2018 year. Similarly, Narinjagundlapalle village has a total extent of 11.35 Sq.km of land and in that, 0.49 sq.km of land is migrated, which means 49 hectares of land losses the soil fertility and desertified.

In a decade from 2000-2010, in Sreerangapuram village, sand migration increased from 2.44 Sq.km to 2.62 sq.km, which is about 262 hectares. Similarly, in Narinjagundlapalle village, it increased from 0.49 sq.km to 0.63 sq.km, i.e. 63 hectares of land is degraded/ desertified. In subsequent decade (from 2010 to 2018), in Sreerangapuram village , it further increased from

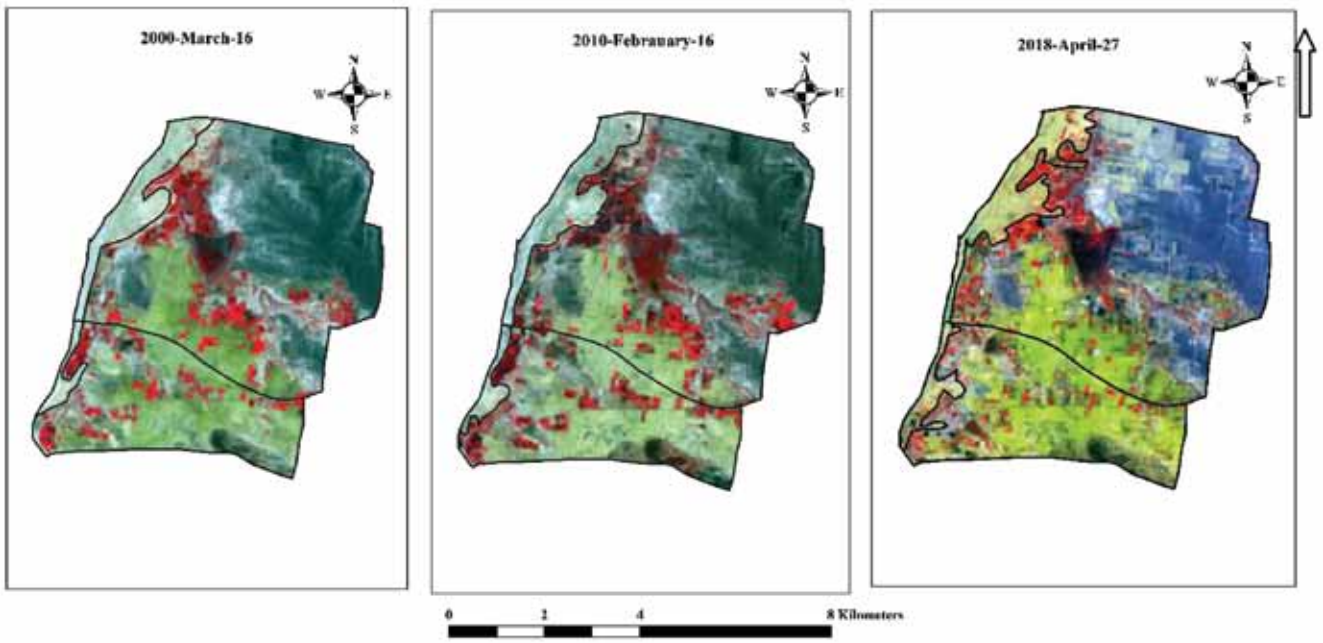

Figure 6. Temporal Landsat imagery of the year 2000, 2010 and 2018, showing migration of sand dunes in Sreerangapuram and Narinjagundlapalle villages

Table 3. Show the GEOMETRIC calculation for the migration of desertification

Village Name	Year			Result
	2000	2010	2018	
Sreerangapuram	2.44 Sq.km (244 Hectares)	2.62 Sq.km (262 Hectares)	2.73 Sq.km (273 Hectares)	Out of 2706 Hectares of land 273 Hectares of land is desertified.
Narinjagundlapalle	0.49 sq.km (49 Hectares)	0.63 Sq.km (63 Hectares)	0.85 Sq.km (85 Hectares)	Out of 1135 Hectares of land 85 Hectares of land is desertified.

2.62 Sq.km to 2.73 Sq.km, that would mean that up to 273 Hectares of the land is desertified. Similarly, in the Narinjagundlapalle village, it increased from 0.63 Sq.km to 0.85 Sq.km. Thus, this study suggests that the migration of sand/sand dunes and desertification has increased enormously, which is likely to pose serious threat to the agricultural as well as for livelihood.

CONCLUSION

In this study, temporal Landsat data from 2000 to 2018, has been used to analyses the trends in land degradation and desertification severity over the past eighteen years. The study reveals that the migration of sand and sand dunes is the main reason for desertification in Beluguppa Mandal of the Anantapur district. This migration is increasing at alarming rates. Remote Sensing Landsat data has been successfully used to develop Desertification Status Maps. The present study reveals that sand desertification in the study area increasing drastically by the change in environmental conditions. The Sreerangapuram village, it has changed by 0.29 sq. km in the past 18 years and similarly, Narinjagundlapalle villages by 0.36 sq.km in the past 18 years. These maps will be very useful to take action plans on controlling desertification. Some of the recommendations can include reduction of the surface wind speeds, in order to avoid sand migration on crop or agricultural field, proper irrigation plans to help to impede the desertification and rehabilitation of slightly or severely decertified lands for productive utilization for agriculture purpose.

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Compliance with Ethical Standards

The authors declare that they have no conflict of interest and adhere to copyright norms.

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