# CHAPTER 5

# IMPACT OF SUBSIDENCE ON THE PLANTS

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# REMOTE SENSING STUDY

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# IMPACT OF SUBSIDENCE ON PLANTS - REMOTE SENSING STUDY

## 5.1 Introduction

Remote sensing technology has been used to distinguish and evaluate the past and present patterns of vegetation in the study area. Speedy data acquisition can be made at a lower cost than traditional ground inspection techniques. The remote sensing technology has been used by many researchers to know the health and growth of plants (Hatfield et al. 1993, Pinter et al. 2003, Henry et al. 2004, Vibhute et al. 2013, Ferguson et al. 2018 and Oerke 2020). It is of the common belief that subsidence affects the health of plants. Lab and field investigations, as discussed in earlier chapters, point out the fact that subsidence does affect the health of plants. Due to the larger pixel size of LANDSAT images, it is not possible to delineate the tensile and compressive strain zones in the subsided panels by remote sensing technology. Moreover, it has been observed in the previous chapter that the tensile strain zone damages the plants while compressive strain leads to the improvement in the plants. Therefore, it is important to ascertain the overall impact of subsidence on the plants' health. Hence, an attempt has been made to assess the impact of subsidence on plants in a holistic view and to draw the general conclusion. In the present study, LANDSAT imagery has been used to know the effect of mining subsidence on plants health.

The study area was the coal mine on which the soil and plant study has been performed through field study on the same panel as discussed in chapter 4. The year 2014 represents the pre-mining condition, and the year 2016 represents the post-mining condition. This study was based on the NDVI (Normalized Difference Vegetation Index) calculation.

### 5.2 Study area

The study site (Figure 4.1) is located in the Anuppur district of Madhya Pradesh at the latitude range in between 23º11'00" N and 23º12'00" N and longitude in between 81°57'00" E and 81°58'30" E. A detailed description of the study area has been given in section 4.2 of chapter 4.

### 5.3 Methodology

The effect that occurs due to mining subsidence on the native flora can be assessed by many methods of Remote Sensing and GIS (Geographic Information System). One of these methods, which is based on the calculation of NDVI, is used for the estimation of flora in this study. NDVI is a standard way of measuring the health of vegetation, so in this method, the impact of subsidence on the change in the health of vegetation has been measured using this technique (Goslee 2011, Streiner 1993, Bivand et al. 2008).

NDVI calculation was done using Eq. (4):

$$NDVI = \frac{\mathrm{NIR} - \mathrm{R}}{\mathrm{NIR} + \mathrm{R}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where NIR = Near-Infrared Band value recorded by the Landsat 8 OLI imageries

R = Red Band value recorded by the Landsat 8 OLI imageries

The NDVI value ranges from -1 to +1 (Walston et al. 2009, Dubovyk et al. 2013). A higher value of NDVI shows a highly productive healthy vegetation, i.e., NDVI value for forest ranges from 0.6 to 0.8 (Assal et al. 2014). The lower value shows lowly productive vegetation. Shrub and grassland show NDVI values of 0.2-0.3 (Diaz and Blackburn 2003, Bhowmik and Cabral 2013). The value closer to -1 represents damaged vegetation (e.g., usually water), whereas less than 0.1 represents a degraded vegetation (e.g., barren areas such as sand, rock, and snow). The NDVI values obtained from the present analysis were classified into five raster zones. Changes in the area coverage of each raster zones before and after mining were calculated, and dynamics in vegetation health and coverage were quantified.

### 5.3.1 Satellite data

Two LANDSAT 8 OLI imageries of the years 2014 and 2016 were used for the analysis. The data of both the years have been acquired from the same months of the corresponding years to consider the seasonal variation and vegetation health. The images with zero cloud cover of the area of interest were downloaded from the United States Geological Survey (USGS) gateway (Padmanaban 2012, Raj Chandar and Kumar, 2012). The selected month for image download was May of 2014 and May of 2016.

### 5.3.2 Image Processing

Topographical map and satellite data sources were used for this study. LANDSAT 8 OLI data of 143 paths and 44 rows of the study area were downloaded from the USGS website. The image processing was done in ENVI 5.1 image processing software. NDVI was calculated. Five classes were made for NDVI images of the study area. The temporal change of vegetation was achieved for the same area with different years. An overview of the methodology adopted for the present study has been presented in Figure 5.1.

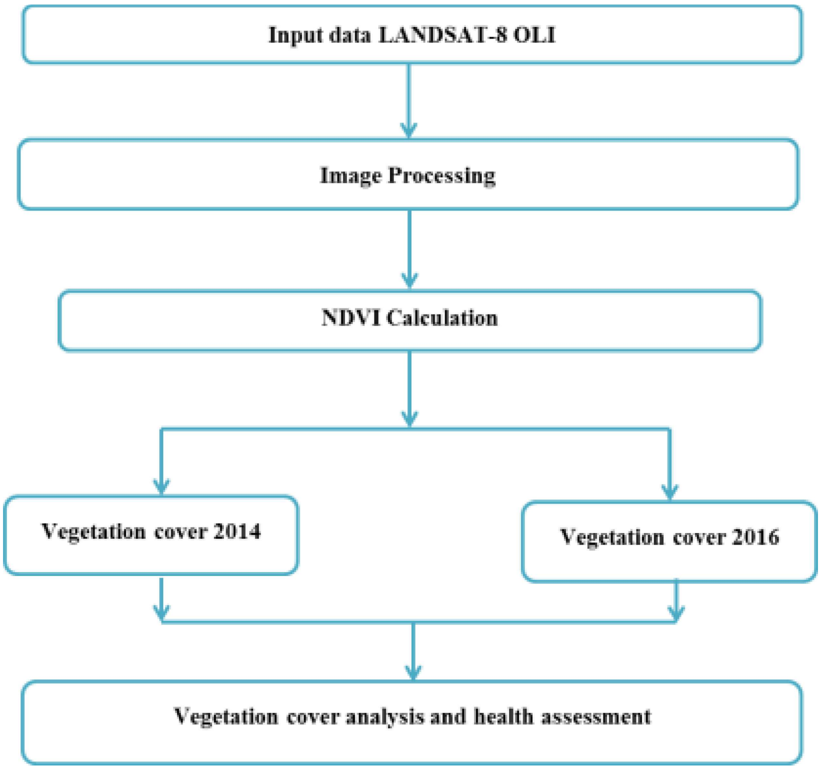


**Figure 5.1** Methodology for the analysis of vegetation health (NDVI)

### 5.4 Results and discussion

Figure 5.2 shows the NDVI map of the study area. This area covers the entire panel along with some surrounding area around the panel. This was done keeping the fact in mind that some part of land outside of the area also gets damaged due to tensile strain zone. Two images were processed. The first image was of the year 2014, which represents the pre-mining condition. The second image was of the year 2016, representing the post-mining condition. The NDVI was calculated for both the images, i.e., post-mining and pre-mining. It has been observed that NDVI ranges from 0.19 to 0.27; hence, the area of interest was found to be covered with shrubs and grasslands. The NDVI range was further subdivided into five subdivisions. Based on the comparative values of NDVI, vegetation with higher values (0.24 – 0.27) was named as healthy vegetation, while vegetation with lower values (0.19 – 0.24) was named as unhealthy vegetation.

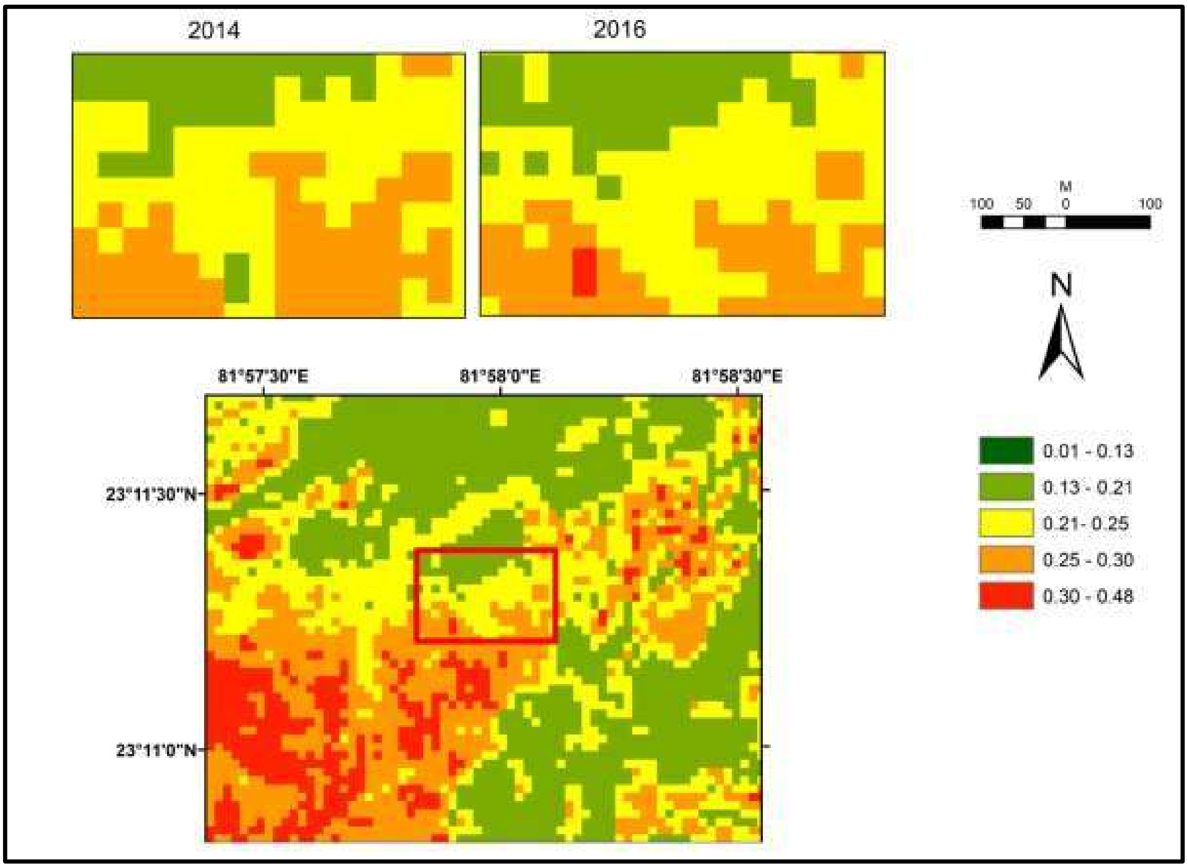


**Figure 5.2** NDVI map of the study area in May 2014 and 2016

The area under each subdivision was calculated for pre-mining as well as for post-mining condition. The result of these observations has been tabulated in table 5.1. It has been observed from the table that the area coverage of healthy vegetation with NDVI subdivisions 0.25 – 0.27 and 0.24 to 0.25 from pre-mining to post-mining condition have decreased from 18000 $m^2$ to 9000 $m^2$ and 20700 $m^2$ to 13500 $m^2$, respectively. The area coverage of unhealthy vegetation with NDVI subdivisions 0.22-0.24, 0.20-0.22, and 0.19-0.20 from pre-mining to post-mining condition has been increased from 15300 $m^2$ to 18900 $m^2$, 10800 $m^2$ to 21600 $m^2$ and 14400 $m^2$ to 16200 $m^2$, respectively. The percent decrease of healthy vegetation with NDVI subdivisions 0.25–0.27 and 0.24-0.25 is 50.00% and 34.78%, indicating that 50.00% and 34.78% of healthy vegetation have been transformed into the unhealthy vegetation with lower NDVI values (i.e., 0.22-0.24, 0.20-0.22 and 0.19-0.20) during 2014-2016.

Overall, the healthy vegetation (NDVI 0.27-0.24) has decreased from 38700 $m^2$ to 22500 $m^2$ (-41.86%), while the unhealthy vegetation (NDVI 0.24-0.19) has increased from 40500 $m^2$ to 56700 $m^2$ (+40.00%). Thus, due to mining subsidence, an overall increase in damaged and unhealthy vegetation has been observed during 2014–2016.

**Table 5.1** Vegetation health changes from 2014 to 2016

| **NDVI Values** | **Area ($m^2$)** | | | **% Change** | |
|---|---|---|---|---|---|
| | **2014** | **2016** | **Change (2014-2016)** | | |
| 0.25 - 0.27 | 18000 | 9000 | -9000 | -50 | Decrease |
| 0.24- 0.25 | 20700 | 13500 | -7200 | -34.78 | Decrease |
| 0.22 - 0.24 | 15300 | 18900 | +3600 | +23.53 | Increase |
| 0.20 - 0.22 | 10800 | 21600 | +10800 | +100 | Increase |
| 0.19 - 0.20 | 14400 | 16200 | +1800 | +12.5 | Increase |
| **Total area** | **79200** | **79200** | | | |

The study indicated substantial changes in vegetation after the mining subsidence, as demonstrated by the differences in pre- and post-subsidence conditions with special reference to the greenness of the vegetation. For example, there was a decrease in greenness in the post-subsidence stage as compared to the pre-subsidence stage, which directly shows that the subsidence has had a detrimental effect on the healthy vegetation of the study area.

The formation of surface troughs and the appearance of lateral movements of the ground lead to the formation of cracks, as well as changes in soil characteristics, which can also have a negative impact on the health of vegetation. Changes in soil characteristics cause biological changes in plants that directly affect their growth. The surface with the maximum slope in subsidence prone land has relatively less organic matter than other areas of the subsidence zone due to the process of soil erosion and natural weathering. Due to this, the amount of nutrients in the soil decreases, hindering the adequate supply of essential micro- as well as macronutrients to the plants and healthy growth of plants. This eventually reflects in the form of reduced area coverage of healthy vegetation.

Furthermore, the formation of cracks in the tensile strain zone leads to the uprooting of trees and plants, drying up and dying of their roots and stems, eventually leading to an increase in area of unhealthy and damaged vegetation.

**5.5 Concluding remark**

Remote sensing technology has been used to distinguish and evaluate the past and present patterns of vegetation in the study area. This study was based on the NDVI calculation. Values of NDVI were in the range of 0.19 to 0.27. The NDVI range was subdivided into five subdivisions. Based on the comparative values of NDVI, vegetation with higher values (0.24 – 0.27) was named as healthy vegetation, while vegetation with lower values (0.19 – 0.24) was named as unhealthy vegetation. The following conclusions have been drawn from the remote sensing study.

**a)** The area coverage of healthy vegetation with NDVI subdivisions 0.25 – 0.27 and 0.24 to 0.25 from pre-mining to post-mining condition were decreased from 18000 $m^2$ to 9000 $m^2$ and 20700 $m^2$ to 13500 $m^2$, respectively.

**b)** The percent decrease of healthy vegetation with NDVI subdivisions 0.25–0.27 and 0.24-0.25 is 50.00% and 34.78%, indicating that 50.00% and 34.78% of healthy vegetation was transformed into the unhealthy vegetation with lower NDVI values (i.e., 0.22-0.24, 0.20-0.22 and 0.19-0.20) during 2014-2016.

**c)** The area coverage of unhealthy vegetation with NDVI subdivisions 0.22-0.24, 0.20-0.22, and 0.19-0.20 from pre-mining to post-mining condition were increased from 15300 $m^2$ to 18900 $m^2$, 10800 $m^2$ to 21600 $m^2$ and 14400 $m^2$ to 16200 $m^2$, respectively.

**d)** Overall, the healthy vegetation (NDVI 0.27-0.24) was decreased from 38700 $m^2$ to 22500 $m^2$ (-41.86%), while the unhealthy vegetation (NDVI 0.24-0.19) was increased from 40500 $m^2$ to 56700 $m^2$ (+40.00%).

It could be observed that as compared to the pre-subsidence stage, there is a decrease in greenness in the post-subsidence stage, which directly shows an overall increase in damaged and unhealthy vegetation in the study area.