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RESEARCH PAPER

Assessment of Urban Growth and Variation of Aerosol Optical Depth in Faridabad District, Haryana, India

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ABSTRACT
Sustainable urbanization under sustainable development goals requires quantitative information on urban landscape. Despite having the fastest growth of urban area and poor air quality, Faridabad, a constituent district of National Capital Region, fails to gain much research attention. Present study based on multi-temporal; freely available satellite image has indicated 3% increase in the built-up against 2% decrease arable land from 2008 to 2018. Further, spatial metrics (Shanon's entropy, class area (CA), number of patches (NP), largest patch index (LPI)) has indicated scattered development of built-up. Increase CA (11470 ha in 2008 and 13806 ha in 2018) and NP (221 in 2008 and 476 in 2018) have indicated isolated development of built-up with small area coverage. Increase in LPI (12.5% in 2008 and 13.5% in 2018) of built up indicated compact growth of dense built-up in the southern and eastern side leading to the vertical expansion of the city area. Linear expansion of the residential built-up, industrial, and commercial area along the highways, roads and railways and vehicular emission has contributed to the high aerosol concentration. While, in the rural region the high aerosol loading has also been observed because of the extensive use of fertilizer and stubble burning. Present research on land-use land cover changes and its impact on air quality could be contributed significantly in urban policy making for climate change adaptation and mitigation strategies.
Keywords: LULC, Spatial Metrics, AOD, Landsat TM, Shanon's Entropy.

INTRODUCTION

Urban growth is an intricate interface between the expansion of urban built-up encroaching into the natural land cover, pressure of rising urban population, transformation of socio-economic-infrastructural conditions and environmental quality deterioration mostly in developing countries (Reis, Silva, & Pinho, 2016). India, the leading country of South Asia has 31.16% urban population according to 2011 census and will account for 35% of the projected world's urban population growth in 2050 along with China and Nigeria(U N, 2018)**.** Faridabad, one of the fastest-growing North-western Indian cities and part of Delhi-National Capital Region (NCR), has followed an increasing trend in the urban population from 7.16% in 1971 to 79.51% in 2011 (Teotia & Kumar, 2015) which causes urban encroachment to agricultural areas, forest fragmentation, urban environmental degradation comprising air quality deterioration, surface water pollution, groundwater level reduction and pollution, solid and sewage waste disposal problem, vehicular congestion reported by few research published on Faridabad (Ghosh, N., Kumar, & Midya, 2021; S. Kumar, Ghosh, & Singh, 2021; S. Kumar, Midya, Ghosh, & Singh, 2021; Sharma, Ghosh, Bilal, Dey, & Singh, 2021; Teotia & Kumar, 2015). To resolve such issues, detailed information about the extent and quantity of

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land use land cover change and pattern of urban growth is significant for urban planners and policymakers. Therefore, the present research has attempted a quantitative assessment of land use land cover change and landscape configuration using open access multi-temporal satellite images from 2008 to 2018.

Among the various impact of unplanned urbanization, air pollution acts like the economic and public health crisis. In India, only a few places located in the southern part met the standards of National Ambient Air Quality Standards (NAAQ) (Chowdhury et al., 2019). Every year, people die prematurely with rising levels of air pollution. Numerous sources negatively impact the air quality across the country among which conversion of green cover and agricultural land to residential areas, industries and mining sites often lead to an increase in pollution level. It exhibits a close relationship between built up area and air pollutants (Superczynski & Christopher, 2011). The most comprehensive variable for the assessment of aerosol load in the atmosphere is Aerosol Optical Depth (AOD) ranging from 0 to 1 (Filonchyk et al., 2019). AOD near to 0 or less than 0.1 indicates clear sky and maximum visibility. While AOD close to 1 indicates the maximum concentration of aerosols in the atmosphere and thus low visibility (Mahajan & Mt, 2015). Aerosol originates either from anthropogenic sources (e.g. forest fire, burning of fossil fuel, stubble burning) or from natural sources (e.g. dust, volcanic etc.). Because of high temporal variation and optical properties of aerosol, alteration of the weather took place by the direct and indirect effect of anthropogenic aerosol. Role of aerosol in the atmosphere is still not fully explored; therefore, spatio-temporal distribution of AOD will add fundamental knowledge for environmental management to reduce the air pollution effect.

Nowadays, satellite remote sensing has immensely used for the measurement of AOD to compensate the lack of ground measurements with limited AERONET station, especially in India (Chitranshi, Sharma, & Dey, 2015; Liu, Shen, & Gao, 2018; Mhawish, Banerjee, Broday, Misra, & Tripathi, 2017; Pal, Chowdhury, Dey, & Sharma, 2018; P. Srivastava, Dey, Agarwal, & Basil, 2014). Moderate resolution Imaging Spectroradiometer (MODIS) is operating for providing the spatial and temporal measurement of AOD and other aerosol properties over land and oceans in regional and global level (Bilal and Nichol, 2017; Remer et al., 2008; Srivastava et al., 2011; Bibi et al., 2015; Nichol and Bilal, 2016; Mhawish et al., 2019; Shen et al., 2019). Such data are used to monitor pollution at regional and global level. However, accuracy of data needs continuous improvement or regular updates as it differs with geography of an area, and retrieval algorithms (Filonchyk et al., 2019). Further geographic information system (GIS) can be applied to analyze the temporal and spatial pattern of air pollution (Jensen, Berkowicz, Sten Hansen, & Hertel, 2001; N. Kumar et al., 2016).

Therefore, the aim of the present study is to analyze the spatio-temporal variation of urban growth and AOD and describe the relation between them in Faridabad district. In the present study, multi-temporal satellite images from 2008 to 2018 have been used to analyze the land use land cover change and evaluate the pattern of built-up growth along with modification of the land covers using spatial metrics. Spatial and seasonal variation of AOD from 2008 to 2018 has also been analysed. Further the relationship between change in urban built up and aerosol concentrations has been analyzed to contribute in the effective planning for controlling air pollution and urban growth in Faridabad district.

MATERIAL & METHODS

Faridabad district is located between 27° 51’ 15”N and 28° 30’ 52”N and the 77° 04’ 39”E and 77° 32’ 50”E (Figure 1). It is surrounded by Delhi in the north, Gurgaon district in the west, Gautam Budh Nagar district in the east and Palwal district in the South. Faridabad is plain land with Yamuna River on its east. Physiographically, entire district is divided into undulating plain and Yamuna khadar region. On the northwestern part of the district, Aravalli hills prohibit the expansion of the built-up area. Faridabad belongs to the hot semi-arid climatic

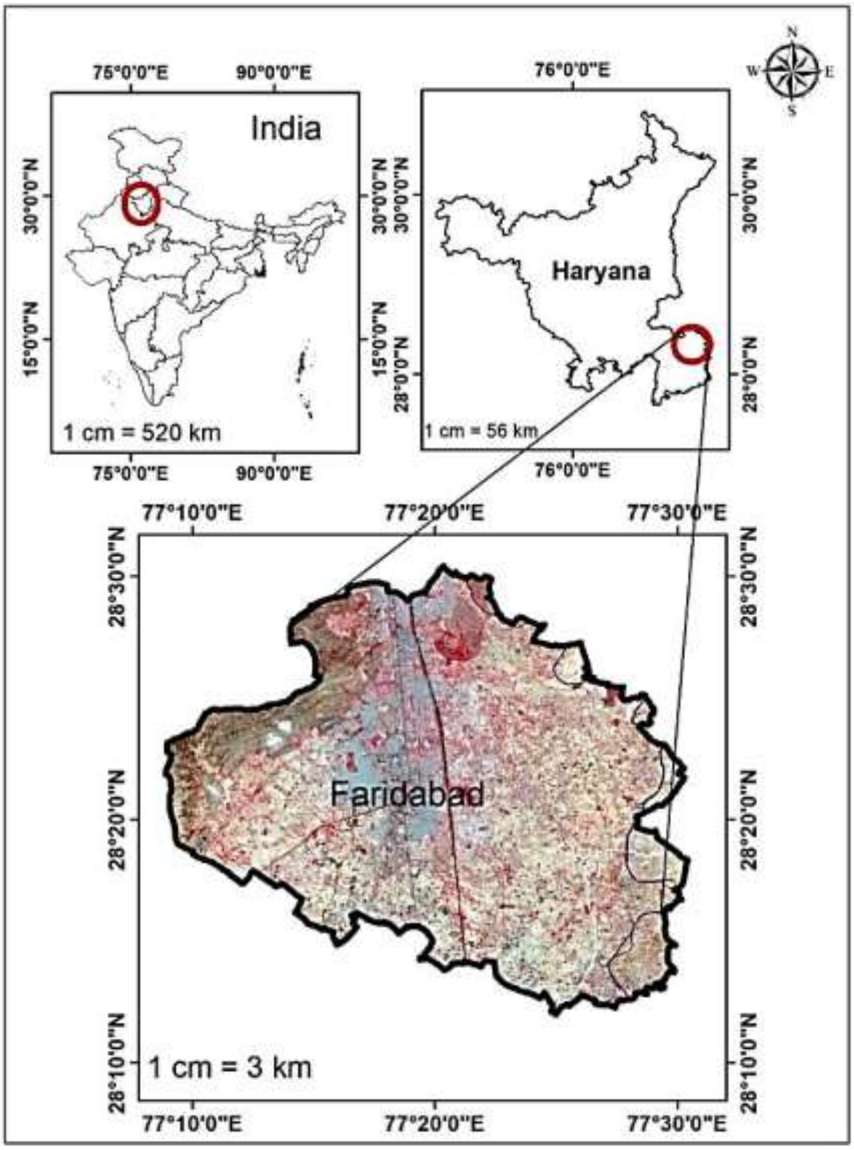

Fig 1: Location map of the Study Area

zone with an average temperature of 39°C with 542 mm annual rainfall. Air is generally dry and sometimes fog occurs in winter season. Mostly the soils are loam (Bhangar) and silty loam (Khadar) in the district. It covers an area of 741 sq. km with 2 Tehsils, 149 villages and 3 towns (S. Kumar, Midya, et al., 2021). According to the 2011 Census report, Faridabad district has 3,58,919 households with population of 18,09,733. Faridabad was initially constructed as small town on the outer portion of Delhi. However, with the time, it expanded to a well grown urban area. National Highway No.2 (Delhi to Mathura) runs through the middle of the district from north to south. With the continuous industrial and urban activities in and around Faridabad, it became so polluted that even the Supreme Court of India has given court orders to stop all building and mining activities within five km of Aravalli range. Faridabad has been ranked the fourth most polluted city in 2018 (*2018 World Air Quality Report.*, 2018), is the most populous city of Haryana and also is a leading industrial center. Even the urbanization and high air pollution has affected the area to a great extent but still aerosol characteristics and their relationship with urbanization are less explored to the best of our knowledge.

In this study, Landsat 5 Thematic Mapper (TM) image with optical bands (30 m spatial resolution) thermal band (120 m spatial resolution and resampled into 30 m) acquired on 29th April 2008 and Landsat 8 OLI (30 m spatial resolution) and TIRS (100 m spatial resolution and resampled into 30 m) acquired on 25th April 2018 downloaded from the United States Geological Survey (USGS) server have been used to prepare the land use land cover maps (Table 1). All the data sets are terrain corrected with Universal Transverse Mercator (UTM) coordinate system, 43 North Zone and WGS 84 Datum. Average monthly AOD based on observations from the MODIS on NASA's Terra satellite at resolution of 0.1 × 0.1 degree has been downloaded from NASA Earth Observations (NEO). Arc Map 10.3.1 and ERDAS IMAGINE 2014 software have been used for processing of data and final map layout.

Table1: Details of the data used in the present study.

Satellite imageries and Other data	Acquisition time	Spectral Resolution (µm)	Spatial Resolution (m/km)	Source
		B1 (0.45 to 0.52)	30	
		B2 (0.52 to 0.59)	30	
		B3 (0.62 to 0.68)	30	
Landsat 5	29 April 2008	B4 (0.76 to 0.86)	30	
		B5 (1.55 to 1.75)	30	United States Geological Survey (USGS)
		B6 (10.40 to 12.50)	120	
		B7 (2.08 to 2.35)	30	
		B1 (0.43 to 0.45)	30	
		B2 (0.45 to 0.51)	30	
		B3 (0.53 to 0.59)	30	
		B4 (0.64 to 0.67)	30	
Landsat 8	25 April 2018	B5 (0.85 to 0.88)	30	
		B6 (1.57 to 1.65)	30	
		B7 (2.11 to 2.29)	30	NASA Earth Observations (NEO)
		B9 (1.36 to 1.38)	30	
		B10 (10.6 to 11.19)	100	
		B5 (11.50 to 12.51)	100	
MODIS	2008 & 2018		111	

In the current study, after pre-processing and extraction of the study area from the multi-temporal satellite images, unsupervised classification approach with K means clustering classifier has been used to identify land cover units following up to Level-I schema by National Remote Sensing Centre (NRSC, 2012). Recoding has been applied to reduce minor misclassification.

To authenticate the LULC maps, accuracy assessment has been performed by comparing the classified data by error matrix (Congalton, 1991). As a reference, the unclassified OLI image has been used because of the unavailability of high-resolution image of the whole district for the same years. Furthermore, Google Earth images and limited ground points have been considered. For calculating the overall accuracy, producer's accuracy, and user's accuracy of both images, stratified random sampling approach available in Erdas Imagine software has been used by taking minimum 50 sample points for each LULC class.

Modules for Land Use Change Simulations (MOLUSCE), a user-friendly plugin for QGIS has been used to study land use land cover change detection (Hakim, Baja, Rampisela, & Arif, 2019; Kafy et al., 2021). The change map has been prepared to understand the transformation of one class to another. Further, spatial metrices has been calculated to assess the landscape configuration. Shannon's entropy has been obtained by determining the fraction of the built up area to the total number of zones to examine the pattern of development using equation 1 (Yeh & Li, 2001).

$$H_n = -\sum_{i=1}^{n} P_i \, log(P_i) \tag{1}$$

where,

H_n denotes Shannon's entropy.

P_i denotes the proportion of the built up in the ith zone to the total built up of all the zones ($P_i = x_i / \sum_{i=1}^{n} x_i$)

x_i denotes the ratio of the urban area with total land area in the ith zone.

n represents the total number of zones.

Value of H_n ranges from 0 to $\log n$. H_n value closer to 0 indicates built-up is concentrated in a small number of zones and closer to $\log n$ depicts evenly spread built-up to all zones.

LULC maps of 2008 and 2018 have been further reclassified into two categories: built-up land and non-built-up areas. To measure the entropy value, the study area has been divided into 13 buffer zones around the city center at 1 Kilometers interval. Final entropy value is calculated based on the entropy values of each zone.

From NEO website, worldwide 0.1-degree gridded monthly AOD of 2008 and 2018 have been downloaded and clipped for the present study area. Gridded output of each month for Faridabad district has been converted to points and an Inverse Distance Weighted (IDW) interpolation technique has been applied to create continuous surface for AOD. Considering four distinct seasons (pre-monsoon/summer (March–May), monsoon (June–September), post-monsoon (October–November), and winter (December–February)) in India, seasonal (pre-monsoon/summer monsoon, post-monsoon, and winter) AOD has been computed by the averaging the value of the respective months. Further the relationship between urban growth and AOD has been analyzed using buffer of 1km for the study area.

RESULTS AND DISCUSSION

Major five land use and land cover (Agricultural Land, Built-up area, Vegetation, Wasteland and Waterbodies) have been identified during 2008 and 2018. Accuracy assessment of the LULC reveals the overall accuracy of 89% and 90% for 2008 and 2018 respectively. Although because of the spectral homogeneity of the LULC classes and medium resolution of the images small building with less over ground area coverage cannot be segregated from the neighboring vacant area. Even in the rural area the grazing land, brick-kilns and mining area has been classified as built-up area.

Table 2: Statistics of LULC change 2008-2018

LULC classes	Area (sq. km) (2008)	Area (sq. km) (2018)	Change in area (sq. km)	Area (%) (2008)	Area (%) (2018)	Change in area (%)
Agricultural Land	500.53	485.53	-15.00	66.92	64.92	-2.01
Built up Area	114.35	138.04	23.69.	15.29	18.46	3.17
Vegetation	24.64	23.26	-1.38	3.32	3.10	-0.21
Waste Land	93.38	93.58	0.2.	12.57	12.49	0.08
Water Bodies	9.12	8.67	-0.46	1.22	1.16	-0.06

In 2008, 66.92 % of total area was covered by agricultural land, followed by built up area (15.28%), waste land (12.57%), vegetation (3.32%) and water bodies (1.22%). While in 2018 built up area has been increased by 3.17% (23.69 sq. km.) however agricultural land has been decreased by 2% (- 15.00 sq. km.). Further vegetation, waste land and water bodies have been reduced (Table 2). Built-up area has expanded in a linear pattern along the Delhi-Agra National Highway No. 44 and New Delhi- Chennai railway line running from north to south direction and thus created an elongated shape of urban area within the boundary of Faridabad Controlled Area (FCA). Built-up encroachment into agricultural land is quite prominent especially in the eastern direction. Small patches of rural built-up has also been observed (Figure 2).

Significant proportion of area under agricultural land has been transformed into built-up especially close to edges of FCA. Also, substantial area under vegetation has been converted into agricultural land in the rural area. Built up area in 2008 was 100.72 sq. km. which has been expanded to 110.95sq.km. in 2018. Indicating an increase of 10.22sq. km. in the decade by encroaching into 22.44 sq. km. agricultural land 4.47 sq. km vegetation and 3.0186 sq.km waste land (Figure 3-4).

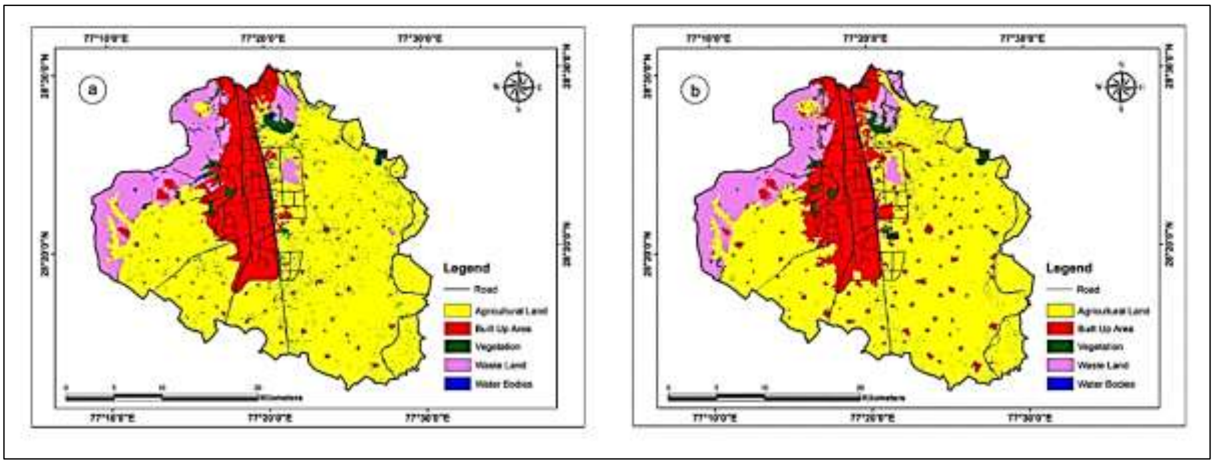

Fig 2: Land use/cover of Faridabad district in (a) 2008 (b) 2018.

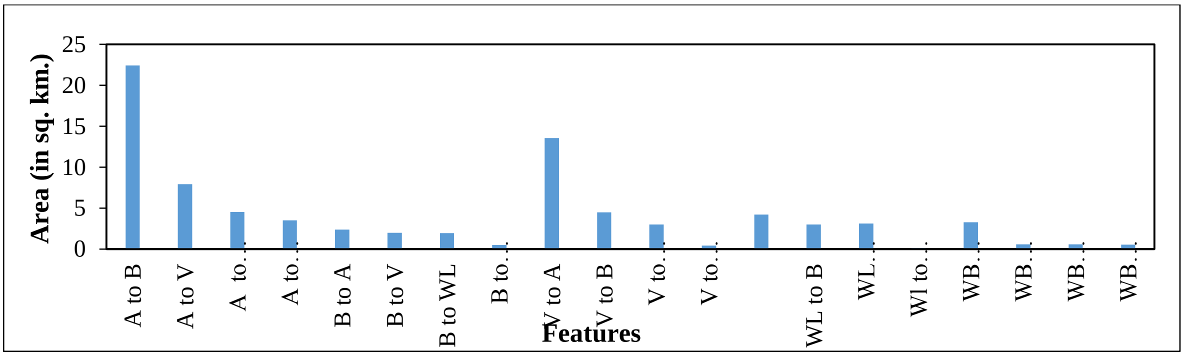

Fig 3: Conversion of one LULC class to another during 2008-2018.

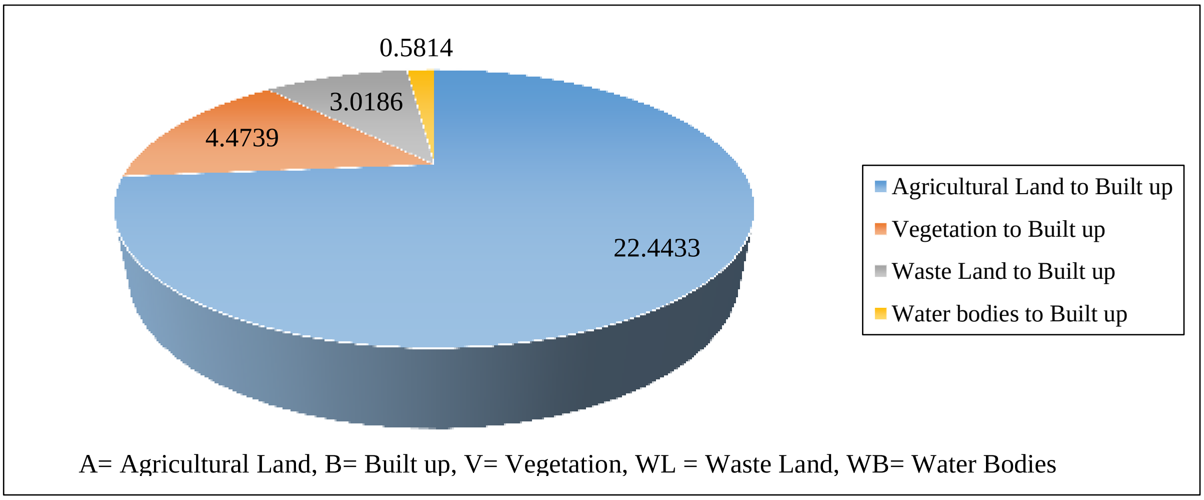

Fig 4: Graphical representation of land cover area transformed into built up area in sq km.

To quantify the spatial distribution pattern of urban built-up within Faridabad Municipal Boundary Shannon's Entropy has been performed by dividing the area into 13 circular buffer zone and statistics has been provided in Table 3. Value of H_n closer to $log(n)$ has revealed that built up is nearly evenly distributed among all zones. High entropy index (H_n=1.05; $log(n)$= 1.11 in 2008 and 2018, $n = 13$) has indicated dispersion of built up from the centre towards the periphery of the study area (Table 4). Built up cluster has been observed close to the centre of the study area due to the less possibility of horizontal development of the city as Aravalli hills act as constricting topography. However, built up has increased in north south direction along the highways in linear pattern. Even scattered development of built-up has also been observed at the periphery of the city because of industrial development (Figure 5).

For assessing the urban built-up distribution pattern of the entire area different spatial metrics have been calculated by analyzing the patches. In the present study patch denotes the LULC unit which makes the landscape of the study area. The number of small patches has been increased in 2018 which indicates fragmentation of the landuse and heterogeneity of the landscape.

Table 3: Zone wise built up and non-built-up area (in sq. km.).

	2008		2018	
Zone no.	**Non-Built up**	**Built up**	**Non-Built up**	**Built up**
1	0.03	3.11	0.00	3.14
2	0.86	8.59	0.61	8.83
3	5.18	10.57	4.18	11.57
4	9.42	12.61	8.58	13.31
5	17.06	10.96	14.77	13.25
6	15.43	10.68	14.24	11.93
7	11.70	10.88	10.44	12.16
8	10.03	8.91	8.36	10.58
9	11.75	8.86	11.00	9.60
10	4.27	7.40	3.34	8.36
11	3.18	5.24	2.80	5.62
12	1.57	2.54	1.92	2.21
13	0.27	0.37	0.26	0.39
Total	90.75	100.72	80.50	110.95

Table 4: Entropy Values for the built-up area in square km.

Years	Non-built up area (in sq. km.)	Built up area(in sq. km)	H_n	Log(n)
2008	90.74	100.72	1.05	1.11
2018	80.49	110.95	1.05	

Number of spatial metrics has been calculated at class level: viz. i) Class Area (CA), ii) Number of Patches (NP) and iii) Largest Patch Index (LPI). Graphical representation of the metrics indicated that the extent of built-up areas was 11470 hectares for 2008 and has been increased to 13806 hectares in 2018 indicating an increase of 2336.22 hectare in a 10-year gap. While agricultural land, vegetation and waterbodies has been declined. Such quantification supports the observation that built-up has been increased at the cost of arable land in the study area. Such impervious urban expansion and wasteland increment affect the surface temperature of the district of Haryana because of the soil characteristics (S. Kumar, Ghosh, Hooda, & Singh, 2019).

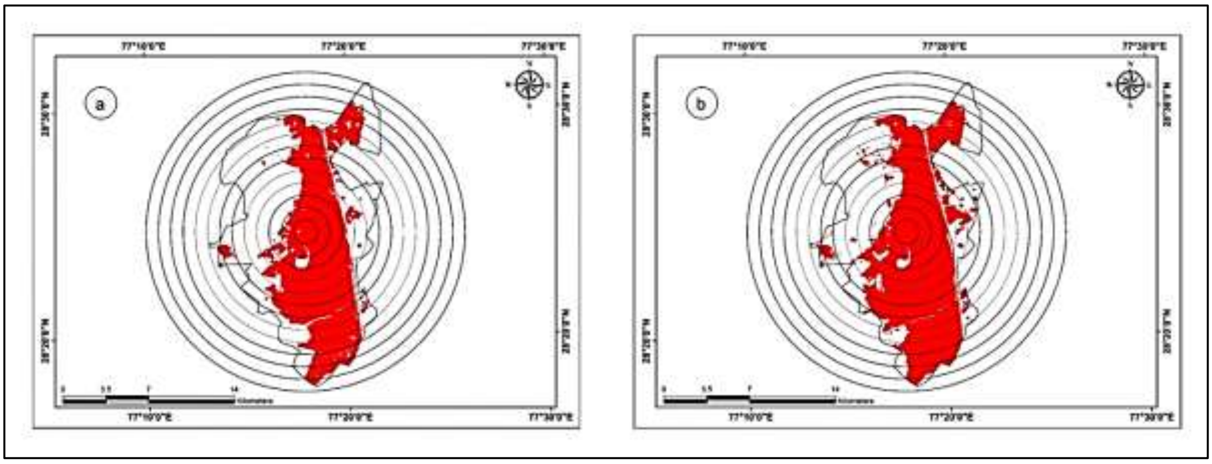

Fig 5: Built-up development in the buffer zones in a) 2008 and b) 2018

CA indicates the composition of the landscape, while the other metrics calculated indicated the configuration of the landscape. NP of built-up has increased from 221 to 476 in the decade. Small built-up patches with less area coverage (indicated by green colour in figure 7) has been increased from 2008 to 2018 indicating the scattered development of built-up in the study area. LPI of built-up (percentage of total area covered by the largest built-up patch) has slightly increased as compact urban built-up zone from the center of the study area extended towards Ballabhgarh on the south and as Greater Faridabad towards east (Figure 6 and Figure 7). CA and NP of the wasteland patches have also increased, due to the increase of vacant land close to construction sites and area reserved area by authority for future building construction (S. Kumar, Ghosh, et al., 2021; S. Kumar, Midya, et al., 2021). NP of wasteland is significantly increased as in the rural-urban junction area various part of agricultural land is converted to wasteland, as it has been reserved for upcoming urban development. Although, few wastelands have already been utilized for residential-industrial growth, which is evident from the conversion of wasteland class to built-up class (Figure 4, Figure 6). Overall, it can be remarked that concurrent occurrence of different urban expansion pattern viz. urban infill, linear urban expansion along with transport network and urban extension as Greater Faridabad result into the vertical enlargement of the Faridabad city region.

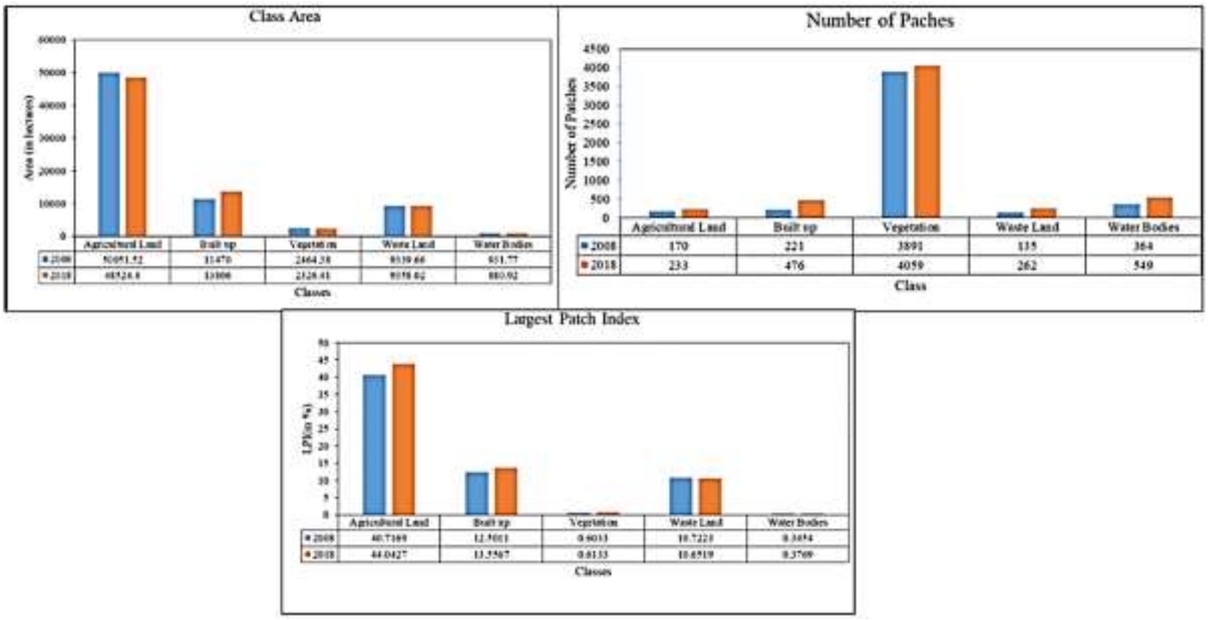

Fig 6: Graphical representation of Class area, Number of patches, Largest patch index (LPI), Edge density of each LULC type.

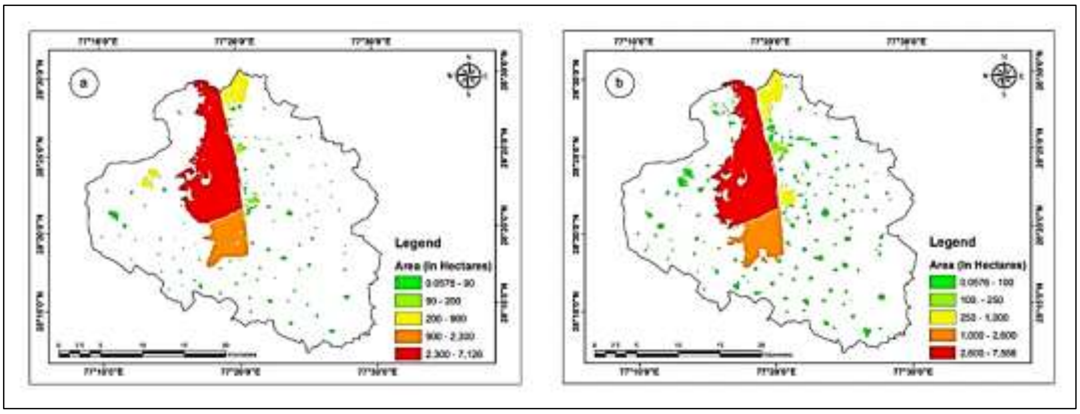

Fig 7: Built up Patch Area maps- a) 2008 and b) 2018.

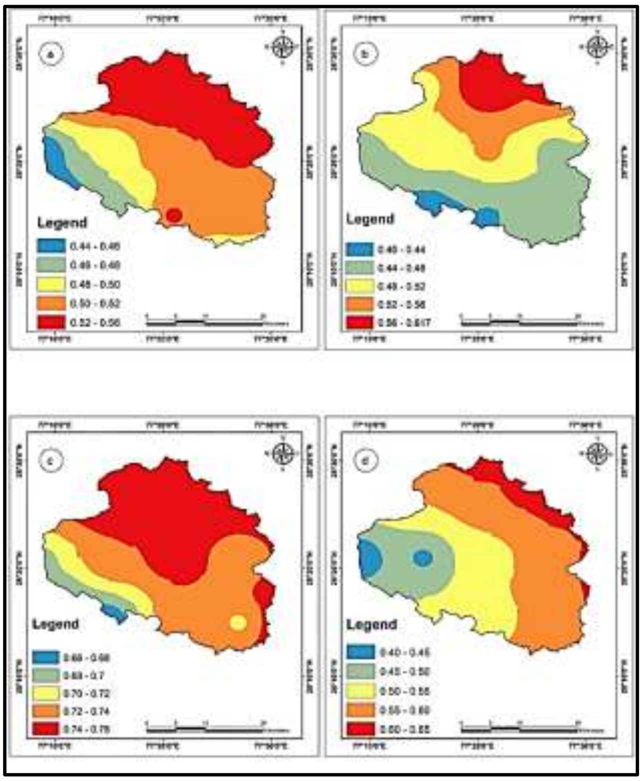

Fig 8: Seasonal AOD maps of 2008-
a) Pre- Monsoon b) Monsoon c) Post- Monsoon and d) Winter.

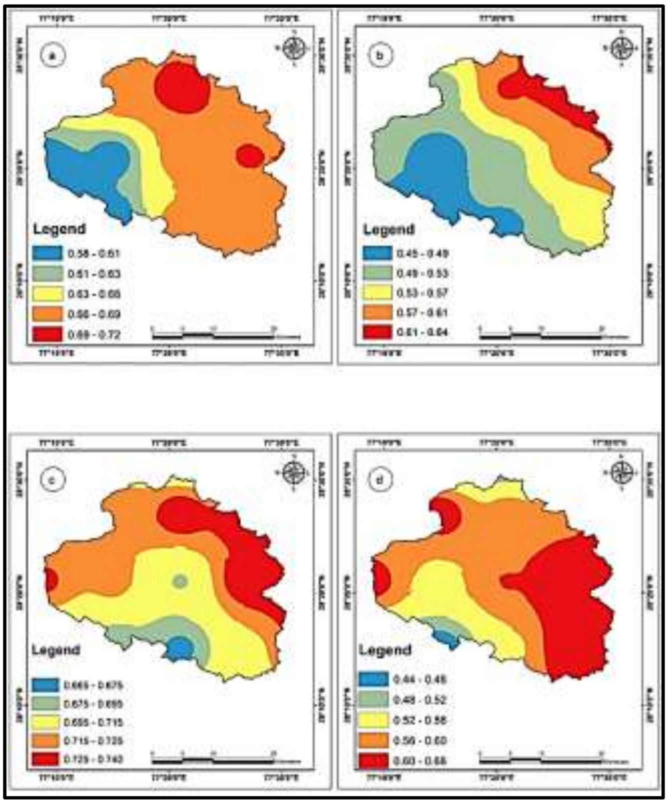

Fig 9: Seasonal AOD maps of 2018-
a) Pre- Monsoon b) Monsoon c) Post- Monsoon and d) Winter.

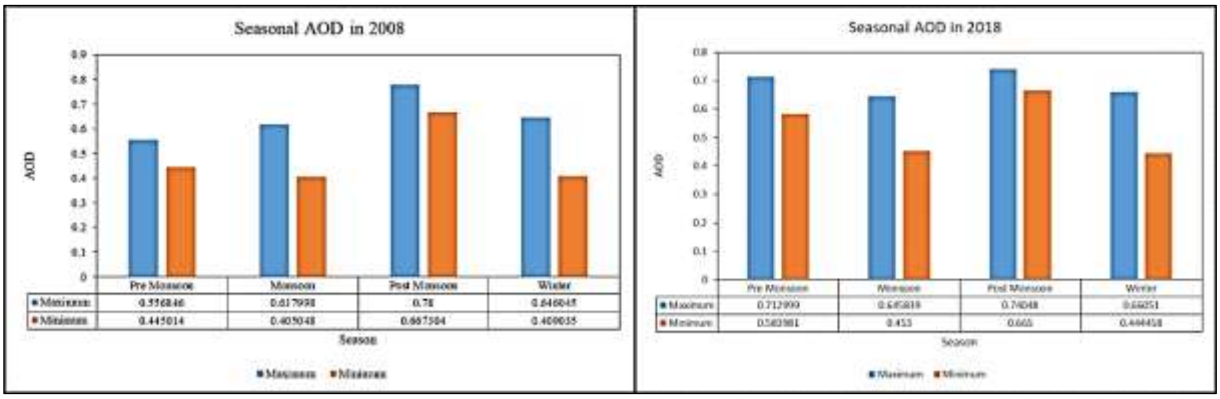

Fig 10: Graphical representation of Seasonal AOD in 2008 and in 2018.

Seasonal variation of AOD has been portrayed for the years 2008 and 2018 with a range from 0.1 to 1 (Figure 8-9). High AOD has been seen in post-monsoon and pre-monsoon for both the years. It is clear from the observations that AOD has been increased in 2018. The mean AOD was 0.51 in pre monsoon 2008 and after the gap of 10 years, it has been increased to 0.66 in 2018 for the same season (Figure 10). It is visible in pre monsoon-AOD (2018) map that whole area has AOD of more than 0.63, except southwestern area. High AOD because of the dust storm in the pre-monsoon season has also been reported in the previously published research (Sharma et al. 2021). There is also change in the trends of pollution in monsoon season. Rains can provide a temporary solution to air pollution. It is visible in monsoon- AOD (2018) map that almost 80% area is below 0.6. Highest aerosol concentration is observed in post monsoon season of both years i.e. 0.74 in 2018 and 0.78 in 2008. In winters, AOD concentration is very high in east and southeast portion of the district. This portion of district represents the agricultural area and the reason for increased AOD might be the stubble burning, fossil fuel burning, over-utilization of the fertilizer. Moreover, substantial emission from industries, brick kilns, heavy vehicles, dust from construction activities and road etc. has been reported as probable reason for high AOD in this region (Chowdhury, Dey, Ghosh, & Saud, 2016; Sharma et al., 2021).

To evaluate the impact of linear expansion of built-up area along the road on aerosol loading, total 18 buffers of 1km width has been created using on both the side of national highway. Mean AOD and built-up proportion of each buffer zone has been calculated (Figure 11-12, Table 5).

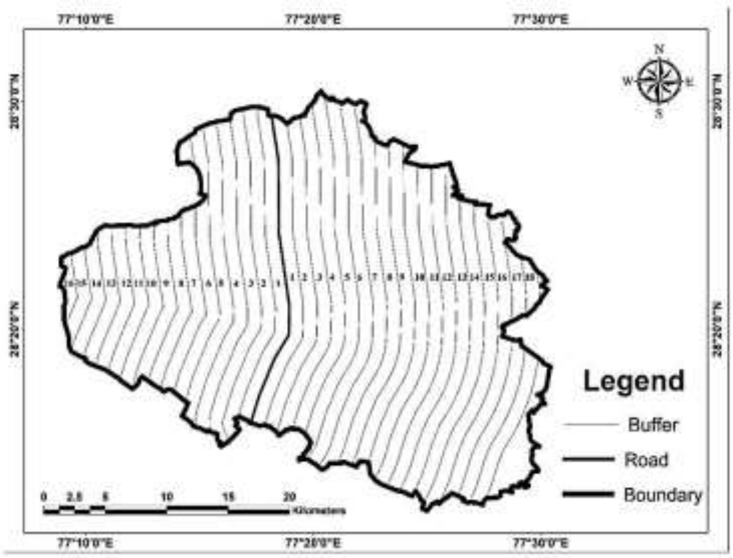

Fig 11: Buffer zone along the road.

In 2008, AOD in 18 zones ranges from 0.502 to 0.517. While, in 2018, it was from 0.656 to 0.680. Built-up proportion is having a decreasing trend as one moves away from the road, while proportion of agricultural land has exhibited a reverse trend. However, a fluctuating trend of AOD has been observed in the 18 buffer zones. Although, it is evident that up to 3 km high built-up proportion has an influence of high range of AOD both in 2008 and 2018. It was reported in earlier research that a transit-oriented polycentric urban growth has been observed around multiple urban centres (Old Faridabad, NIT and Ballabhgarh) in Faridabad district. Further, linear urban expansion close to highways has also been observed (S. Kumar, Ghosh, et al., 2021). Likewise, in 15-18 km away from the road the aerosol loading is high both in 2008 and 2018. In those zones, proportion of agricultural land is high, therefore, extensive use of fertilizer, stubble burring may affect the aerosol concentration.

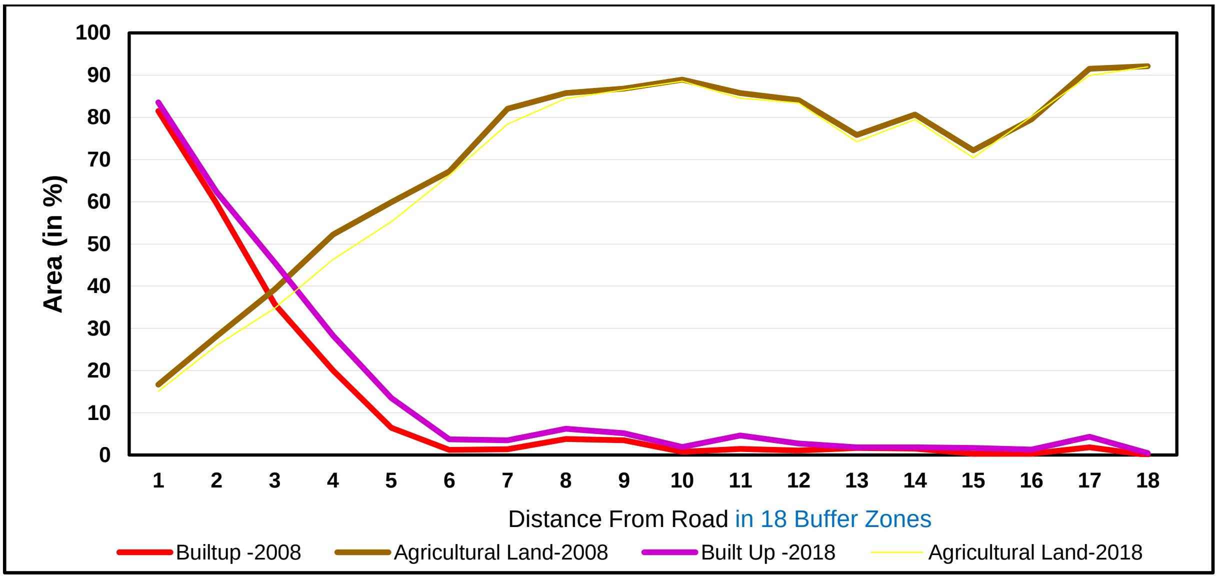

Fig 12: Graphical representation of Variation in Built up and Agriculture area between 2008 and 2018.

Table 5: Variation of Mean AOD, Built-up and Agricultural Land in different buffer zones

Distance From Road	Mean AOD		Built Up (%)		Agricultural Land (%)	
	2008	2018	2008	2018	2008	2018
1	0.516	0.660	81.51	83.56	16.73	15.09
2	0.514	0.659	59.58	62.34	28.15	25.98
3	0.514	0.658	35.69	45.58	39.28	34.82
4	0.515	0.659	20.03	28.27	52.27	46.36
5	0.516	0.660	6.46	13.48	59.92	55.27
6	0.517	0.661	1.27	3.76	67.15	66.25
7	0.515	0.659	1.36	3.53	81.99	78.41
8	0.512	0.657	3.83	6.24	85.75	84.47
9	0.511	0.657	3.53	5.17	86.75	86.49
10	0.508	0.656	0.77	1.95	88.87	88.50
11	0.507	0.657	1.49	4.68	85.69	84.48
12	0.506	0.659	1.08	2.79	84.09	83.37
13	0.504	0.659	1.68	1.86	75.82	74.23
14	0.502	0.660	1.55	1.85	80.66	79.47

Distance From Road	Mean AOD		Built Up (%)		Agricultural Land (%)	
15	0.502	0.664	0.31	1.73	72.15	70.40
16	0.506	0.670	0.37	1.30	79.52	80.19
17	0.514	0.681	1.87	4.35	91.50	89.92
18	0.510	0.680	0.00	0.45	92.08	91.97

Due to lack of uniform policy interventions can result in disproportionate distribution of emission sources which results in air pollution and LULC changes.

CONCLUSION

Assessment of urban growth and its multidimensional impact over air quality is complex and difficult to assess quantitatively due to the data constraints. To fill this research gap, present study has utilized recent development in remote sensing and GIS technologies and generates a database to examine the changes in the land use and land cover and quantify the resultant urban growth pattern in Faridabad from 2008 to 2018. Moreover, it also analyzed the seasonal variation of AOD which is an indicator of aerosol loading during that decade. Current study revealed that built up area (+23.69 sq. km) has been increased at the cost of productive agricultural land (-15.00 sq. km) and vegetation (-7.82 sq. km). Built up area development has been occurred along the roads which gives an expansion of the city area in the north-south direction. Further, spatial metrics (viz. CA, NP. LPI) analysed the spatial structure of urban growth. Both CA and NP for built up have been increased from 2008 to 2018 which has indicated expansion of the built up area and scattered development of isolated buildings. Moreover, the present study observed high mean AOD in the pre monsoon (0.51) and post monsoon (0.74). Impact assessment of built-up expansion on AOD has indicated high AOD along the highways and roadways where the built-up density is high. However, in the rural area high proportion of agricultural area has also contributed towards high aerosol concentration because of over-use of fertilizer and stubble burning. Anthropogenic activities (vehicular pollution and construction activities, crop stubble burning) present in the high-density built-up and rural agricultural region have been identified as one of the major factors for high aerosol concentration. Such study will help to locate the areas in the districts with heavy aerosol loading which needs proper monitoring and management. Installation of the automatic weather station particularly in the locations can be of great help to design the adaptation and mitigation measure to improve the air quality which is one of the major goals of sustainable development. Further, regular, and systematic ground observations will improve the accuracy and validation of such satellite-based measurement. Further, such research can promote the need of the awareness plan for the society to make people informed about the negative impact of poor air quality. Present study also suggests the installation of good network of AERONET stations to obtain information about the air quality information in real time.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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