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Determination of Land Surface Temperature in Relation to Changing Land-Use / Land Cover Pattern at Urban Area of Bilaspur City [CG] through Temporal Remote Sensing & GIS

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Abstract: ***The land surface temperature and land-use / land cover for the urban portion of Bilaspur [CG] has been studied through Remote Sensing & GIS. The changing pattern of land-use /land cover in between years 2012 & 2017 has been documentated along-with land surface temperature through Landsat MSS & THERMAL band. The eight types of land-use /landcover features namely: Agricultural, Built-up, Mixed Built up, industrial, Open land, River-rine, Tree clad/sparse vegetation and Surface water bodies have been identified and monitored. The negative [minus] and positive [plus] changes in land-use/ land cover in relation to land surface temperature have been quantified as area increased and decreased respectively. The retrieval of land surface temperature has revealed the urban growth settlement and its adverse impact on conservation of local land, vegetation and water resources. The land surface temperature for all eight land-use /land cover have been obtained in the incremental order of 5-7 ° C during the 15 years [in between 2002-2017] for 30.50 Sq. Km geographic area for the urban portion of Bilaspur city.***

Keywords: Land Surface Temperature, Remote Sensing, GIS

1. Introduction

The Remote Sensing basically deals with spectral characterization of objects over land surface. The function of human related activity on land surface causes variety of land-use / land cover for specific geographic area. The change in land-use / land cover pattern with respect to particular time interval is inferred through supervised classification of Landsat MSS data, as per G I S study.

All the objects on land surface including land-use/ land cover emit radiation-depending upon their physical properties and amount of sun radiance. The emissivity [interaction in between physical property and sun radiance] of individual land-use/land cover has fine response among thermal band in wavelength of 8-32 µm and is utilized for estimation of land surface temperature [1].

Remote Sensing data for the area of study utilized as [a] MSS [Multi Spectral Scanner] of landsat-7, belonging to 2002, launched in 1997 for identification cum monitoring of land-use/land cover features, [b] TIRS [Thermal Infra Red Scanner] of Landsat-8, belonging to 2017, launched in 2013 for determination cum monitoring of land surface temperature for the same area of study.

The rapid urban growth in Bilaspur city has adversely impact on the loss of Agricultural land, Vegetation, Surface water bodies as well as gain of concrete structure-as Built up, Mixed Built up, transportation network [Cement Concrete Road] possessing their characteristics spectral signature. This has resulted in increment of land surface temperature and their quantification has been attempted through temporal Remote Sensing.

2. Area of Study

The location of study has geographic area of 30.50 Sq. Km. It belongs to urban growth with population of 3, 35,295 [2011 census] for Bilaspur city [CG]. It has been cross cut by Arpa river of decaying stage. The geographic coordinates for area of study has Latitude N 22° 07 ‘50” to N 13’ 30” and Longitude E 82 ° 05 ‘ 30” to E 82 ° 16’ 00”. The existing urban population of Bilaspur is estimated as 4, 55,000 [in April 2021] on the basis of 2011 census It is illustrated as Fig.1.

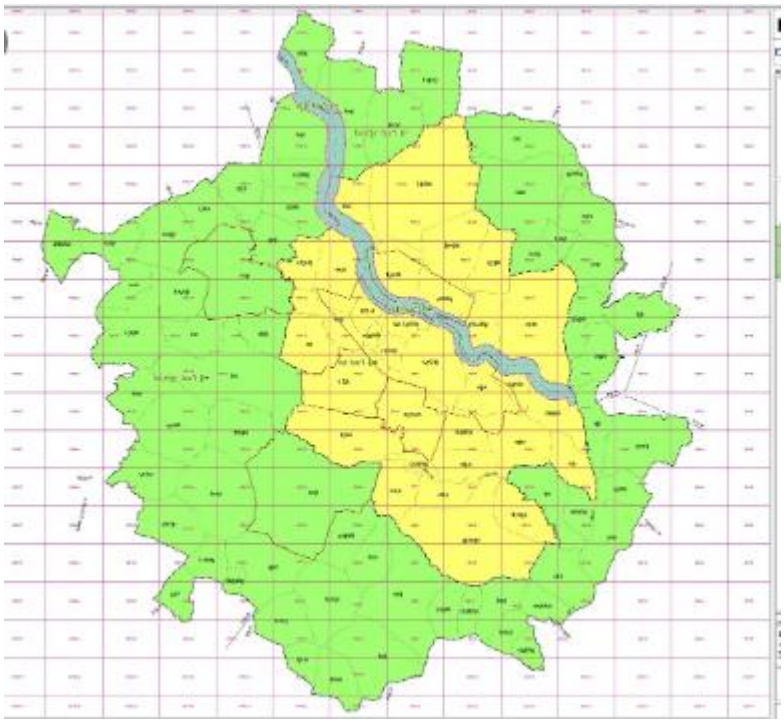

Figure 1: Location Map of Area of Study

3. Evolved Methodology & Objectives

The evolved methodology has two approaches namely- conventional and advance. The conventional approach is based upon Relevant Literature Review. The advance approach is based upon Remote Sensing & GIS study.

Seven Relevant Literature Review of international and nationallevel have been documented pertaining to urban complex. Temporal Landsat data of MSS & TIRS have been utilized for change detection of land-use/ land cover pattern and land surface temperature through analysis of Landsat data user hand- book [8].

Land surface temperature is defined as temperature of particular location on the earth surface in relation to local vegetation cover, surface water and anthropogenic activities. It has been determined for Guwahati [Assam] through Landsat-10 data through analysis of Digital Number and spectral response of land-use/ land cover features in the range of 14° C to 28 ° C for the month of January 2019 [7].

Landsat Thematic Mapper [TM] of 1989 and Landsat Enhanced Thematic Mapper [ETM] of 2000, 2005& 2009 have been studied for Shimla [Himachal Pradesh] for assessing rapid urbanization and related land surface temperature in the range of Minus 2° C to 21 ° C [11].

Land surface temperature is important factor for global climate change studies and climate model, as per studies conducted at Delhi. The emissivity per pixel has been retrieved directly from Landsat 7 [+ETM] for period of October 2009. The land-use/ land cover features like dense to sparse vegetation, agricultural crop land, waste land, and surface water bodies and urban built up with land surface temperature in range of 22 °C to 34 °C [6].

Land surface temperature has been correlated with Corona virus pandemic disease [COVID-2019] for urban complex in Delhi with respect to variation in day and night temperature. The data used for during 29 March 2020 to 30 April 2020 period with 8 days interval and 1 Km spatial resolution through MODIS band 31 & 32 in thermal infra- red range of 11-32 µm. The data was available for 10.30 AM & 10.30 PM through USGS. The land surface temperature for day[10.30 AM] is 26°C to 45 °C has been responsible for spread of COVID-2019, than night temperature [10.30 PM] of 13°C to 27°C [10].

Land surface temperature has been correlated with air pollutant parameters as NO2, O3& PM10 through temporal Landsat-8 data of 2013, 2015 in residential cum industrial area of Jakarta [Indonesia] in the range of 22 °C to 37°C [3].

Land surface temperature has been correlated with change of land-use/cover pattern for Chennai during August1991- October 2000 through Landsat- TM & Landsat- ETM+ with respect to road, building and dark colored objects [9].

Landsat-5 [TM] of August 1993 and Landsat-8 [TIRS] of September 2017 have been compared with variation of land surface temperature in rage of 22 °C -33 °C with respect to change of land-use/ land cover as Barren land, Shrub and River bed , Sparse vegetation, Built up at urban portion of Dire Dawa city [Ethiopia] [5].

Land surface temperature for land-use/land cover features of urban area are more influenced by their physical properties than sun irradiance and emissivity as observed through Landsat data of India, Indonesia & Ethiopia, close to tropic of cancer and equator respectively.

The analysis and interpretation of Remote Sensing data has been confined to [a] Determination of Digital Number [DN] of land-use/ land cover feature into spectral radiance per

pixel through landsat hand book guide, [b] Correlation of spectral radiance to top of atmosphere Brightness through thermal contact for individual used band, [c] Conversion of top of atmospheric temperature in to Celsius [°C] through empirical formula for computation of Land surface temperature. The G I S is used for identification and monitoring with change detection of land-use/ land cover through supervised classification [8]. The objectives for the area of study have been as follows:

- Identification cum monitoring of major land-use/land cover feature with change detection
- Estimation of land surface temperature for each land-use/ land cover features through standard formula
- Correlation of land surface temperature with respect to each land-use/land cover feature with its temporal behavior.

4. Result & Discussion

The urban area of Bilaspur city [CG] has eight major land-use/ land covers namely: Agricultural, Residential, Transportation network [Road], Commercial, Recreational, Public Utility Facilities, Tree clad /Sparse Vegetation area and surface Water bodies [4]. The Remote Sensing data used for the area of study belongs to Band 2,3,4 & 7 of Landsat- 7 of month March 2002 and Band 2,3,4,5 & 10, 11 of Landsat-8 of month May 2017 for envisaging the each of the following objectives:-

- Identification cum monitoring of major land-use/land cover feature with change detection through landsat data through Supervised classification;-

All the eight detailed land-use/ land cover for the area of 30.50 Sq. Km have been identified with delineation of change detection for the interval of 15 years [2002-2017] throughsupervised classification with GIS study. The quantification of changing pattern of each land-use/ land cover has been summarized as Table1. It is illustrated as Fig.2.

Table 1: Change quantification in all eight land-use/land cover features in urban area of Bilaspur city [CG] during interval of 15 years

S N	Land-use/ land cover feature	Area [Hector] in 2002	% in 2002	Area [Hector] in 2017	% in 2017	Gross ---Gain Area [Hector]	Change ----Plus %	IN -15 ------Loss Area [Hector]	Years -----Minus %	Per Year ----Area [Hector]	Change --------- %
1	Agriculture	172.96	5.67	78.07	2.56	-	-	94.89	3.11	6.32 [-]	0.21
2	Built up	1544.20	50.64	1716.60	56.29	172.40	5.67	-	-	11.49 [+]	0.38
3	Mixed Built up	476.19	15.61	532.79	17.47	56.60	1.86	-	-	3.77 [+]	0.12
4	Industry			7.10	0.23						
5	Open Land	414.15	13.58	292.44	9.59	-	-	121.71	3.99	8.11 [-]	0.26
6	River-ine	185.74	6.09	191.80	6.29	6.06	0.2	-	-	0.40 [+]	0.01
7	Tree clad area	193.43	4.57	137.82	4.52	-	-	1.61	0.05	0.11 [-]	0.003
8	Surface water bodies	116.98	3.84	93.15	3.05	-	-	23..83	0.79	1.59 [-]	0.03
9	Total	3049.65	100	3049.70	100	235.06	7.73	242.04	7.94		

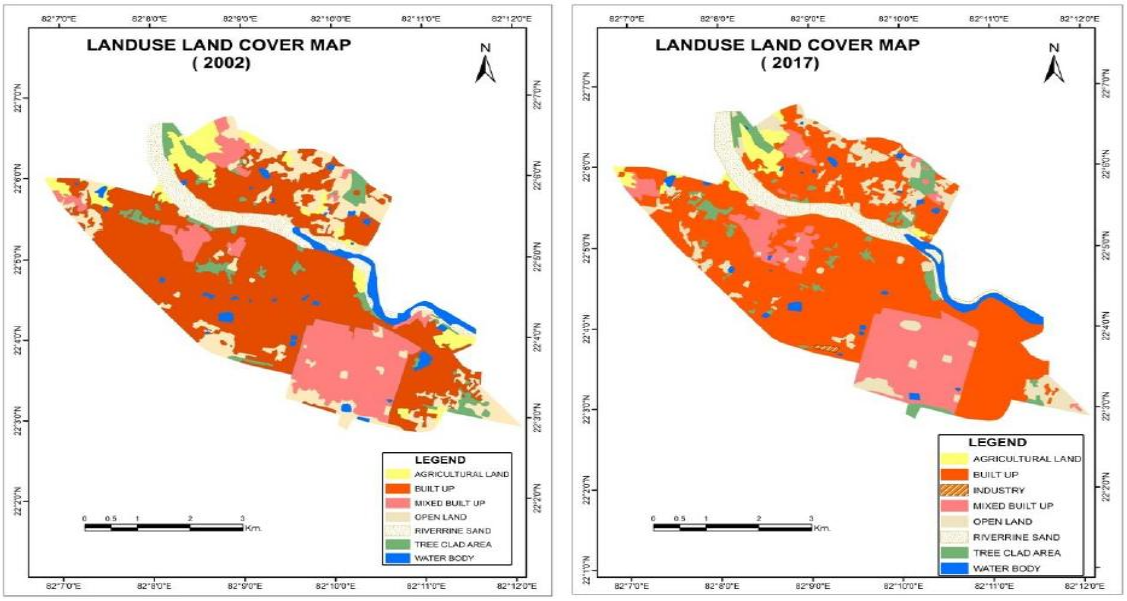

Figure 2: Comparison of land-use /land cover features for area of study during 2002-2017 period through supervised classification

The change pattern for identified land-use/ land cover features during period 2002-2017 has been due to their rapid transition on account of human related function and developmental activities. It is the manifesto of fast urban growth in term of mixed built up area, industrial zone and loss of surface water bodies, open land, agricultural land- the favourable response for land surface temperature enhancement.

Estimation of land surface temperature for each land-use/ land cover features through standard formula:-

It involves five steps, as per scrutiny of Landsat data user hand book, GIS study and are as follows:

1) The spectral radiance range for all eight land-use/ land cover has been obtained for band 6.1 [11µm] & band 6.2 12 µm] of Landsat -7 ETM
2) The spectral radiance range as maximum- minimum has been converted into temperature in Kelvin and later on into Centigrade for individual feature through empirical formula.
3) Lands at -8 TIRS of band 10& 11 have been studied for obtaining brightness temperature of identified each land-use/land cover feature.
4) The land surface temperature for 2002 through Landsat-7 has been computated in the range of 23.85 to 40.09 °C. It has been further sub-classified into five categories namely: 23.85-30.20, 30, 20-33.01, 33.01-35.0, 35.00-37.050 & 37.50-40.09 °C.
5) The land surface temperature for 2017 through Landsat-8 has been computated in the range of 30.07 to 45, 00 °C. It has been also further sub-classified into five categories namely: 30, 07-34.76, 34.76-36, 81, 36, 81-38.2, and 38.2 41.02, 41.02-45.00 °C.

The land surface temperature for entire area of studied urban city of Bilaspur during interval of 15 years [2002-2017] temporal analysis of Landsat data has been illustrated as Fig.3.

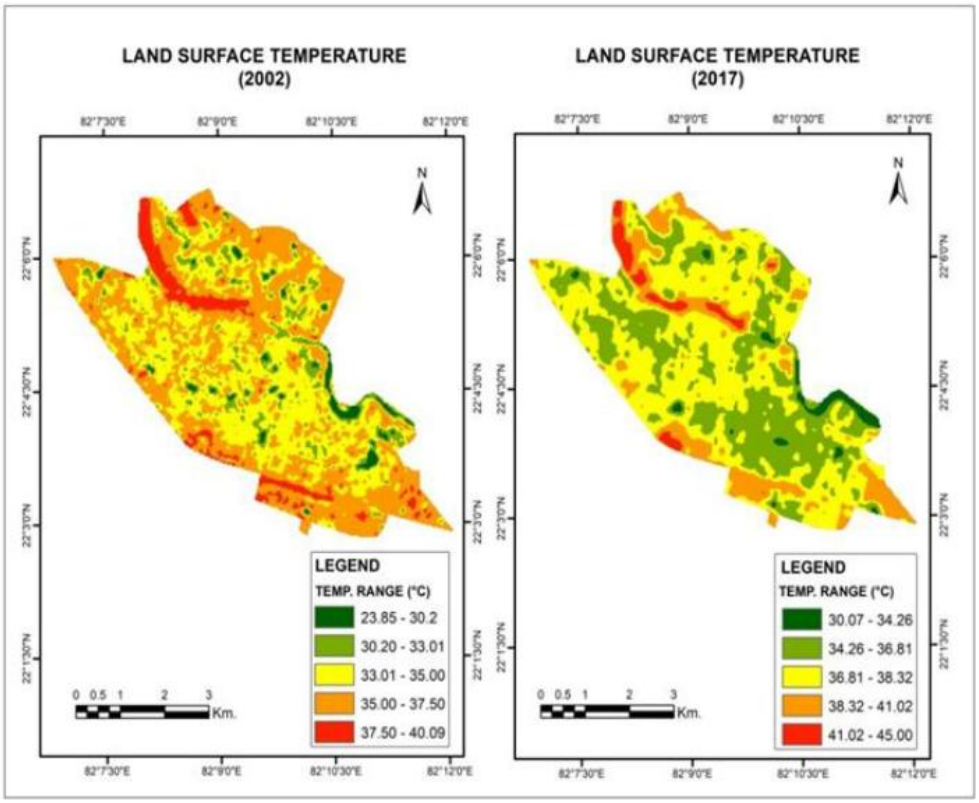

Figure 3: Comparison of land-surface temperature during 2002-2017 periods through Temporal Landsat data for urban area of Bilaspur city

Correlation of land surface temperature with respect to each land-use/land cover feature with its temporal behavior:-

The land surface temperature for identified eight land-use/land cover features for the period of 2002 and 2017 year has enhanced trend- as indicative of clear cut fast urban growth for Bilaspur city [CG]. The maximum-minimum range of land surface temperature has been observed as 40 °c to 23°C; during 2002 year which is increased in 2017 year as 45 °C to 30.7 ° C respectively.

Three land-use/land cover features namely Urban Built up, River-ine and Surface water body as Arpa river containing water has been correlated with sub-class of land surface temperature as 40.00 -37.50°C, 33-30 °C & 25-23 °C of 2002 year respectively. It is illustrated as Fig.4.

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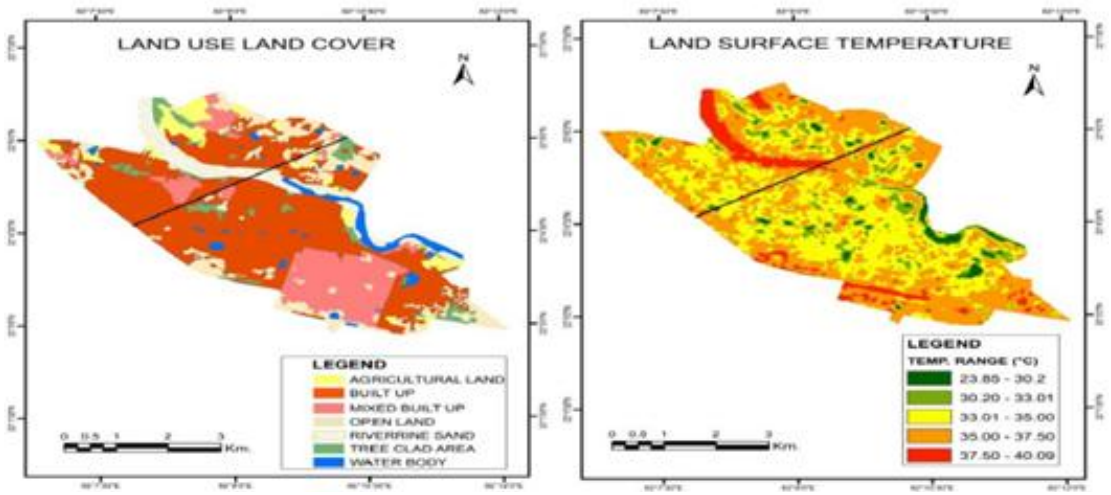

Figure 4: Correlation of land-surface temperature during year 2002-with respect to Land-use/land coverfeatures for urban area of Bilaspur city

The interpretation of maximum-minimum range of land surface temperature for year of 2017 has been sub-classified in to five categories in relation to prevailing changed land-use/land cover pattern. The details have been summarized in Table 2. The correlation has been illustrated as Fig.5.

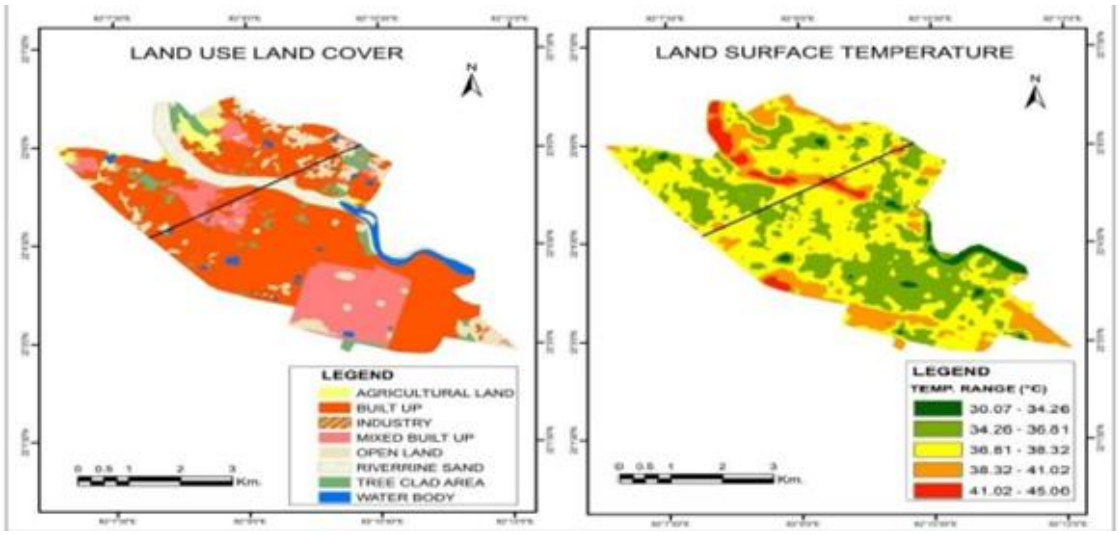

Figure 5: Correlation of land-surface temperature during year-2017 with respect to changed land-use/land cover patterns for urban area of Bilaspur city

Table 2: Correlation of land surface temperature with changed land-use/ land cover pattern during 2017 for urban area of Bilaspur city

SN	Sub-category of land surface temperature [°C]	Prevailing changed land-use/land cover features in 2017	Remarks
1	45.00-41.02	Sand excavation in Arpa river bed	Transformation of river-ine almost
2	41.02-38.32	Change of open land in to Industrial zone	Transformation of open land almost
3	38.32-36.81	Mixed Built up area	Extensive extension
4	36.81-34.26	Tree Clad area	
5	34.26-30.07	Arpa river [surface water body]	Warmer by7 °C than 2002 period

5. Conclusion

The specific geographic area of under study has fast rate urbanization growth with enhancement of land surface temperature during the studied period of 2002-2017. It has been widely converted with concrete building [urban built up to mixed built up], Asphalt [Cement-Concrete road net-work] and other similar impervious material [tiles] on the land surface. It has enhanced land as well as water surface temperature during fifteen years by 5- 7 °C. It has reduced considerably open land, tree clad area, surface water bodies. The conducted study has revealed the following silent aspects:-

- Urban growth in Bilaspur city has increasing trend of average land and water surface temperature @ 0.5°C per year.
- Protection of sparse vegetation, tree clad area, recreational garden, Green roof top seems to be essential for comfort of residents in urban area.
- Unplanned anthropogenic activities reduce the accumulation of direct solar radiance for proper land-use planning.
- The higher land surface temperature during day period [10.30 AM] in relation to lesser land surface during night period [10.30 PM] for same urban growth area has increasing trend of air pollution [3] as well as spreading of COVID-19 epidemic disease[10].
- The reliable and accurate land surface temperature measurement is important tool for proper planning and mitigating the Urban Heat Flux [2].
- Temporal Remote Sensing- particularly Landsat data analysis and G I S study has been proved as authentic, reliable, précised and up to date tool for identification cum monitoring for illegal sand extraction along river bed- as one of the chief source of Fine Aggregate in Construction/Building sector.

6. Acknowledgement

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