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Impact analysis of vegetation cover on land surface temperature (LST) at Lakhodair landfill and Mehmood Booti open dump site of Lahore, Pakistan

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Key words: Lakhodair Landfill site, Mehmood Booti open dump site, Land Surface Temperature (LST), Normalized Ddifference Vegetation Index (NDVI), infrared sensors.

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Abstract

The vegetation cover reduces as well as controls LST near landfill and dump sites in many cities of the world e.g. Lahore, Pakistan. For this purpose, this study relayed on various thermal and infrared sensors of Landsat digital data. The aim of research was to compare temperature (LST) in relation to vegetation index (NDVI). The results showed higher NDVI of 0.4%-0.5% near Lakhodair Landfill and 0.1%-0.2% NDVI at open dump site of Mehmood Booti. Therefore, Landfill site depicts normal LST in June about 39˚C and higher LST of about 50˚C near dump site. In contrast, Lahore experienced 0.2% - 0.5% NDVI and 39˚C - 41˚C LST in June. Conclusions revealed that closed Landfill sites are amiable for the environment as compared to open dump sites. Government should take initiative to convert dump sites into Landfills, in order to protect the environment and health of population living in near vicinity.

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Introduction

An enormous population growth, rapid urbanization and industrial development, contributes a bulk of solid waste each day to be managed, which becomes an insurmountable task in Lahore, which was a city of approximately 10 million people in 2015, 32nd according to world urban population (Akhtar, 2013). If this solid waste is not properly managed each day, it can cause pollution and also increase the land surface temperature which poses a danger to all living creatures on this earth. Therefore, Lakhodair Landfill and Mehmood Booti dump sites have been developed to control the solid waste management. These Landfills are much more planned and stand in sharp contrast to open dumping sites (LWMC, 2014).

The Lahore city is divided into nine major towns and 150 union councils. About 5,700 tons of solid is generated from different sources with high percentage of organic waste (67%) daily with the generation rate of 0.84kg/ capita per day (Batool, 2009). Currently, 60% of municipal solid waste is stored, collected, transported and disposed in open dumps (on dumping sites of Saggian, Bagarian, Kahna Kacha, Mehmood Booti and Lakhodair) while 40% remains uncollected and lies along road sites, streets, railway lines, depressions, vacant plots, drains, around waste containers (where available) open heaps at road sides, informal collection points and open sewers (Tariq, 2013).

The dumping site is defined as a piece of land where waste material is dumped in an illegal manner which is not be confused with a permitted municipal solid waste landfill or a recycling facility. It is also defined as an unsanitary dumping of solid waste (Beaumont, 2014). As Laner (2012) defined the dump sites as those places which are designated for disposal of normally solid and semi solids materials, resulting from human and animal activities that was consider useless, unwanted or hazardous (Laner, 2012). While landfilling refers to sanitary disposal of solid waste in which an area of land that is used to dump rubbish, either directly on the ground (land raising) or filling an unwanted hole in the ground (landfilling). During landfilling trash is buried in a large deep hole and it is designed, located and operated on the base of national, international guidelines (Arena, 2013). Landfills is established in abandoned or unused quarries mining voids or borrow pits (Silva, 2004).

The NDVI is a good indicator for identifying long term changes in the vegetation covers and their status (Baihua and Isabela 2015). Vegetation cover changes are the main factor that causes surface temperature changes. As Khandelwal (2016) described that the thermal infrared (TIR) remote sensing provides a unique method for obtaining LST information at the regional and global scales since most of the energy detected by the sensor in this spectral region is directly emitted by the land surface. The NDVI was the most influential factor in controlling LST measures through partitioning solar radiation into fluxes of sensible and latent heat and by limiting the proportion of vegetation near landfill and dump sites (Khadelwal, 2016).

There were a number of potential reasons to explain the fluctuation of the measured LST near landfill and dump sites. The open disposal of solid waste causes many environmental problems e.g. release harmful gases due to the decomposition of waste as compared to closed Landfill site which are designed to minimize the environmental, health and ecological damage from the disposal of solid waste (Faisal, 2011, Abdullah, 2012 and Chen, 2015). The aerobic digestion takes place with the presence of oxygen, and as a result the digestion process, high amount of heat flux is generated during the decomposition of the organic compounds. The process has been most apparent near the surface of dump site due to the open dumping activities resulting in a high surface temperature (Effat, 2014). Since Landsat image acquires the instantaneous heat flux of the land surface in the thermal infrared wavelength, the derived LST refers to the heat flux generated at the near surface wastes of the landfill and dump sites. In addition, the type of vegetation cover may have certain influence on the thermal absorption and emission (Ebistu, 2013 and Tomlinson, 2011). Frey

(2017) and Santa Maria (2015) performed temporal analysis on LST in relation to NDVI near solid waste disposal sites by using Landsat thermal and infrared sensors. They clearly revealed that LST of open dumps was always higher than the closed landfill. According to Frey (2017) remote sensing data was helpful for observing temperature variations due to the vegetation cover near disposal of solid waste sites (Frey, 2017). Landsat 4-5 TM and OLI/TIRS have been extensively used to study land surface temperature variations near landfill and dump sites and to relate them to land cover characteristics such as vegetation cover (Kuenzer, 2017).

The use of remote sensing data in different aspects of land surface temperature & landfill sites, ecosystem analysis, evaluation and monitoring is well established and widely applied in several studies around the world (Idrissi, 2016). Presently, there are many environmental satellites with varying spatial and spectral resolutions that are suitable for mapping and monitoring the landfill and dump sites (Oguz, 2013). Several Landsat satellite sensors have been used to compare the landfill site from dump site according to their land surface temperature (LST) and vegetation index (NDVI) e.g. Landsat 4-5 TM and Landsat 8 OLI/TIRS (Khalil, 2017). As Peng and Zohu (2017), defined that the Land surface temperature (LST) as a good indicator of the energy balance at the Earth's surface and one of the key parameters in the physics of land-surface processes on a regional as well as global scale. It combines the results of surface atmosphere interactions and energy fluxes between the atmosphere and ground (Peng and Zohu, 2017). LST is generally defined as the skin temperature of the surface which refers to soil surface temperature for bare soil, canopy surface temperature of vegetation (Chatterjee, 2017). The LST is determined by the effective radiating temperature of the Earth's surface, which controls surface heat and water exchange with the atmosphere (Avdan, 2016). During (2015) scientists have extracted and modelled various vegetation biophysical variables using remotely sensed data. Normalized Difference Vegetation Index (NDVI) is one such widely adopted index (Zhang, 2015). Inverse relationship has been reported between LST and NDVI and it has been concluded that vegetation can lower the surface temperature i.e. vegetation has cooling effect on the temperature of an area (Kamran and Pirnazar, 2015). With the increase in availability of remote sensing data from different sensors and improved computation techniques, the study of LST dynamics has taken a big leap (Valssova, 2014).

It is an established fact that the LST in urban centres varies from city centre towards the suburbs greatly, however does there exist any significant variation between the LST of the open dumping sites and landfill sites, still needs to be explored. There is also a need to investigate if the NDVI of the concerned sites also undergoes variation with their LSTs. The current study aims at exploring this hypothesis for Lahore, the provincial capital of Punjab province.

Materials and methods

Study area

Lahore is the second largest city of Pakistan in terms of population size. In Lahore two study areas, Lakhodair landfill and Mehmood Booti dump sites were selected for this research as these two sites receive the bulk of solid waste generated in this provincial capital, with a generation rate of 0.84kg/capita per day (Batool *et al.* 2009), handling which becomes an insurmountable task in Lahore.

Mehmood Booti is the largest dumping site of Lahore and the only authorized dumping site owned by the City District Government Lahore (CDGL), while Lakhodair is the first proper landfill created by the government. About 5,700 tons of solid waste is generated from different sources in Lahore daily with high percentage of organic waste (67 percent). If this solid waste is not properly managed each day, thus this paper deals with a comparison of these two significant sites. Poor waste management can cause pollution and also increase the Land surface temperature which poses a danger to all living creatures on this earth. Therefore, Lakhodair landfill is being developed by LWMC in Lahore since 2012 to manage all the solid waste in such a way that is friendly for the environment. But, in contrast, Mehmood Booti create an adverse impact on an environment due to the open disposal of solid waste. Lakhodair landfill is located at 31°37'36.62" N latitude and 74°25'07.64" E longitude within Lakhodair village while Mehmood Booti dump site is located at 31°36'39.90" N latitude and 74°23'08.57" E longitude within Muhammad Union council of Wagah town Lahore as shown in Fig. 1.

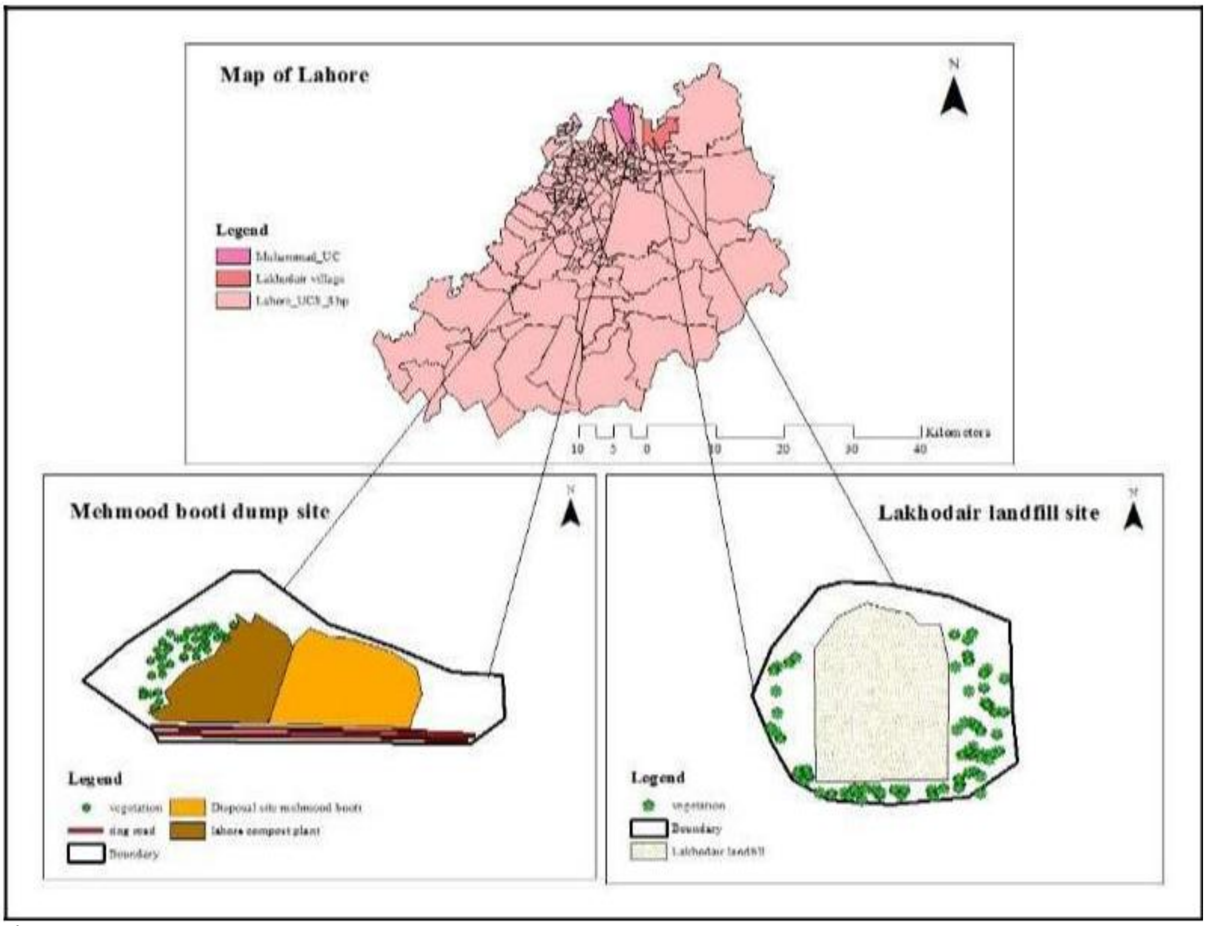

Fig. 1. Locational map of Mehmood Booti dump and Lakhodair Landfill site in Lahore.

Data sets

For the retrieval of LST and NDVI, the data were collected for the period of 2008 to 2015. The acquisition dates were 5-06-08, 14-06-11 and 11-06-15. The images were downloaded from earth explorer. In order to determine LST and NDVI near solid waste disposal sites, the remote sensing data was collected from United States Geological survey (USGS) Earth explorer. Further, the two satellite sensors e.g. Landsat 4-5 TM and Landsat 8 OLI/TIRS were acquired from the datasets of USGS, Landsat Archive pre-collection. The Landsat 4-5 Thematic Mapper (TM) consist of seven spectral bands with a spatial resolution of 30 meters. In this sensor, the thermal band 6 was used to determine LST with a wavelength of 10.40 - 12.50Hm. While Red and Near infrared (NIR) bands were used for calculating the NDVI. On the other hand, Landsat 8 OLI/TIRS consist of 11 spectral bands. Thermal band 10 and band 11 were used for the retrieval of LST with a wavelength of 10.60Hm-11.19Hm and 11.50Hm-12.51Hm. The Lahore shape file was extracted from DIVA-GIS in which landfill and dump sites were further acquired by exporting data on ArcGIS 10.3.

Method to calculate LST from Landsat 4-5 TM

According to Sobrino (2004) and Markham (2003), there are two main steps for determine LST from landsat 4-5 TM. Firstly, DN values should needed to convert into radiance then radiance should be convert into brightness temperature by applying formulas according to its MTL data (Sobrino 2004 and Markham 2003). After data collection, Arc Geographic Information system (GIS) 10.3 software was used for further data processing and analysis. In data processing, for the retrieval of LST, add thermal bands 6, 10 and 11 of Landsat 4-5 TM and Landsat 8 OLI/TIRS, then add shape file of landfill and dump sites with the help of add data toolbar of ArcGIS 10.3.

After that, to determine NDVI, add red, Near Infrared (NIR) bands.

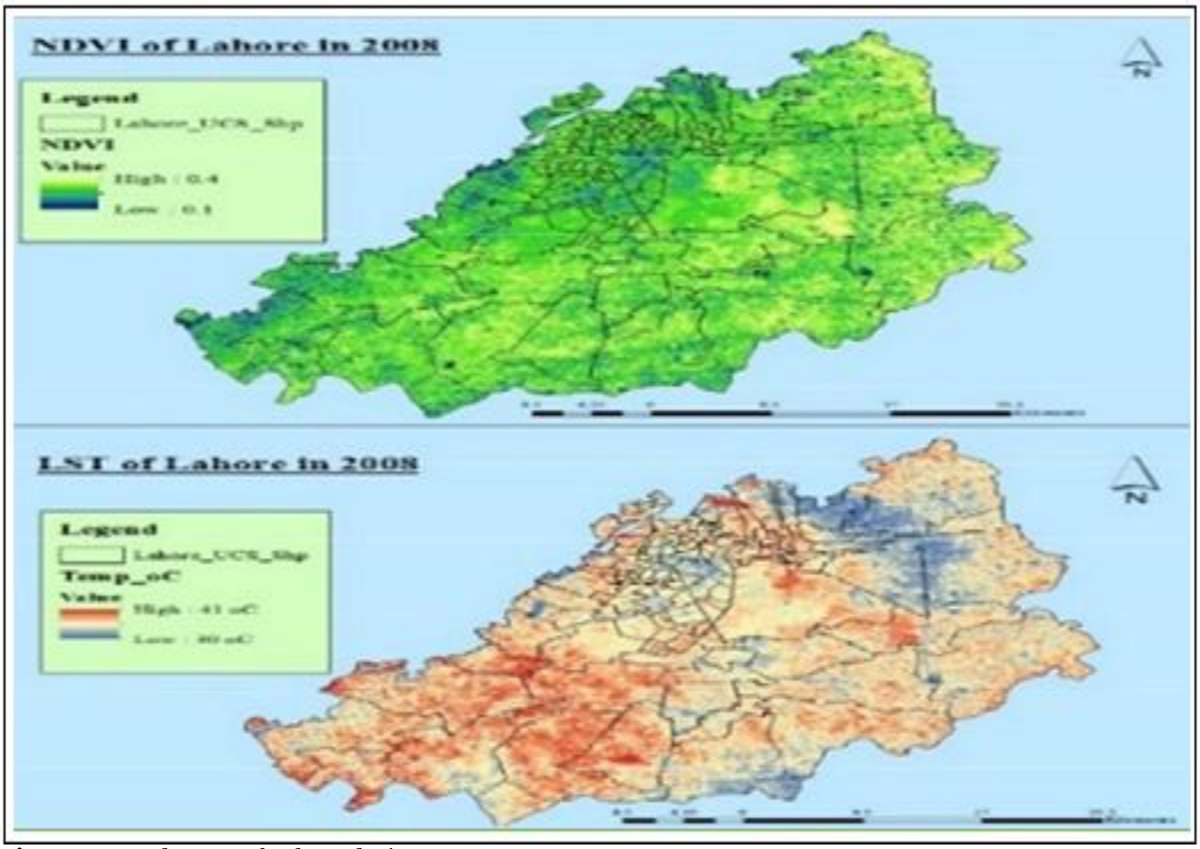

Fig. 2. LST and NDVI of Lahore during 2008.

Retrieval of spectral radiance Top-of-Atmosphere (TOA) spectral radiance (Lλ) can be obtained from L1 data products with calibrated digital numbers (Qcal) using the radiometric rescaling calibration coefficients or post calibration dynamic ranges of spectral radiance (Lminλ – Lmaxλ) of the thermal bands (Markham *et al.*, 2003).

In order to convert calibrated Digital Numbers (Qcal) to TOA spectral radiance, the quantization range of the band is used (Qcalmin – Qcalmax) and formula shown in Eq. 1 (Chandar *et al.*, 2003 and Frey *et al.*, 2017).

$$L\lambda = (LMAX\lambda - LMIN\lambda / Qcal\ max - Qcal\ min)(Qcal - Qcal\ min) + LMIN\lambda \quad \text{Eq. 1}$$

Where Qcal is the quantized calibrated pixel value in DN Greyscale is band-specific rescaling gain factor in (watts/(m2. ster.Hm))/ DN, Brescale is band specific rescaling bias factor in (watts/(m2. Ster.Hm), Lmin is the spectral radiance that is scaled to Qcalmin in watts/ (m2 .ster .Hm), Lmax is the spectral radiance that is scaled to Qcalmax in watts/(m2. ster.Hm), Qcalmin is the minimum quantized calibrated value (corresponding to Lmin) in DN and Qcalmax is the maximum quantized calibrated pixel value (corresponding to Lmax) in DN.

Radiance conversion into Brightness temperature Thermal band data can be converted from spectral radiance to an effective brightness temperature. The brightness temperature assumes that the Earth's surface is a black body, the spectral emissivity of which is 1. Thermal radiance values were converted from spectral radiance to brightness temperature using thermal constants with the following equation as shown in Eq. 2 (Markham and Sobrino 2004).

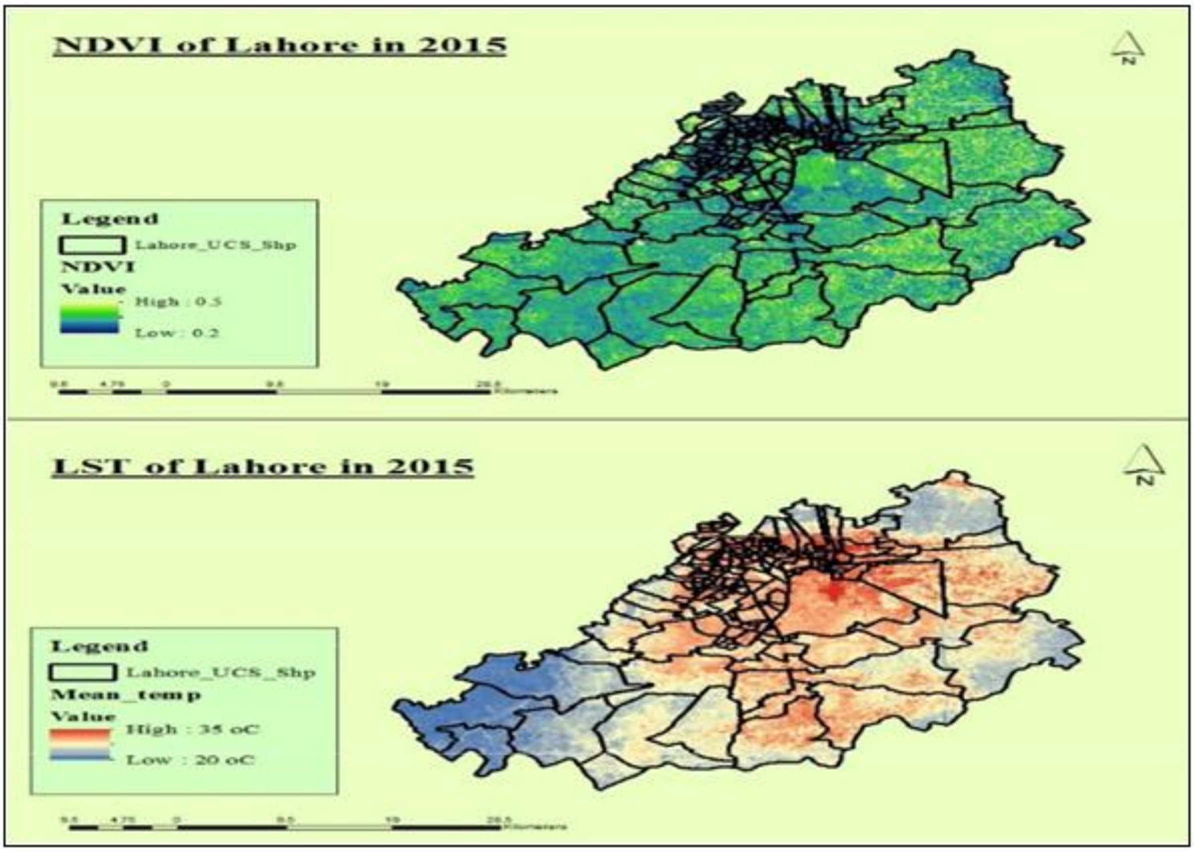

Fig. 3. LST and NDVI of Lahore during 2015.

T = K2/Ln(K1+1)/Lλ Eq. 2

Where T is satellite brightness temperature (kelvin), Lλ is TOA spectral radiance, K1 is the calibrated constant 1 from the metadata and K2 is the calibrated constant 2 from the metadata file.

Finally, derived land surface temperature in Kelvin which was further converted to Celsius by subtracting from 273.15.

Method to calculate LST from Landsat 8 OLI

For retrieval of LST from Landsat 8 OLI, two thermal bands are required to apply the same procedure as using in Landsat 4-5 TM. Firstly, radiance should be calculated by converting its DN values of both thermal bands, then LST can be calculated by converting radiance into brightness temperature of each thermal band (Sobrino, 2004).

Conversion to digital numbers into spectral radiance

Landsat 8 OLI and TIRS data products are distributed as quantized calibrated digital numbers (Qcal) in 16-bit unsigned integer format. Landsat 8 TIRS band 10 (10.60-11.19Hm) data were converted to TOA spectral radiance (Lλ) using the radiometric rescaling coefficients such as band-specific multiplicative rescaling factor (ML) and band-specific additive rescaling factor (AL) provided in metadata file (USGS 2015).

In order to calculate brightness temperature; first need radiance to be calculated, then with this radiance, brightness temperature has been calculated.

The DNs to TOA radiance, OLI/ TIRS band data was converted to TOA spectral radiance using the Eq. 3: (Sobrino, 2004 and Martins, 2016).

Lλ = MLQcal + AL Eq. 3

From the uncorrected TOA spectral radiance, radiant temperature of a pixel can be retrieved.

Retrieving the land surface temperature (LST) from Landsat thermal sensor

The Landsat 8 sensor acquire temperature data and store this information as a DN. After calculating the radiance, the TIRS band data was converted into brightness temperature using the thermal constant provided in the metadata file and Eq. 4 as shown below (Barsi, 2007 and Wang, 2015).

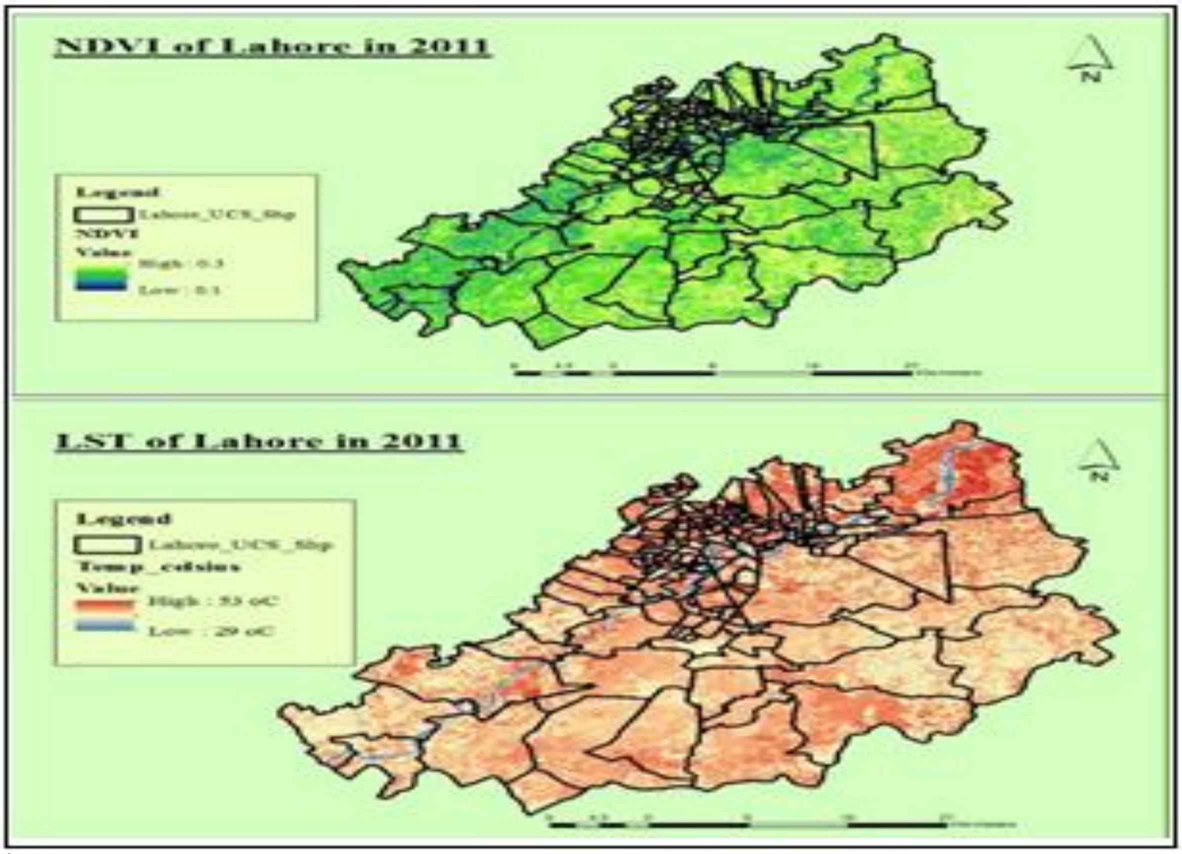

Fig. 4. LST and NDVI of Lahore, 2011.

T = K2/Ln(K1+1)/Lλ Eq.4

Where:

T = At- satellite brightness temperature Lλ = TOA spectral radiance.

K1 = Band specific thermal conversion constant from the metadata file (K1 constant).

K2 = Band specific thermal conversion constant from the metadata file (K2 constant).

Next, the mean value temperature of both band 10 and band 11 were calculated by putting the thermal values in cell statistics of Arc toolbox.

Estimation of Land surface emissivity from the NDVI

Threshold method

The Land surface emissivity (ε) is a proportionality factor that scales blackbody radiance (Planck's law) to predict emitted radiance, and it is the efficiency of transmitting thermal energy across the surface into the atmosphere. In this sense, ε must be known in order to estimate land surface temperature accurately from radiance measurement. In order to determine land surface emissivity from NDVI, the formula was given in Eq. 5 (Sobrino, Paolini, 2004 and Chen, 2015).

Land surface Emissivity from NDVI ε= 0.004 Pv + 0.986

LST = BT / 1 + w * (BT / p) * ln (e) Eq. 5

Where:

BT is the satellite temperature, w is the wavelength of emitted radiance (At 11.5Hm wavelength correspond to band 10 of Landsat 8), p is h * c / s (1.438 * 10^ -2 m K) and h is Planck's constant (6.626* 10^ - 34 Js), s is the Boltzmann constant (1.38 * 10^-23 J/K), c is velocity of light (2.998 * 10^8 m/s) and p is equals to 14380.

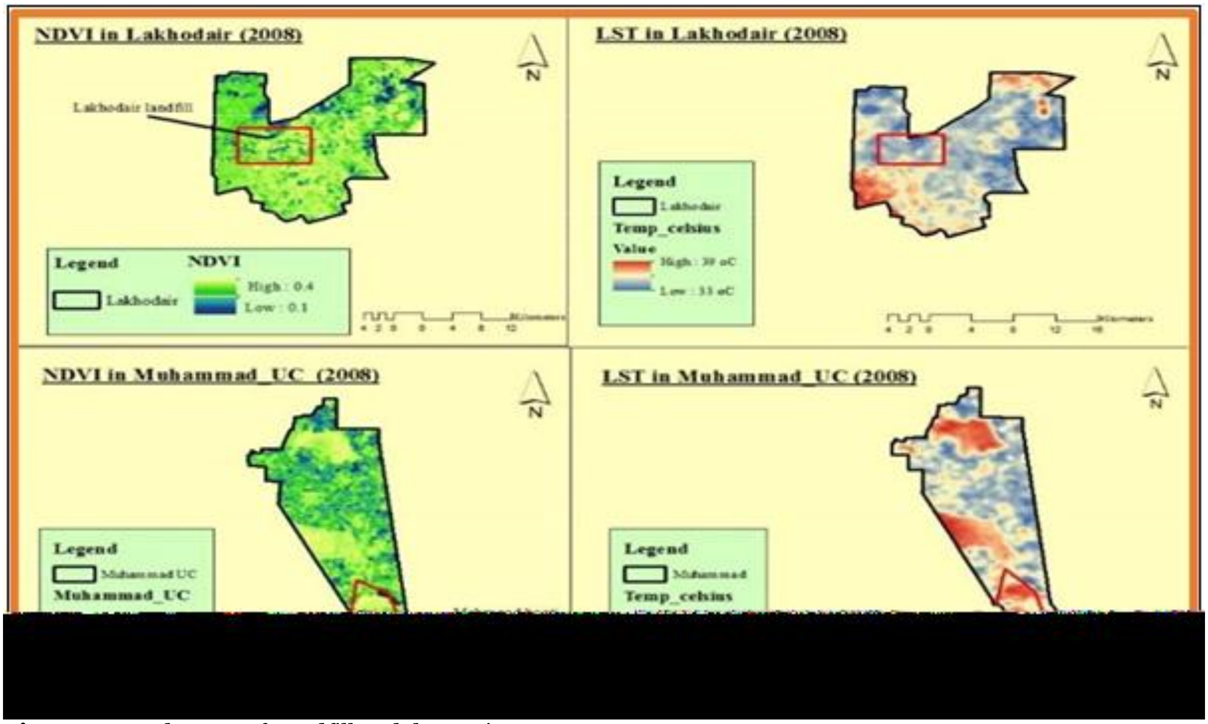

Fig. 5. LST and NDVI of Landfill and dump sites, 2008.

According to (Stathopoulou, 2009, Sobrino, 2004 and Chen *et al.* 2017), land surface emissivity has been determined by NDVI threshold method which was further explained below:

$\varepsilon = \varepsilon$ soil if NDVI < 0.2 Eq. 6

$\varepsilon = \varepsilon$ veg if NDVI > 0.5

$\varepsilon = (\varepsilon \text{ veg} * Pv) + \varepsilon \text{ soil} (1-Pv)$ if $0.2 \leq$ NDVI ≤ 0.5

Where:

ε soil = soil emissivity

ε veg = vegetation emissivity

Pv = vegetation cover fraction

According to Sobrino (2004) and Martins (2016) ε soil and ε veg were estimated at 0.97 and 0.99 respectively (Sobrino 2004 and Martins 2016).

After using these values in the formulas above Eq. 6, the new equation 4 was derived as shown below:

$\varepsilon = 0.97$ if NDVI < 0.2

$\varepsilon = 0.99$ if NDVI > 0.5

$\varepsilon = 0.004 * Pv + 0.986$ if $0.2 \leq$ NDVI ≤ 0.5

$\varepsilon = 0.004$ Pv $+ 0.986$

After that, the proportion of vegetation can also be derived by using formula as shown in Eq. 7 Proportion of vegetation (Pv) = (NDVI – NDVImin / NDVImax – NDVImin) Eq. 7.

When LSE and Pv was determined, the cell statistics was used to find out the mean temperature value of both band 10 and 11 and then calculated subset of an area by extraction. The Land surface temperature was calculated after analysis.

Procedure to determine NDVI

The total amount of vegetation index near landfill and dump sites was determined by using red and Near Infrared (NIR) bands. Firstly, red and near infrared bands were added and shape file in ArcGIS 10.3 and then calculate NDVI with the help of raster calculator according to formula as shown below: (Bellon, 2017 and Sobrino, 2004).

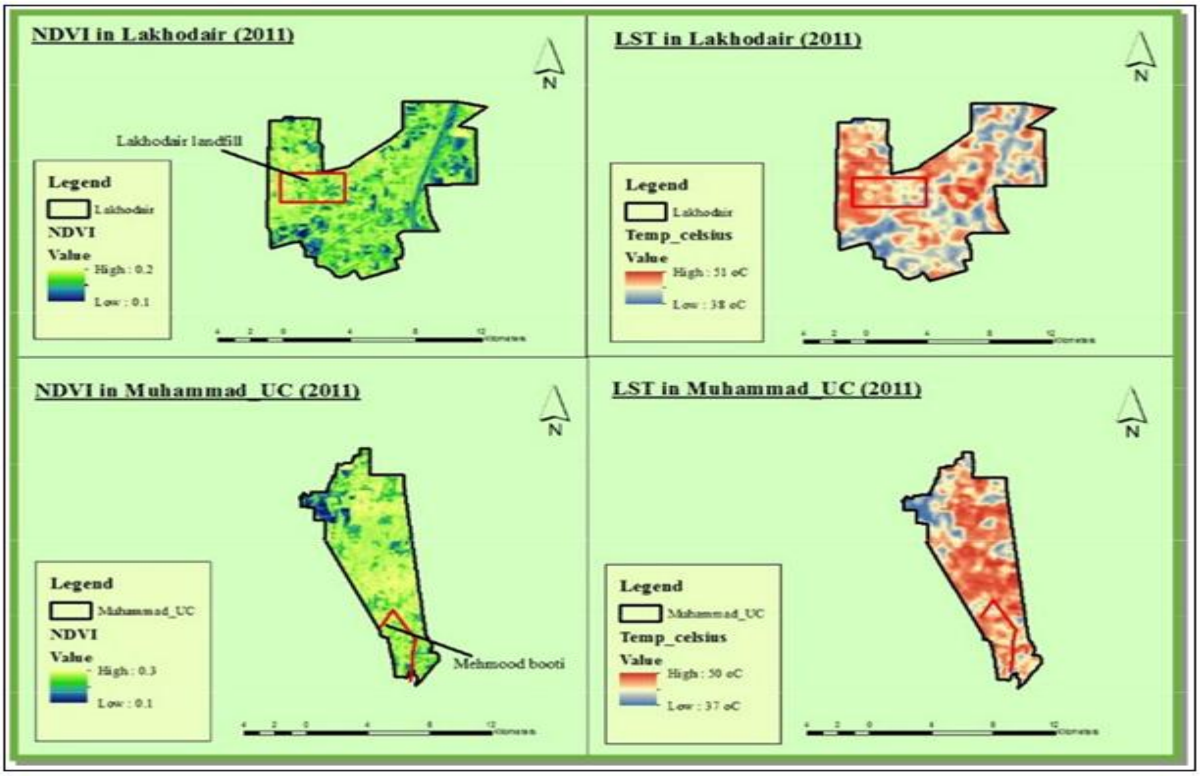

Fig. 6. LST and NDVI of landfill and dump sites, 2011.

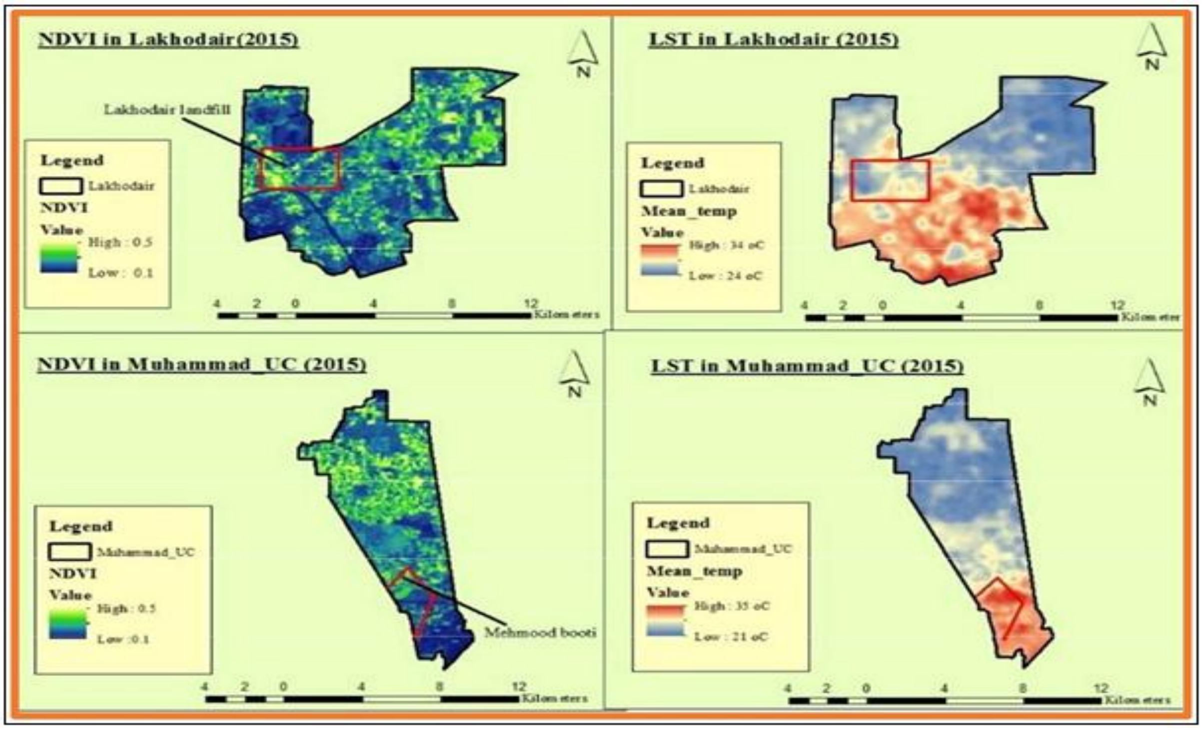

Fig. 7. LST and NDVI of landfill and dump sites, 2015.

NDVI = NIR – Red / NIR + Red

The NDVI is an important indicator near landfill and dump sites for controlling their LST, for e.g. LST is lower when NDVI is high and vice versa (Chen, 2015).

Results and discussion

The results showed that Lakhodair landfill experienced lower LST due to the presence of higher NDVI during 2008 and 2015 in summer June while Mehmood Booti dump site experienced higher LST during 2008 and 2015 due to the presence of poor NDVI. However, only the year 2011, when Mehmood Booti was experienced lower LST as compared to Mehmood Booti dump site due to the construction landfill activities near Lakhodair. The two factors e.g. high vegetation index NDVI and proper waste management near landfill and dump site helped to control their LST. Therefore, Lakhodair village within Wagah town experienced lower LST due to the existence of proper and well-developed landfill as compared to Muhammad Union council which is an urban area of Wagah town and experienced higher LST due the existence of open disposal site Mehmood Booti. On the other hand, due to the higher disposal activities and presence of low NDVI, some areas of Lahore also experienced higher LST during 2008, 2011 and 2015.

LST and NDVI of Lahore since 2008

Fig. 2 showed the LST and NDVI of Lahore in summer June 2008. The LST and NDVI of Lahore was discussed according to its four major pockets e.g. North eastern, North western, Central and South eastern. The results unveil that the higher LST of about 42˚C was experienced near the central and south eastern part of Lahore, as compared to 38˚C in the north western and north eastern side of Lahore, due to the existence of lesser NDVI with a value of 0.004%. In north eastern side of Lahore, the highest

LST of about 40˚C was experienced near Barki, Cantonment, Dhaloki, Gajjumata, due to the presence of low NDVI of 0.1%, whereas the lowest LST of about 37˚C was experienced near Bhaseen, Dogari Kalan, Bhangali, Hadiara, Kamahan, Minhala, due to the existence of higher NDVI 0.2%. On the other hand, north western side of Lahore, the highest LST experienced near Abu Bakar Colony, Gujjar Pura and Kasur Pura of about 40˚C due to the 0.1% NDVI but the lowest LST experienced near Lakhodair, Muhammad Colony, Sabzazar, Hanjarwala, Garrhi Shahu, Kot Begum and Aziz Colony about 39˚C due to the 0.3% NDVI.

However, in central and south eastern part of Lahore, the highest LST experienced near Sultanke, Shamake Bhattian, Maraka, Haloki, Paji and Chung of about 41˚C due to the 0.03% NDVI and lowest LST experienced near Pandoki, Jia Bagga and Dholanwal about 38˚C due to the presence of 0.1% NDVI.

LST and NDVI of Lahore since 2011

Fig. 3 showed that the land surface temperature LST and NDVI of Lahore in summer June 2011. The LST and NDVI of Lahore discuss according to its four major pockets e.g. North eastern, North western, Central and South eastern. The results unveil that the higher LST was experienced near the western and eastern parts of Lahore about 51˚C as compared to central and south eastern side of Lahore 40˚C due to the existence of little NDVI 0.1%.

In north eastern side of Lahore, the highest LST experienced near Bhaseen, Dogari Kalan, Bhangali, Kamahan, Minhala and Cantonment about 50˚C due to the presence of low NDVI 0.1% whereas lowest LST experienced near Hadiara, Barki, Dhaloki, Gajjumata about 41˚C due to the existence of higher NDVI 0.2%. On the other hand, in north western side of Lahore, the highest LST was experienced near Lakhodair, Muhammad Colony, Sabzazar, Hanjarwala, Garri Shahu, Kot Begum, Aziz Colony, Mozang, Shad Bagh, Shadman, Wassanpura, Siddiqia Colony, Sham Nagar, Sanda Kalan and Bhagat Pura about 48˚C due to the existence of 0.05% NDVI but the lowest LST experienced near Abu Bakar Colony, Gujjarpura and Kasurpura about 40˚C due to the 0.2% NDVI.

However, in central and south eastern part of Lahore, the highest LST experienced near Pandoki, Jia Bagga, Dholanwal, Haloki, Paji and Chung about 46˚C due to the 0.03% NDVI and lowest LST experienced near Shamake Bhattian, Maraka,

Sultanke about 39˚C due to the presence of 0.2% NDVI. The findings show that the year of 2011 was considered as the warmest year of Lahore.

LST and NDVI of Lahore since 2015

Fig. 4 revealed that Lahore experienced moderate temperature in summer June 2015 as compared to 2008 and 2011. The results unveil that the higher LST 39˚C and less NDVI 0.1% was experienced near western side of Lahore whereas moderate LST 30˚C and higher NDVI 0.3% was experienced near eastern side and lowest LST 29˚C and higher NDVI 0.4% was experienced near the central and south eastern part of Lahore. In north eastern side of Lahore, the highest LST experienced near Bhangali, Minhala and Cantonment about 32˚C due to the presence of low NDVI 0.04% whereas the lowest LST experienced near Dogari Kalan, Kamahan, Bhaseen, Hadiara, Barki, Dhaloki, Gajjumata of about 29˚C due to the existence of higher NDVI 0.3%. On the other hand, in north western side of Lahore, the highest LST experienced near Lakhodair, Garrhi Shahu, Kot Begum, Aziz Colony, Mozang, Shad Bagh, Shadman, Wassan Pura, Siddiqia Colony, Sanda Kalan, Bhagatpura, Shahdara, Dhair, Taj Bagh, Salamatpura, Samnabad and Ravi of about 38˚C due to the existence of 0.2% NDVI but the lowest LST experienced near Abu Bakar colony, Gujjarpura, Kasurpura, Sabzazar, Hanjarwal, Sham Nagar, Shahpur and Muhammad Colony of about 28˚C due to the 0.3% NDVI. However, in central and south eastern part of Lahore, the highest LST experienced near Dhaloki and Pandoki about 37˚C due to the 0.1% NDVI and lowest LST experienced near Shamake, Bhattian, Maraka, Sultanke, Jia Bagga, Dholanwal, Haloki, Paji and Chung of about 25˚C due to the presence of 0.4% NDVI.

LST and NDVI of Lakhodair landfill and Mehmood Booti dump sites since 2008

The Landsat TM was used to calculate the inverse relationship between LST and NDVI of Lahore landfill Lakhodair and Mehmood Booti dump site. Fig. 5 showed that Lakhodair landfill experienced 33˚C to 39˚C LST with 0.1% to 0.4% NDVI but the Mehmood Booti experienced higher LST 33˚C to 43˚C with only 0.2% NDVI. In summer June 2008, Lakhodair landfill had a moderate temperature due to the proper management of solid waste and presence of higher NDVI but in contrast the Mehmood Booti had higher LST due to the presence of lowest NDVI and improper waste disposal management.

LST and NDVI of Lakhodair landfill and Mehmood Booti dump sites since 2011 compared to Lakhodair landfill in 2011. In summer June, landfill experienced higher temperature about 38˚C to 51˚C with only 0.2% NDVI but the temperature of dump site was 37˚C to 50˚C with 0.3% NDVI. The findings unveil that the landfill experienced higher LST as compared to open dump due to the existence of little NDVI.

LST and NDVI of Lakhodair landfill and Mehmood Booti dump sites since 2015

The Landsat 8 OLI sensor indicate the mean maximum surface temperature and vegetation index of landfill and dump site. Fig. 7 showed that the vegetation index NDVI of dump and landfill was same 0.5% but they experienced different surface temperature in 2015. The Lakhodair landfill experienced 34˚C LST and Mehmood Booti experienced 35˚C LST. The Mehmood Booti experienced higher LST as compared to Lakhodair landfill in 2015 not because of lower existence of vegetation but also presence of improper solid waste management.

Conclusion

Conclusion revealed that closed Landfill Lakhodair has been safe and suitable method for solid waste disposal as compared to open Mehmood Booti dump site. Higher NDVI 0.4% was present near Lakhodair Landfill which was helpful for control Land surface temperature here about 39˚C in the month of summer June while Mehmood Booti open dump site had lower NDVI only 0.2%. Therefore, the Land surface temperature here reached to about 51˚C. Due to the open dumping activities and lower NDVI, the temperature of some areas of Lahore e.g. Barki, Cantonment, Gajjumatta, Bhaseen and Dogari Kalan etc. reached to 51˚C. (Shaker *et al.*, 2009; Yeung *et al.*, 2007; Santamaria *et al.*, 2015; Sobrino and Raissouni *et al.*, 2000) clearly revealed that LST of open dumps was always higher than the closed landfill site. It is recommended that the government should also take steps to convert Mehmood Booti dump site into Landfill site such as Lakhodair landfill, in order to protect the environment. A landscape program should also be developed near Mehmood Booti to control LST. The government must provide awareness to the young generation about this worst-case scenario. Plantation of vegetation near dump places must be carried out, in order to protect the environment as well as human health. Government or the authorities of dump and landfill sites are advised to install thermo scales/ thermometers to detect the temperature at the sites. If the temperature increases from the normal, then the authorities can take measures to control temperature.

It is also suggested that the solid waste can be used as bio-fuel energy generation in future.

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