IMPACT OF LANDFILL MICROCLIMATE ON LAND USE LAND COVER USING REMOTE SENSING AND GIS

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KEY WORDS: Landfill, Vegetation indices, Microclimate.

ABSTRACT

Dumping of municipal waste at landfill sites, in vicinity of urban centers, has become a common practice nowadays. Microclimate created in surrounding areas of the landfill site have negative impact on vegetation. In the present study, effect of landfill site on LULC has been investigated using Sentinel-2 and Landsat 8 OLI data. The variation of LULC may be represented by different vegetation indices, such as Chlorophyll Index (CI) and Normalized Difference Vegetation Index (NDVI). Spatio-temporal behavior of the vegetation indices clearly shows the negative impacts of microclimate created near landfill site, which affects vegetation health near the landfill site. Buffer analysis is used to mark the distance upto which vegetation is affected by landfill and it is observed that the measure is 100m.

1. INTRODUCTION

In India the solid waste management is a major challenge to the municipal corporations. The collection of the municipal solid waste (MSW) is nearly 80% and the rest of the waste is left unattended on the sides of roads or in small dumps (TERI, 2003). Of the collected solid waste, 10-20% of the waste is recycled or composted, and the remaining 80-90% is directly disposed in the landfills (Kumar et al., 2001; Sharma et al., 2002 ;Joseph et al., 2003).

Some of the studies carried by Stohr et al., (1994) and Johnson, (1993) for detection of landfill using spectral characteristics and band mathematics by using the space and air-borne multispectral data. Further, some studies were carried out (Hopper, 1996; Jones and Elgy, 1994) to find the vegetation stress on closed reclaimed sites by leachate release and by gas emission. Jones and Elgy, (1994) found that it is difficult to demonstrate a relation between soil characteristics, plant health and landfill gas dynamics. The capability of hyperspectral data to improve monitoring of landfill contamination over multispectral data is studied by Folkard and Cummins (1998).

The use of space-borne data for change detection and monitoring was carried by Kwarteng and Al-Enezi, (2004) and Dewidar, (2002). In place of multispectral images Synthetic Aperture Radar (SAR) has been used for monitoring and to see behavior of landfill site. Ottavianelli (2007) used SAR to differentiating between landfill and other land features. For monitoring the degradation of vegetation by landfill site is studied by Mahmood, et al, (2016). Top-down approach that is from satellite imagery to terrestrial rover has been used by Manzo et al, (2017) for environmental monitoring. High resolution data of (Pleiades and Worldview 2) has been used to identify environmental point of interest.

The objective of this paper is to study the impact of landfill microclimate on the vegetation by using the remote sensing techniques. Vegetation indices like NDVI and CI has been used to map vegetation degradation spatially and to mark out the zone of influence of landfill to which it affects the surrounding vegetation.

2. MATERIALS AND METHOD

2.1. STUDY AREA

The study has been undertaken for Bareilly city in the state of Uttar Pradesh (India). With an area about 235 km2 and the approximate population of 0.9 million census of India (2011), it lies at 28°21' 50.4" N, 79° 24' 54" E (WGS84) and an average altitude of 268m above mean sea level. The climate is warm and temperate in Bareilly. The summers are much rainier than the winters in Bareilly. According to Köppen and Geiger, this climate is classified as Cwa. The average annual temperature in Bareilly is 25.1 °C and average rainfall of about 1093 mm.

The landfill situated at 28˚ 21' 37.04" N, 79˚ 23' 34.79" E with an area of around 4 hectares. These study areas have been selected because of availability of agricultural area around the landfill site. The main focus of this study is to assess the impact of microclimate developed by landfill and its impact on the vegetation.

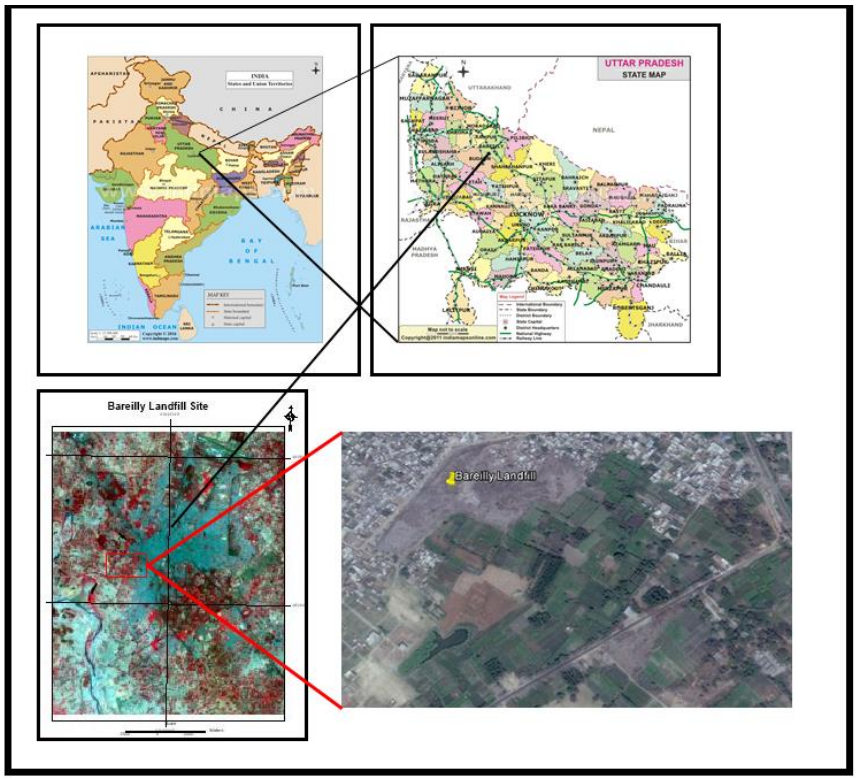

Figure 1. Study area

2.2. DATASET AND STUDY SCHEME

Sentinel- 2 and Landsat 8 OLI have been used to study the temporal and spatial effect of landfill microclimate on vegetation. Total 24 images of Sentinel-2 were available from which 14 cloud free scene has been selected for study from November 2015 to April 2017 of Sentinel-2 sensor and Top of Atmosphere product is being used, and for Landsat 8, out of 40 images available, 21 cloud free datasets are downloaded and surface reflectance product has been used from October 2015 to July 2017. The images were downloaded from USGS site.

Table 1. Selected images for the study

Landsat 8 OLI		**Sentinel-2a**	
Oct, 19 2015	Nov, 22 2016	Nov, 14 2015	May, 27 2017
Nov, 04 2015	Dec,06 2016	Nov, 24 2015	
Nov, 20 2015	Feb, 10 2017	Mar, 23 2016	
Dec, 22 2015	Feb, 26 2017	Apr, 22 2016	
Feb, 08 2016	Mar, 14 2017	Nov, 18 2016	
Mar, 11 2016	Mar, 30 2017	Nov,28 2016	
Apr, 12 2016	Apr, 15 2017	Mar, 28 2017	
Apr, 28 2016	May,01 2017	Apr, 17 2017	
Nov, 06 2016		May, 07 2017	

To study the effect of microclimate on surroundings of landfill, distance dependent analysis is being carried out. Multi ring buffer analysis has been used around landfill site to study degradation of vegetation. As the effect is intense near landfill and decreases as the distance increases from the landfill site, to study the effect first 5 buffers to the landfill

facility are of 20m and next 4 buffers of 50 m intervals. The Landsat 8 data is resampled to 10m using bilinear interpolation algorithm. Then zonal statistics are computed for each layer by laying the buffer zones. The study focusses on the wheat crop because the availability of maximum data set is from November to April, which is generally, a time period of wheat crop.

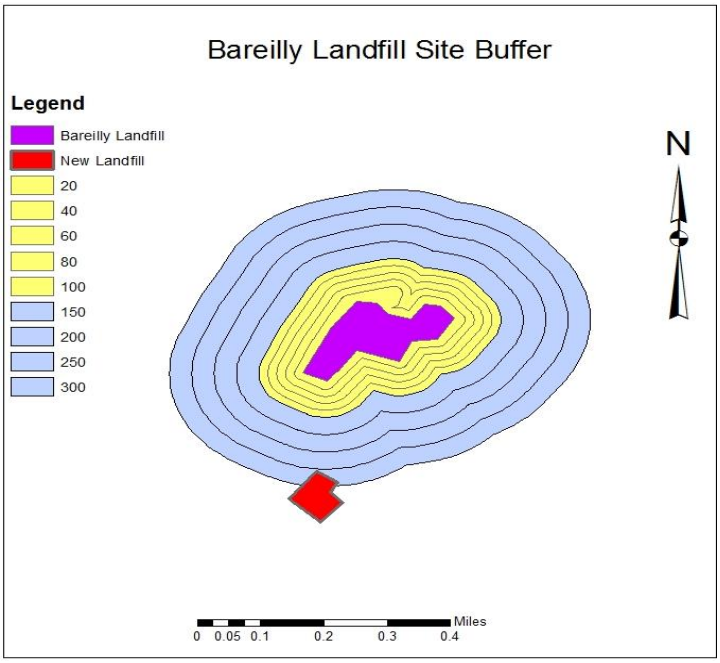

Figure 2. Multi ring buffer around the landfill

To study the impact caused by landfill, vegetation condition around landfill may be used. So the spectral indices which shows the vegetation health used in this study are CI and NDVI. The indices such as NDVI and CI are slope based in which NDVI is the ratio between Near Infrared (NIR) and Red (Rouse et al., 1973), CI is contrasting between Near Infrared (NIR) and Green bands Gitelson et al. (2003,2005). These Indices are commonly used for mapping and monitoring spatiotemporal behavior of vegetation.

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (1)$$

$$CI = \frac{NIR}{GREEN} - 1 \quad (2)$$

3. RESULTS AND DISCUSSION

Due to presence of landfill site it is observed that there is degradation of crop health as an effect of soil pollution (Shaylor et al., 2009; Phil-Eze, 2010). This results in disruption in the metabolism of plants, resulting into the poor vegetation that can be detected through indices such as CI and NDVI.

3.1. Normalized Difference Vegetation Index (NDVI)

NDVI variation from edges of landfill site to a buffer distance of 300 m is done. The NDVI profile has been studied from year 2015 to 2017 and the wheat season (Nov-Apr) selected to analyze the NDVI profile. There is an improvement in NDVI as the distance increases from the landfill site. Around the landfill site, a large area has been cropped with the wheat crop, resulting in improved values of NDVI depicting improved vegetation.

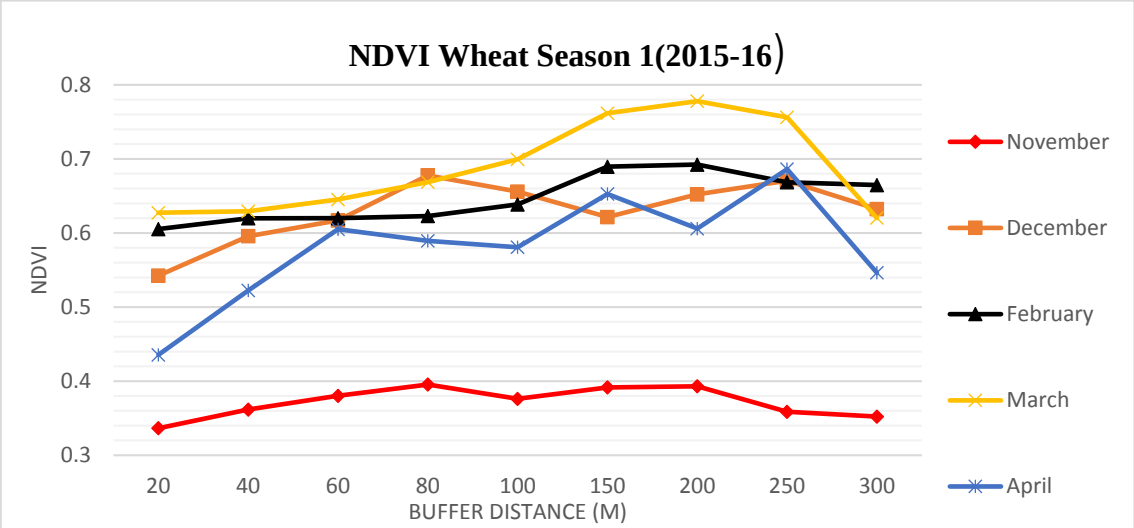

Figure 3. NDVI profile around landfill with multi-ring buffer analysis

In November NDVI value ranges from 0.3 to 0.4 because of the period of sowing the wheat crop, hence very less values as compared to other months. However, it is seen that NDVI value is less near the landfill and an improving trend seen as distance increases. Increase in NDVI value for December, February and March is because of maturing of wheat crop and maximum at March then again value decreases. In Figure 3&4 the effect of landfill on vegetation is clearly seen as the distance increases, there is an improvement in the NDVI value in every month. The effect of landfill contamination fluctuates more up to the 100m distance and then it's stable. However, there is a decrease in the NDVI values after 250m buffer, it is because of the presence of new landfill site as shown in Figure 2.

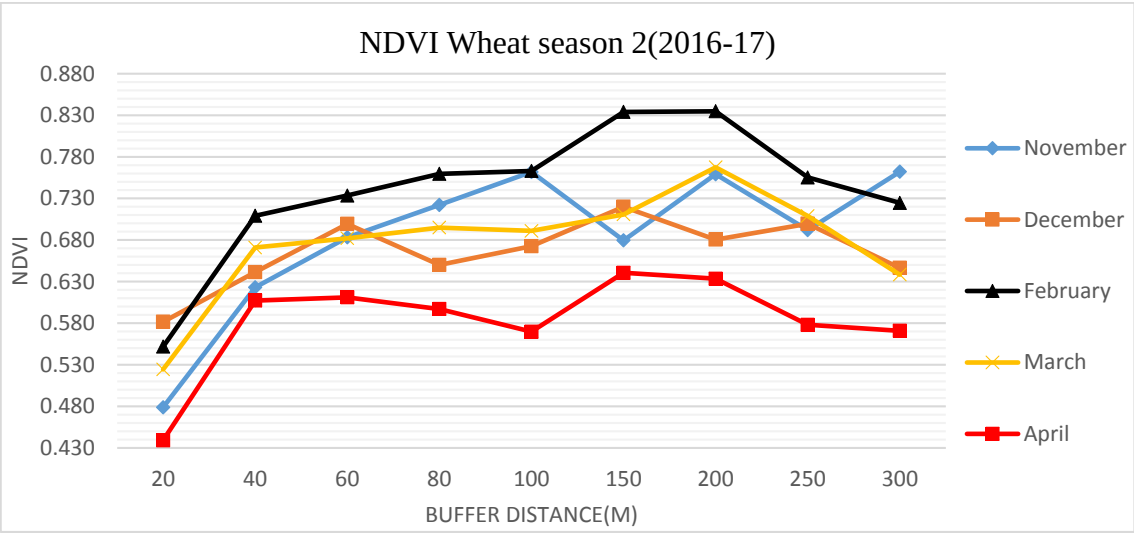

Figure 4. NDVI profile around landfill with multi-ring buffer analysis

3.2. Chlorophyll Index (CI)

Variation in CI with the increasing distance from landfill for two seasons are shown in Figure 5&6. It is clearly seen from the given figures that as the distance from landfill increases there is an increase in the value of CI. The maximum effect of vegetation degradation is upto 100m after that there is revival of vegetation health or increase in chlorophyll value. However, the damage done by microclimate is intense near the landfill site.

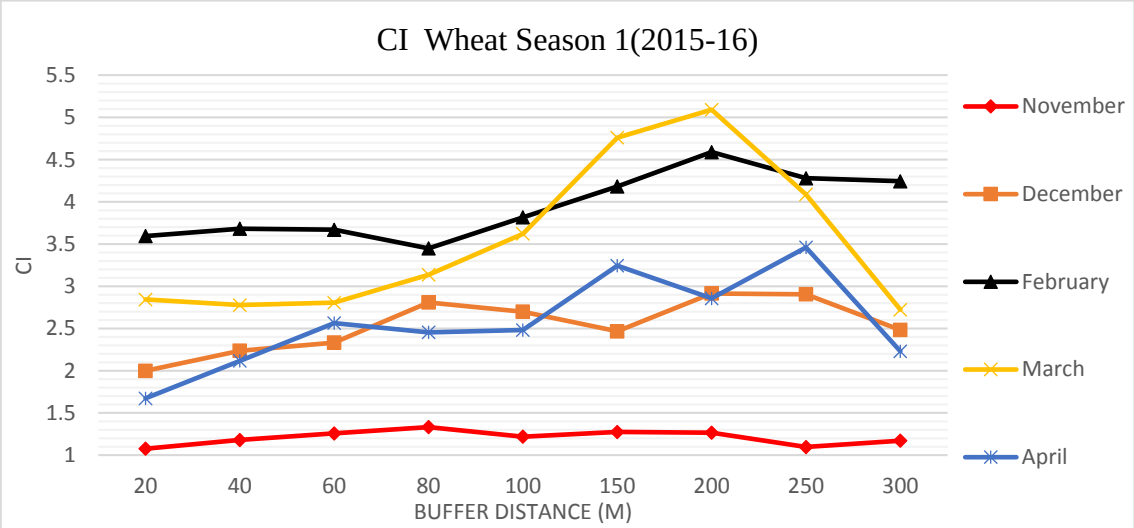

Figure 5. CI profile around landfill with multi-ring buffer analysis

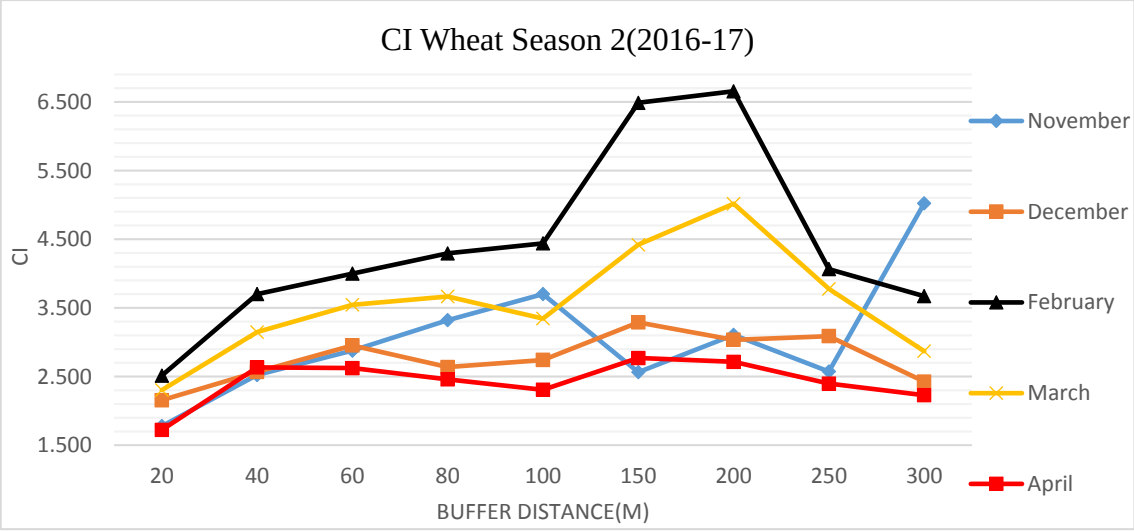

Figure 6. CI profile around landfill with multi-ring buffer analysis

4. CONCLUSION

This research has been carried out to study the impact of landfill microclimate using remote sensing imagery of Landsat 8 and Sentinel 2. Use of remotely sensed data for environmental impact assessment of landfill microclimate has been verified. In this study vegetation indices such as NDVI and CI have been used to assess the environmental damage and both indices shows the degradation is upto100m range of landfill site. After that, there is an increase in values which shows good vegetation health.

ACKNOWLEDGEMENT:

This study has been carried out under a doctoral program supported by the Ministry of Human Resource Development, India. The author gratefully acknowledges the MHRD, India, for financial support.

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