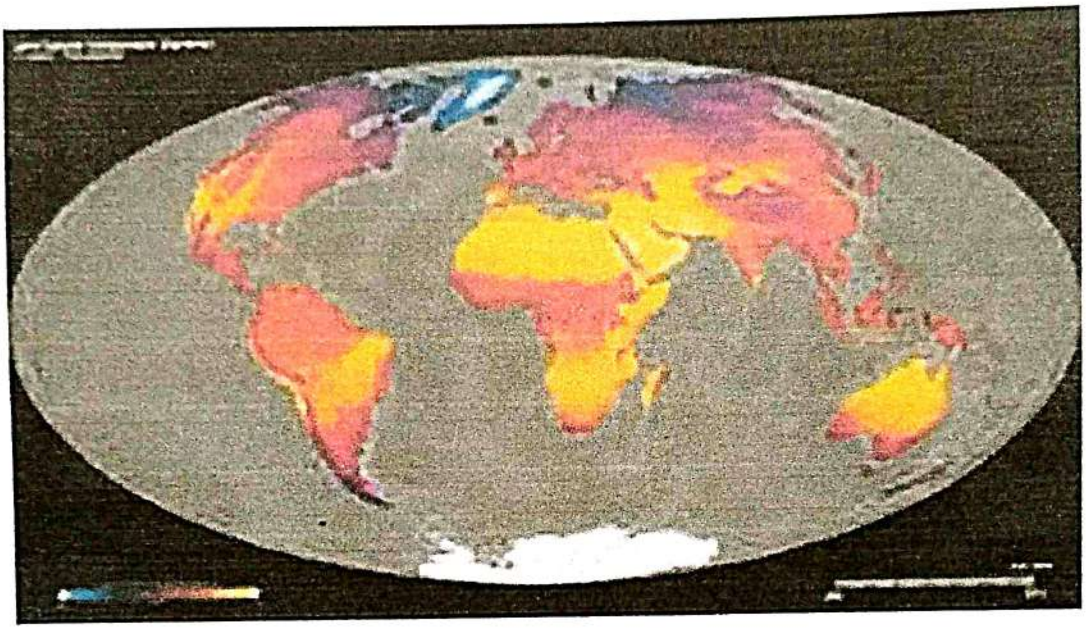
*DISSERTATION*

*ON*

# *"Analysis of Land surface Temperature change in Asansol using Geospatial Technology"*



**The dissertation submitted for the Partial Fulfillment of M.Sc. in Geography**

**Paper-496 (Under Vidyasagar University)**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DEPARTMENT OF GEOGRAPHY

HALDIA GOVERNMENT COLLEGE

# SUPERVISOR'S CERTIFICATE

This to certify that Mr/Ms. Maitrayee Maity, Roll PG/VUF...GEO IV No. 003 has prepared this dissertation on "***Analysis of Land surface Temperature change in Asansol using Geospatial Technology***" under my supervision for M.A./M.Sc. Sem-III, Examination in Geography, 2019 as a partial fulfilment of Paper- 396B. It is further certified that during the tenure of research she/he has followed the rules and regulations as laid down by the Vidyasagar University.

Date: 14·08·23

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Examined 23.08.23

## PREFACE

It has been observed throughout the World that areas under surface water bodies(wetlands) and vegetation covered areas are extremely sensitive in terms of urban-industrial expansion although both of which have a significant importance for maintaining urban ecological balance. Land use and land cover change and its impact on LST has been analysed using Landsat images of 1993 and 2018, result of which shows that temperature is increasing continuously due to the urban industrial and mining activities in Asansol Subdivision(Das et al., 2020). Land surface temperature study of Asansol Durgapur region using Landsat images over the period 1993 to 2015 shows that LST increases 0.06°C yearly in winter and 0.43°C yearly in summer(Choudhury et al., 2019). Urban Heat Island effects of Chandigarh City and surrounding region has been analysed by using remote sensing data from MODIS and ASTER GDEM. Support Vector Regression model has been developed from LST values for analysing the UHI effects along with the comparison with ANN(Mathew et al., 2019). Result shows that SVR is more applicable than ANN. Linear time series model has been developed for the prediction of LST in Jaipur city in India by using extracted LST values from MODIS and ASTER data. Enhanced Vegetation Index, elevation, result of which shows a high correlation between predicted and measured LST values(Mathew et al., 2016). Urbanization is categorized by the quick transformation of agrarian land, water bodies, and vegetation cover, into a settlement (Ding and Shi, 2013). The unprecedented modification of land use patterns sometimes creates serious environmental problems like Urban Heat Island. LST and UHI concepts are used to describe the varying nature of LULC pattern in diverse urban regions (Arnfield, 2003; Memon et al., 2008; Mirzaei, 2015; Rinner & Hussain, 2011; Zhao et al., 2016). Recently various LULC indices like NDVI, NDWI, NDBI are frequently used in LST associated studies to analysis their influence on fluctuating urban ecological status(Amiri et al., 2009; Kuang et al., 2015; Li et al., 2011; Peng et al., 2016; Song et al., 2014). For accommodating the fast growing urban population, the paved land cover has increased the effects of which is increased land surface temperature(Ramachandra, 2012). Urbanisation and industrialisation along with fast changes in land use/land cover are accountable for environmental problems like air pollution, water pollution, greenhouse gas emissions, and boosted urban heat islands (Shao et al., 2006; Chan and Yao, 2008). Rapid transformation of land use/land cover owing to urban expansion intensely affects biodiversity and ecosystem function, in addition to local and regional climate(Luck & Wu, 2002). LST differs based on surface reflectance and roughness of diverse land use/land cover pattern. Asansol Urban area has failed to maintain per capita share of green space in the context of sustainability (Siddique et al., 2020).

A comprehensive study on the nature of changing LST and transformation of vegetative land and surface water covered area and their inter relationship in Asansol Urban Area (AUA) over the last thirty years is crucial for sustainable development. Asansol Urban Area has been selected as the present study area due to the following reasons: 1. Asansol is the 2$^{nd}$ largest urban industrial agglomeration of West Bengal in Eastern India after Kolkata. 2. Coal mining activities play a vital role in the study area which is associated with the development of various kinds of small, medium and large industries. 3. Rapid urbanization and transformation of landuse and landcover are very prominent in Asansol Urban Area along with rising population. 4. Urbanization, industrial expansion, land conversion all are highly related to land surface temperature change.

The present study has been designed to fulfil the following objectives -1. To assess the nature of LST change over the last three decades. 2. To analyse the nature of transformation of vegetation cover and surface water forms. 3. To explain the inter relationship among LST, NDVI, MNDWI and NDBI.

The present study will help the reader to understand the methods of extracting LST and various spatial indices including NDVI, NDBI and MNDWI from Landsat imageries and how to explain the relationship between LST and various spatial indices. This study also will help the urban planner to rethink the policy regarding urban industrial expansion in different urban agglomerations in the world.

## Acknowledgement

There is a term in English literature "One Man Army' this is not existing in the real field of life; it is an imaginary concept. Every human being is not self-sufficient, they are a social element in the vast world in every case, moment and events of life. So in my purpose of research work is not exceptional the eternal truth for the fulfil of my research work. I have taken many helps from many persons so I want to thank them from my deepest heart for their noble works.

I wish to record my sense of gratitude to those who have helped me in several ways in course of preparing this dissertation. I am indebted to many organisation and individuals for their enthusiastic collaboration in the preparation of this dissertation.

I convey my deep gratitude to my honourable supervisor Mr. Sarbeswar Haldar, Assistant professor in Geography, Haldia Govt. College, under whose constant guidance , constructive suggestions and inspiration this term paper has been prepared in time.

I would also like to express my sincere gratitude to my family, my friends for their love, affection, co-operation and support throughout my project work period and making it successful. This will be memorable for my life. I would like to thanks my friend and my classmate for my last minute editing. My honest thanks is to the institute itself. for it gave me some of the best people, some of the best books, some of the best friends, some of the best moments and some of the memories that I could never have.

Finally, I am highly thankful to all the faculty members of the department of Geography, Haldia Govt, College and to my all friends for their constant co- operation in preparing this dissertation.

Maitrayee Maity
Signature

Date : 14.08.23.

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# Prelude to the Study

## Introduction

It has been observed throughout the World that areas under surface water bodies(wetlands) and vegetation covered areas are extremely sensitive in terms of urban-industrial expansion although both of which have a significant importance for maintaining urban ecological balance. Over the last decades remote sensing data plays an important role in research of various disciplines. LST is the fundamental factor that controls the biological, chemical and physical methods on the earth(Pu et al., 2006). The LSTs taken out from satellite derived sensors have been used in several studies like heat-balance, climate modelling and observation of global change (Bhattacharya et al., 2010; Fall et al., 2010). Despite LST assessment, the TIR region of the electromagnetic spectrum has enormous prospective to determine land surface allied variations in any region. and is widely used in various segments in Earth science (Alexander, 2020; Khan et al., 2020).

Landsat imagery is very useful for interpreting the land surface temperature and the interrelationship between LST and various LULC indices. Relationship between LST and NDVI has been analysed using pre-monsoon Landsat images of various timespan in Raipur city of India, result of which shows a rising trend of land surface temperature and negative relation between LST and NDVI throughout the period of observation(Guha et al., 2020). The study of LULC Changes and LST of Saudi Arabian cities using Landsat images has shown that urbanization is associated with an increase in the land surface temperature over the last few decades(Rahman et al., 2017). Spatial variation of urban land surface temperature in Tehran city of Iran is greatly related to NDVI, LULC, altitude which has been analysed by utilizing the Landsat 8 imagery(Shafizadeh-Moghadam et al., 2020). A series of Landsat imageries have been utilised for understanding the influence of urbanization on surface urban heat island in sub-tropical desert cities including Beer Sheva in Israel, Hotan in China, Jodhpur in India, Kharga in Egypt, and Las Vegas in USA(Fan et al., 2017). Landsat images of different seasons have been utilized for the plotting of LST during 1990 to 2016 in Barrackpore city of West Bengal and various spatial indices including NDVI, NDBI and NDWI are also have been derived, the result of that studies shows a rising LST and negative association between LST and NDVI(Das et al., 2020).

Land use and land cover change and its impact on LST has been analysed using Landsat images of 1993 and 2018, result of which shows that temperature is increasing continuously due to the urban industrial and mining activities in Asansol Subdivision(Das et al., 2020). Land surface temperature study of Asansol Durgapur region using Landsat images over the period 1993 to 2015 shows that LST increases 0.06°C yearly in winter and 0.43°C yearly in summer(Choudhury et al., 2019). Urban Heat Island effects of Chandigarh City and surrounding region has been analysed by using remote sensing data from MODIS and ASTER GDEM. Support Vector Regression model has been developed from LST values for analysing the UHI effects along with the comparison with ANN(Mathew et al., 2019). Result shows that SVR is more applicable than ANN. Linear time series model has been developed for the prediction of LST in Jaipur city in India by using extracted LST values from MODIS and ASTER data, Enhanced Vegetation Index, elevation, result of which shows a high correlation between predicted and measured LST values(Mathew et al., 2016). Urbanization is categorized by the quick transformation of agrarian land, water bodies, and vegetation cover, into a settlement (Ding and Shi, 2013). The unprecedented modification of land use patterns sometimes creates serious environmental problems like Urban Heat Island. LST and UHI concepts are used to describe the varying nature of LULC pattern in diverse urban regions (Arnfield, 2003; Memon et al., 2008; Mirzaei, 2015; Rinner & Hussain, 2011; Zhao et al., 2016). Recently various LULC indices like NDVI, NDWI, NDBI are frequently used in LST associated studies to analysis their influence on fluctuating urban ecological status(Amiri et al., 2009; Kuang et al., 2015; Li et al., 2011; Peng et al., 2016; Song et al., 2014). For accommodating the fast growing urban population, the paved land cover has increased the effects of which is increased land surface temperature(Ramachandra, 2012). Urbanisation and industrialisation along with fast changes in land use/land cover are accountable for environmental problems like air pollution, water pollution, greenhouse gas emissions, and boosted urban heat islands (Shao et al., 2006; Chan and Yao, 2008). Rapid transformation of land use/land cover owing to urban expansion intensely affects biodiversity and ecosystem function, in addition to local and regional climate(Luck & Wu, 2002). LST differs based on surface reflectance and roughness of diverse land use/land cover pattern. Asansol Urban area has failed to maintain per capita share of green space in the context of sustainability (Siddique et al., 2020).

A comprehensive study on the nature of changing LST and transformation of vegetative land and surface water covered area and their inter relationship in Asansol Urban Area (AUA) over the last thirty years is crucial for sustainable development. Asansol Urban Area has been selected as the present study area due to the following reasons: 1. Asansol is the 2nd largest urban industrial agglomeration of West Bengal in Eastern India after Kolkata. 2. Coal mining activities play a vital role in the study area which is associated with the development of various kinds of small, medium and large industries. 3. Rapid urbanization and transformation of landuse and landcover are very prominent in Asansol Urban Area along with rising population. 4. Urbanization, industrial expansion, land conversion all are highly related to land surface temperature change.

The present study has been designed to fulfil the following objectives -1. To assess the nature of LST change over the last three decades. 2. To analyse the nature of transformation of vegetation cover and surface water forms. 3. To explain the inter relationship among LST, NDVI, MNDWI and NDBI.

The present study will help the reader to understand the methods of extracting LST and various spatial indices including NDVI, NDBI and MNDWI from Landsat imageries and how to explain the relationship between LST and various spatial indices. This study also will help the urban planner to rethink the policy regarding urban industrial expansion in different urban agglomerations in the world.

## Objectives

The present work has been designed for fulfilling the following objectives in Asansol Urban Area-

1. To know the long- term land surface temperature condition of Asansol Urban Area.
2. To understand the intra annual and inter annual nature of land surface temperature change Asansol Urban Area.
3. To find out the probable causes of land surface temperature change in Asansol Urban Area.

## Review of Literature

It has been observed throughout the World that area under surface water bodies(wetlands) and vegetation covered area are extremely sensitive in terms of urban-industrial expansion although which have a significant importance for maintaining urban ecological balance. Over the last decades remote sensing data plays an important role in research of various disciplines. Land surface temperature is one of the vital factors that control the physical, chemical and biological processes on the earth(Pu et al., 2006). The LSTs extracted from satellite borne sensors have been used in several, heat-balance, climate modelling and global change observing studies(Bhattacharya et al., 2010; Fall et al., 2010).The limited scope of globally in-situ observations of surface temperature, satellite derived LST provides comparatively large spatial variability, high resolution, consistent and repetitive coverage of measurements of earth surface conditions on a regional or global scale (Malik & Shukla, 2018; Yan et al., 2020). Despite LST estimation, the TIR region of the electromagnetic spectrum has enormous potential to estimate land surface related changes in any region, and is widely applied in every sector in Earth science (Alexander, 2020; Khan et al., 2020).

The process of urbanization emerged as a driving force of economic, social, demographic, and environmental change. Urbanization is characterized by the rapid conversion of agricultural land, vegetation cover, and water bodies, into a built-up area (Ding and Shi, 2013). The unpresidental change of land use pattern sometime creates serious environmental problems like Urban Heat Island due to the reduction of vegetation and water bodies. Land surface temperature and urban heat island concept are used to describe the changing nature of land use/land cover pattern in heterogeneous urban area (Arnfield, 2003; Memon et al., 2008; Mirzaei, 2015; Rinner & Hussain, 2011; Zhao et al., 2016). Recently various LULC indices like Normalized Difference Vegetation Index(NDVI), Normalized difference Water Index(NDWI), Normalized Difference Build up Index(NDBI) are frequently used in LST related studies to analysis their impact on changing urban ecological status(Amiri et al., 2009; Kuang et al., 2015; Li et al., 2011; Peng et al., 2016; Song et al., 2014). For accommodating the fast growing urban population, the paved land cover has increased the effects of which is increased land surface temperature(Ramachandra, 2012). Urbanisation and industrialisation along with fast changes in land use/land cover are accountable for environmental problems like air pollution, water pollution, greenhouse gas emissions, and boosted urban heat islands (Shao et al., 2006; Chan and Yao, 2008). Rapid transformation of land use/land cover owing to urban expansion intensely effects biodiversity and ecosystem function, in addition to local and regional climate(Luck & Wu, 2002). LST differs based on surface reflectance and roughness of diverse land use/land cover pattern. Asansol Urban area has failed to maintain per capita share of green space in the context of sustainability (Siddique et al., 2020).

## Date base and Methodology

### *Acquiring LANDSAT 8 (OLI ) Images*

Landsat 8 (OLI) images of January (2015&2020). May (2015&2020) and September (2015&2020) have been acquired from USGS Earth Explorer. All the collected sets of data were pre-referenced with WGS84 datum and Universal Transverse Mercator Projection system but atmospheric and radiometric correction have been done in software environment (Erdas Imagine 2014 & Arc GIS 10.3). Detail specifications of the downloaded images are given below (Table.1).

### *Method of Extraction of Land Surface Temperature (LST)*

The LST for the months of January, May and September in 2015 and 2020 have been extracted from thermal band 10 of Landsat images following the method previously used by different scholars and scientists. Detail procedures for extraction of LST has been described in numerous articles (Asgarian et al., 2015; Choudhury et al., 2019; Das et al., 2020; Ding & Shi, 2013; Govind & Ramesh, 2019). Following five steps have been performed systematically in Arc GIS 10.3 software for extracting the land surface temperature from thermal band (Fig.2).

### *Conversion of Digital Number (DN) to Top of Atmospheric (TOA) Radiance*

In Landsat 8 imagery band 10 is thermal band and following equation has been used for calculating spectral radiance (Lλ) [1].

$$L\lambda = ML * QCAL + AL \qquad [1]$$

Where

$L\lambda$ = Spectral Radiance of top of the atmosphere

ML = the band specific multiplicative rescaling factor (0.0003342)

QCAL = Quantized and Calibrated Standard Product Pixel value (band 10 image)

AL = the band specific additive rescaling factor (0.1)

### *Conversion of spectral radiance to At-satellite brightness temperature (BT)*

Following equation has been used for converting radiance into brightness temperature (BT) [2].

$$BT = \left(\frac{K2}{ln[(\frac{K1}{L\lambda})+1]}\right) - 273.15 \qquad [2]$$

Where

BT = At-satellite brightness temperature

$K_1$ = Band Constant (774.8853 for band 10 of Landsat 8)

$K_2$ = Band Constant (121.0789 for band 10 of Landsat 8)
273.15 is used to convert the temperature from Kelvin to Celsius.

**Table.1 Details of Image Specification**

| Satellite | Sensor | Path/Row | Year | Month | Bands | Resolution | Wavelength |
|---|---|---|---|---|---|---|---|
| Landsat-8 | OLI & TIRS(Operational Land Imager and Thermal Infrared Sensor) | 139/44 | 2020 | May & October | Band 1-Coastal aerosal | 30 | 0.43-0.45 |
| | | | | | Band 2-Blue | 30 | 0.45-0.51 |
| | | | | | Band 3-Green | 30 | 0.53-0.59 |
| | | | | | Band 4-Red | 30 | 0.64-0.67 |
| | | | | | Band 5- Near Infrared(NIR) | 30 | 0.85-0.88 |
| | | | | | Band 6- SWIR 1 | 30 | 1.57-1.65 |
| | | | | | Band 7- SWIR 2 | 30 | 2.11-2.29 |
| | | | | | Band 8- Panchromatic | 15 | 0.50-0.68 |
| | | | | | Band 9- Cirrus | 30 | 1.36-1.38 |
| | | | | | Band 10- Thermal Infrared(TIRS) 1 | 100 | 10.6-11.19 |
| | | | | | Band 11- Thermal Infrared(TIRS) 2 | 100 | 11.50-12.51 |
| Landsat-5 | Thematic Mapper | 139/44 | 1990, 2000 & 2010 | May & October | Band 1-Visible Blue | 30 | 0.45 - 0.52 |
| | | | | | Band 2- Visible Green | 30 | 0.52 - 0.60 |
| | | | | | Band 3-Visible Red | 30 | 0.63 - 0.69 |
| | | | | | Band 4-NIR | 30 | 0.76 - 0.90 |
| | | | | | Band 5- SWIR 1 | 30 | 1.55 - 1.75 |
| | | | | | Band 6-Thermal | 120 | 10.40 - 12.50 |
| | | | | | Band 7- SWIR 2 | 30 | 2.08 - 2.35 |

### *Proportion of vegetation (Pv)*

Proportion of vegetation can be calculated from Normalized Difference Vegetation Index by using the following equation(Pv) [3]

$$Pv = \{(NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min})\}^2 \qquad [3]$$

### *Land surface emissivity (e)*

Now we can get corrected emissivity by applying the given equation (e) [4].

$$e = 0.0004 * Pv + 0.986 \qquad [4]$$

### *Land Surface Temperature (LST)*

Finally we can calculate the ground surface temperature by using following equation [5] (Fig.3).

$$\text{LST} = \frac{BT}{[1 + \{(\lambda * \frac{BT}{\rho}) * Ln(e)\}]} \qquad [5]$$

Where, LST = Land surface temperature, $\lambda$ = wavelength of emitted radiance, $\rho = h*c/\sigma$ ($1.438*10^{-2}$ m K ), $\sigma$ = Boltzmann constant ($1.38 * 10^{-23}$ J/K), h = Planck's constant ($6.626 * 10^{-34}$ J s ), c = velocity of light ($2.998 * 10^{8}$ m/s), e = emissivity.

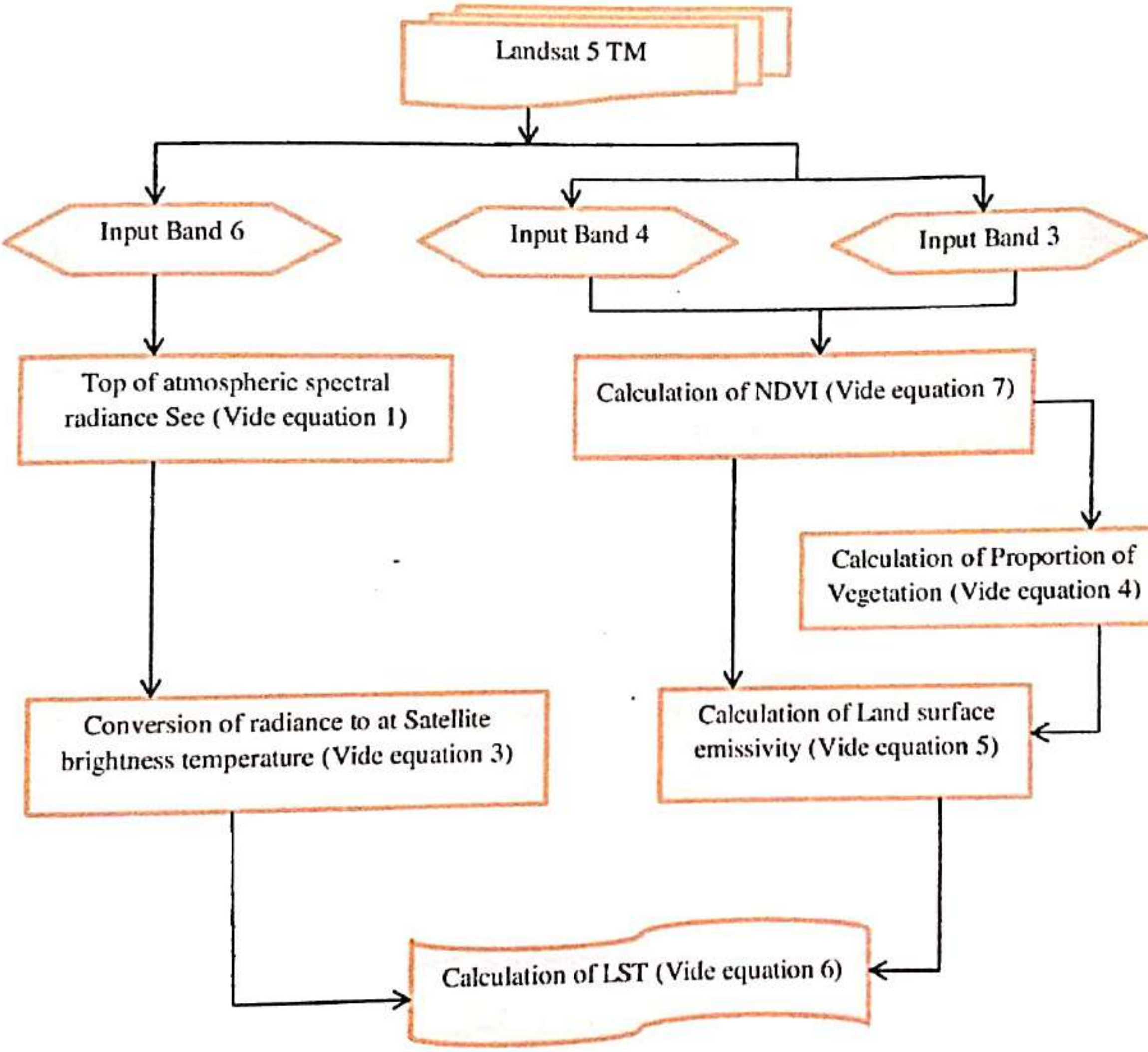
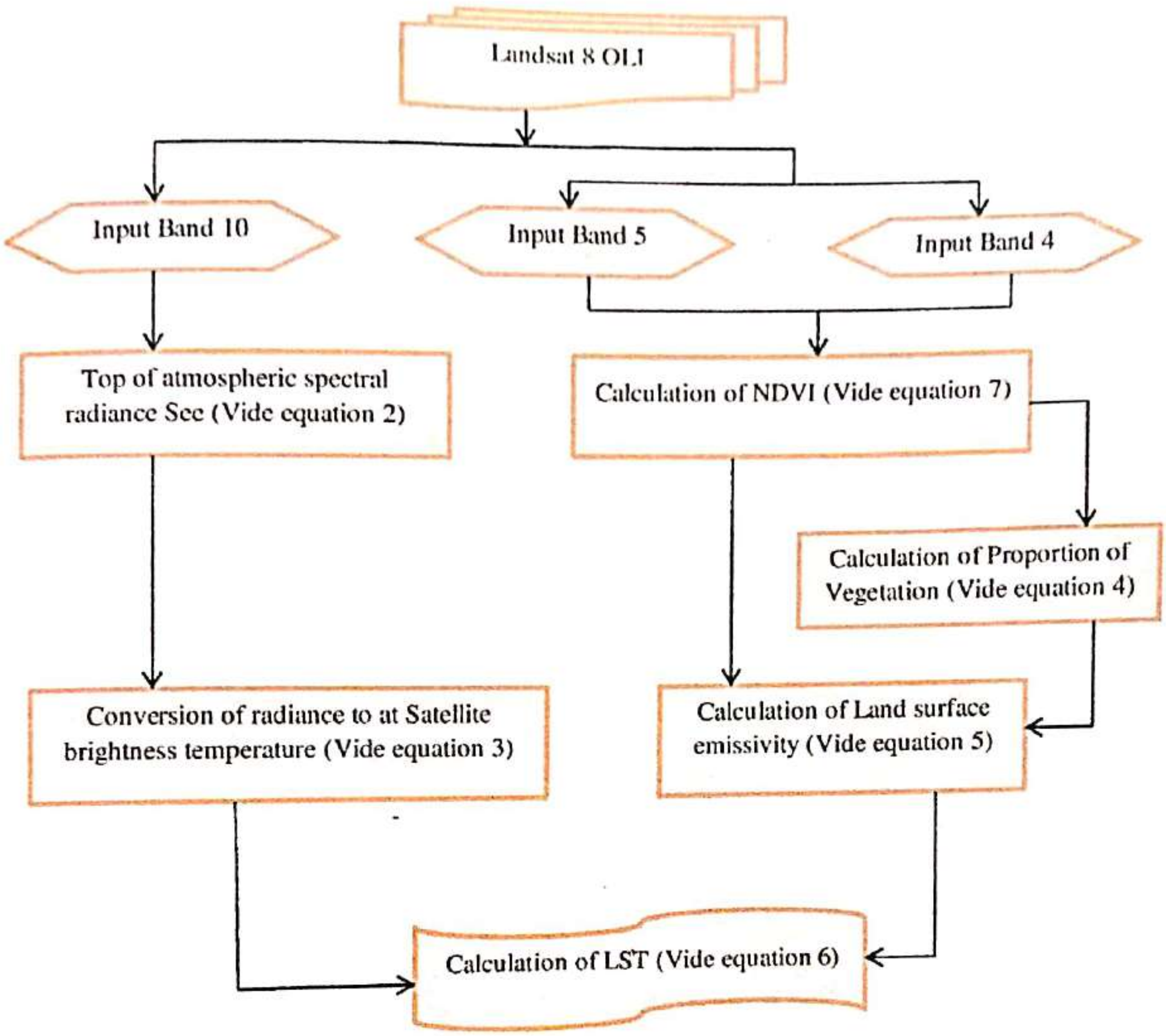



Fig.2 Extraction of LST from Landsat 5 TM imageries

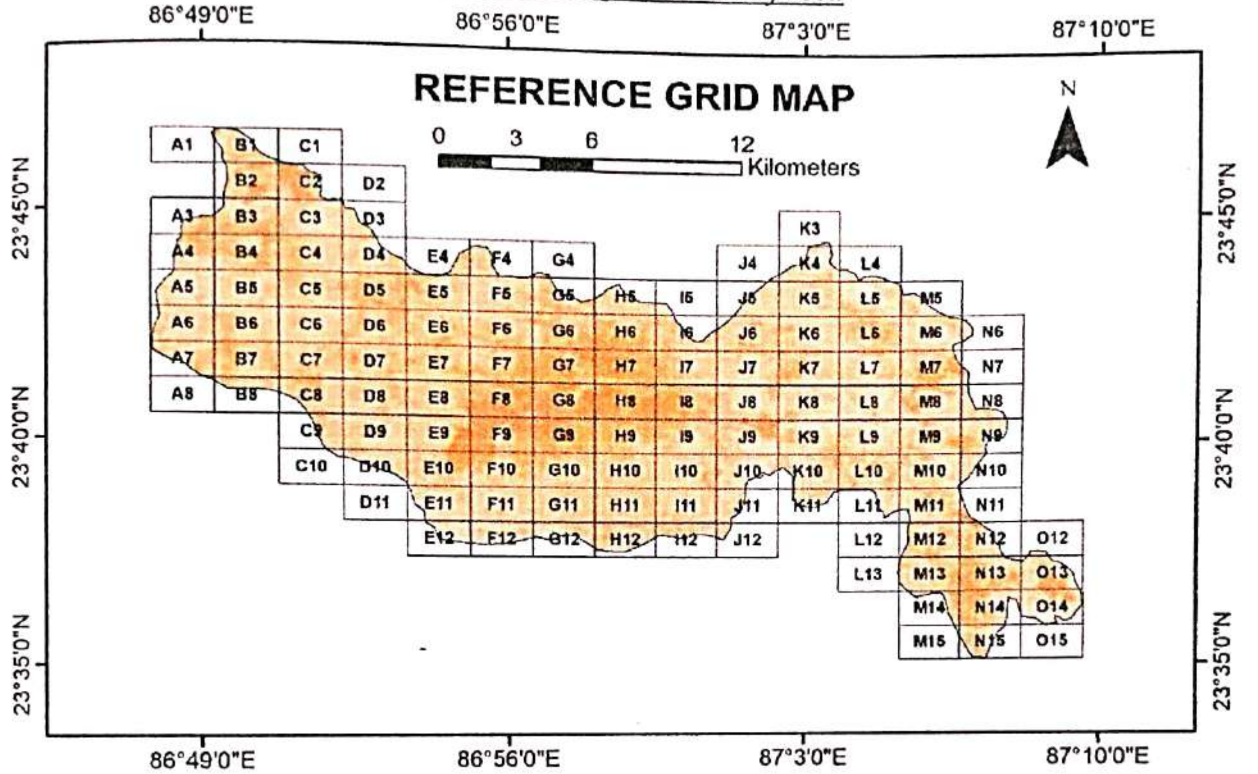



<u>Fig.3 Extraction of LST from Landsat 8 OLI imageries</u>

### *Methods for calculating rate of change and Regression analysis*

For the measurement of the last five years trend of rising temperature grid wise extracted values of LST for the year 2015 and 2020 have been used with the help of Statistics and raster calculator tools in Arc GIS 10.3 Software (Table.2). For analysing the change of surface water bodies, vegetation and build up area, single feature supervised image classification techniques incorporating the associated spatial indices (NDWI & MNDWI for water bodies, NDBI for build-up area and NDVI for vegetation) for the year 2015 and 2020 have been performed separately for surface water bodies, vegetation and also for build-up area using Erdas Imagine 2014(ESRI) software (Fig.9, 10, 11). On the basis of these maps areal changes have been computed (Table. 3). Accuracy assessment (Kappa Co-efficient) has been done using Google earth which shows more than 90% over all accuracy.

Fig.4 Grid map of the study area




Regression and Correlation analysis between LST and spatial indices have been done in MS-Excel. For this purpose primarily grid wise extracted values of LST, NDVI, NDWI, and MNDWI from their respective attribute table have been exported from Arc GIS and imported in MS-Excel and finally regression analysis has been done (Fig.12).

## The Study Area

Asansol, 2nd largest Urban Agglomeration in the State of West Bengal after Kolkata Metropolitan Area is situated at the extreme western part of Paschim Burdwan district. The latitudinal and longitudinal extension of the study area are 23°35'12"N to 23°46'37"N and 87°09'35"E to 86°47'40"E(Fig.1). Initially Asansol emerged as a municipality in the year 1886, but it has achieved the municipal corporation status in 1994 by incorporating Burnpur Notified Area, some collieries and some rural parts of Asansol Community Development Block. According to the Kolkata Gazette notification of 3 June 2015, the municipal areas of Kulti, Raniganj and Jamuria were included within the jurisdiction of Asansol Municipal Corporation and is now considered as 2nd largest urban agglomeration of West Bengal in Eastern India(AMC,2018). The total area is 326.48Km$^2$ having nearly 1.243414 Million population (Census 2011). Presently AMC comprises of 106 Wards divided into 10 Boroughs, out of which 28 wards are under Kulti Municipality, 11 are under Raniganj Municipality, 13 are under

Jamuria Municipality and rests are directly controlled by the Asansol Municipal Corporation. The urban agglomeration is physiographically situated at junction of the Chottanagpur plateau in the west and the Ganga plain in the east. Ajay and Damodar river have boarderedd the urban area southern and western part respectively. The entire area is predominantly characterized by humid tropical climate having three distinct seasons( Summer, Monsoon and dry Winter) which comes under the subtype of Aw(Tropical Savanna) in Koppen Climatic Classification. North-west to south east slope is observed having an average elevation of 122metre in the urban area.

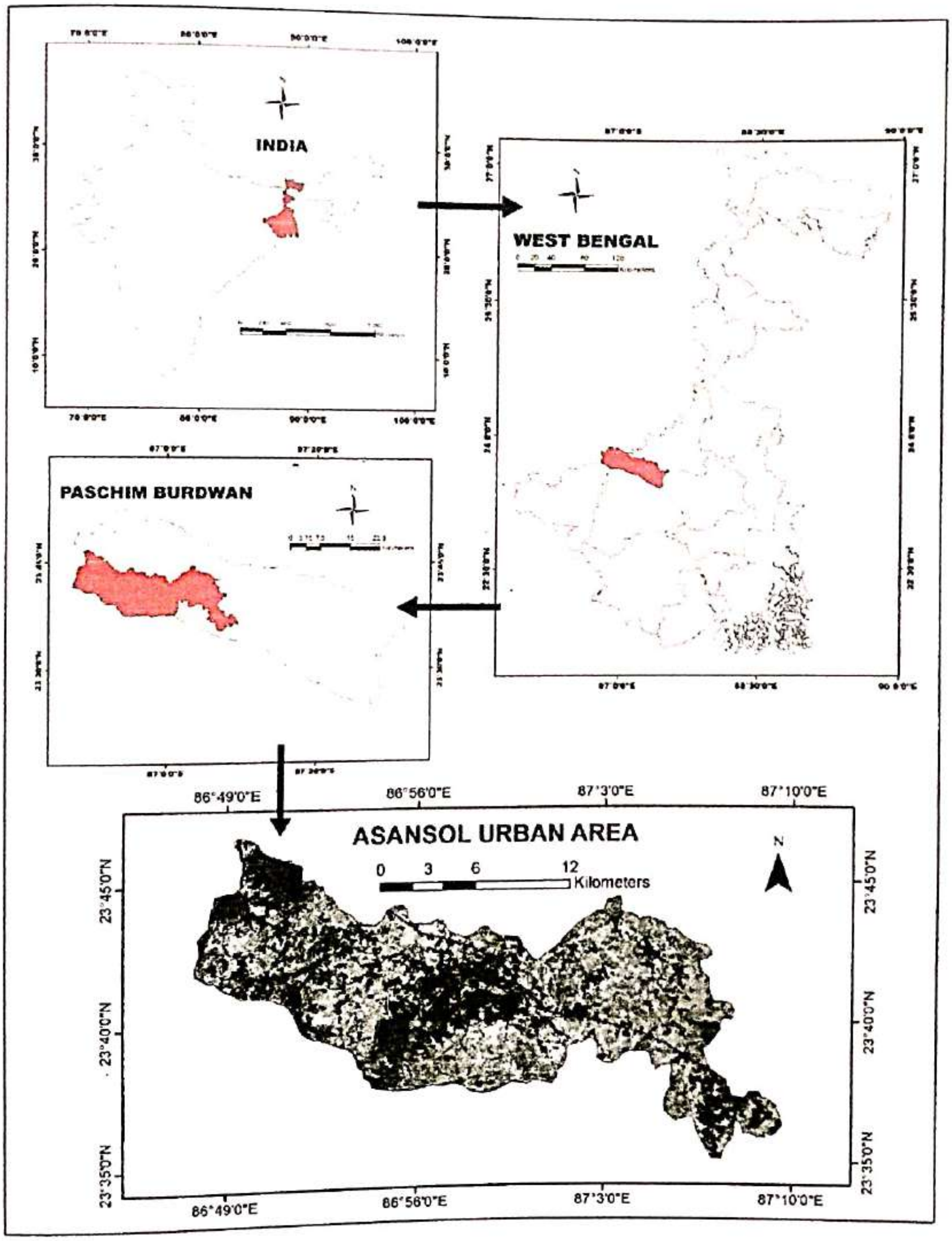


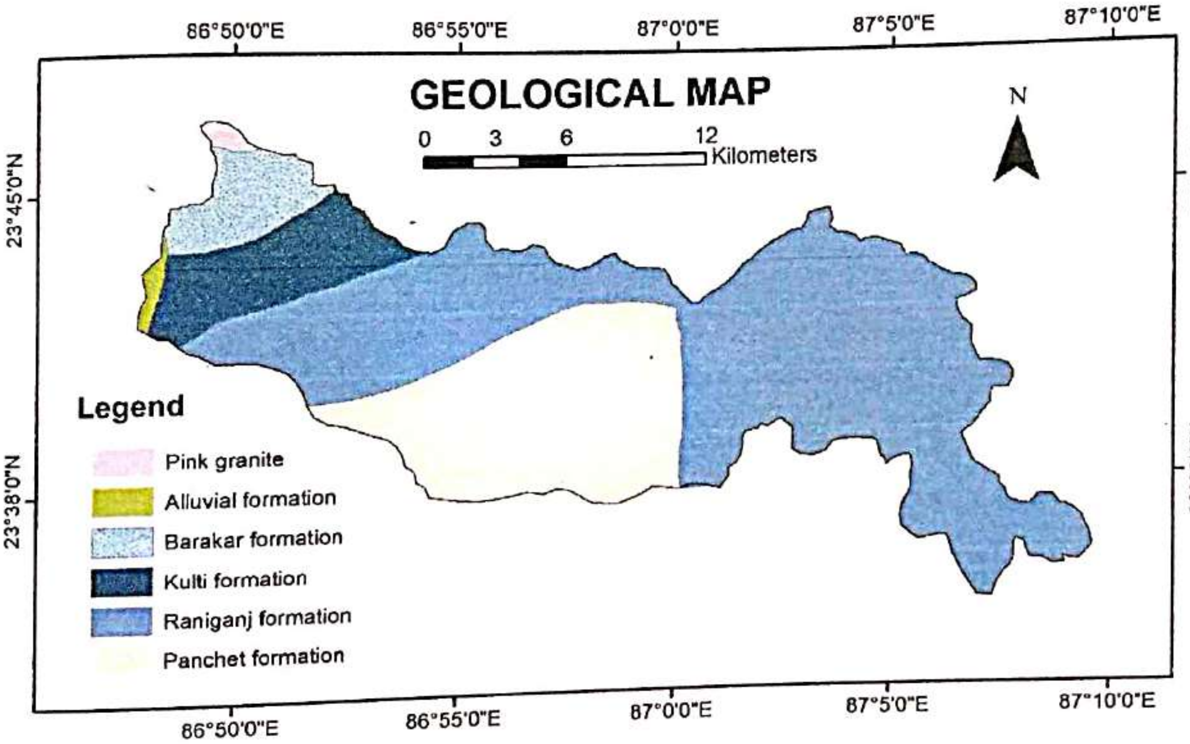

**Fig.1: Location of the Study Area**

# Physical Background of the Study Area

## Physical Background of the Study Area

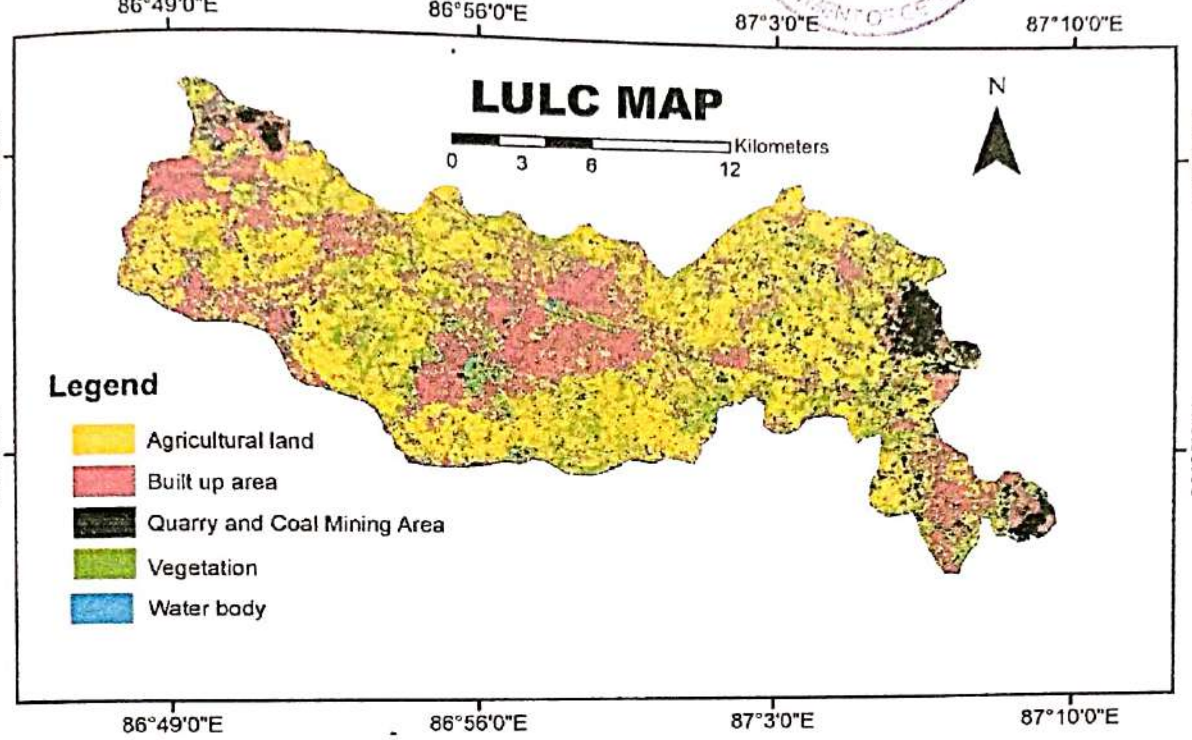
### *Geology*

Geology is also important for selecting suitable location for surface RWH as it controls the rate of infiltration. There are observed six lithological units in Asansol Urban Area. A major portion of AUA is occupied by rocks of raniganj formation which is followed by the structure of panchet formation. Another two important formations are kulti and barakar formation. Raniganj, kulti and barakar formation belong to Damuda group and mainly consist of sandstone, shale and coal originated in Permian age. Panchet formation is mainly consists of sandstone and shale and belongs to gondwana super group. A minor part of AUA is composed by pink granite and alluvium formation. Pink granite is a part of chotonagpur granite genesis complex and biotite and quartz biotite granite gneiss are main elements. Alluvium formation is a part of recent formation consists of sedimentary deposition.



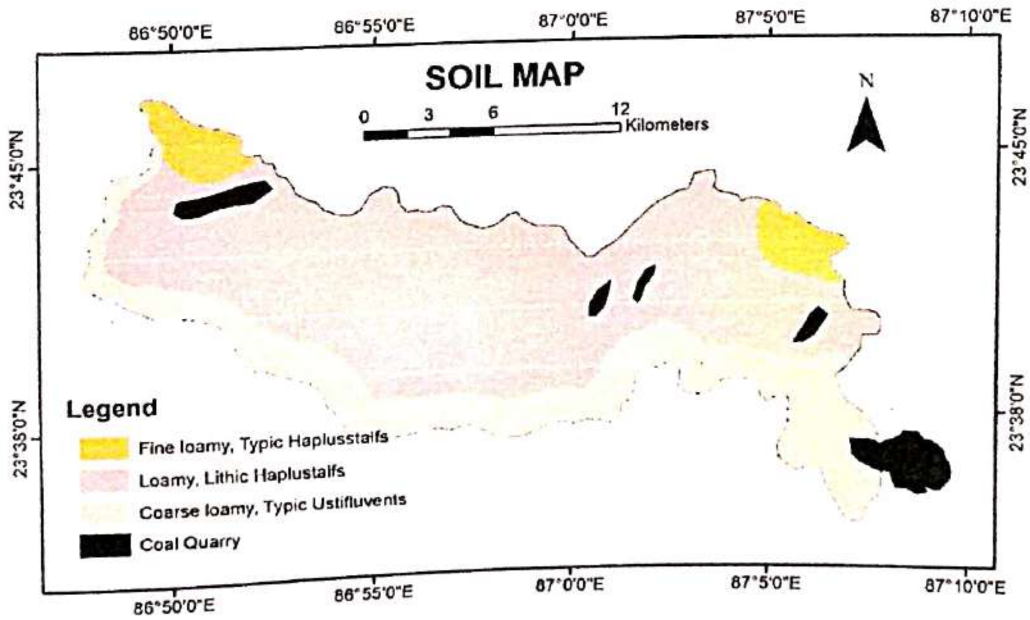

### *Land use land cover*

LULC study is essential for identifying surface RWH. In general, an open portion is required for surface rainwater harvesting which is impossible to identify without LULC study. Near about 24% of AUA is covered by built up area which is totally unsuitable for surface RWH. Agricultural land is the largest unit of AUA which occupied nearly 60% of the area. Some part of AUA is covered by quarry and mining areas. Another two important parameters are water bodies and vegetation. By analysing the LULC pattern of AUC maximum weight has been given on agricultural land as it is the only area having potentiality of surface RWH.



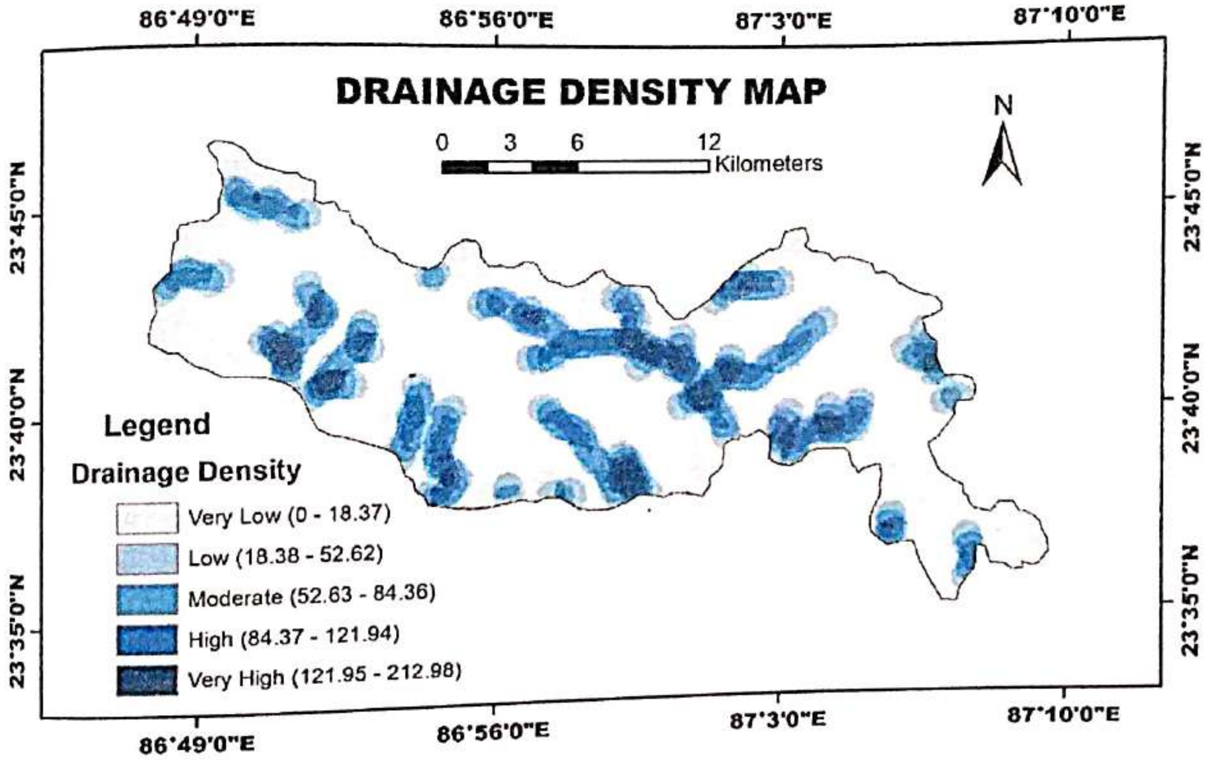

## *Soil*

Surface water retention capacity depends on soil texture to great extent. For constructing surface RWH system soil having very low permeability is required. Mainly different types of loamy structure are found in AUA. Mainly three varieties of loamy soil i.e. fine loamy, loamy and coarse loamy are observed in this area. Considering the permeability condition of this three categories soil, maximum weight for identifying suitable location for surface RWH has been given to fine loamy soil which is followed by loamy and coarse loamy.



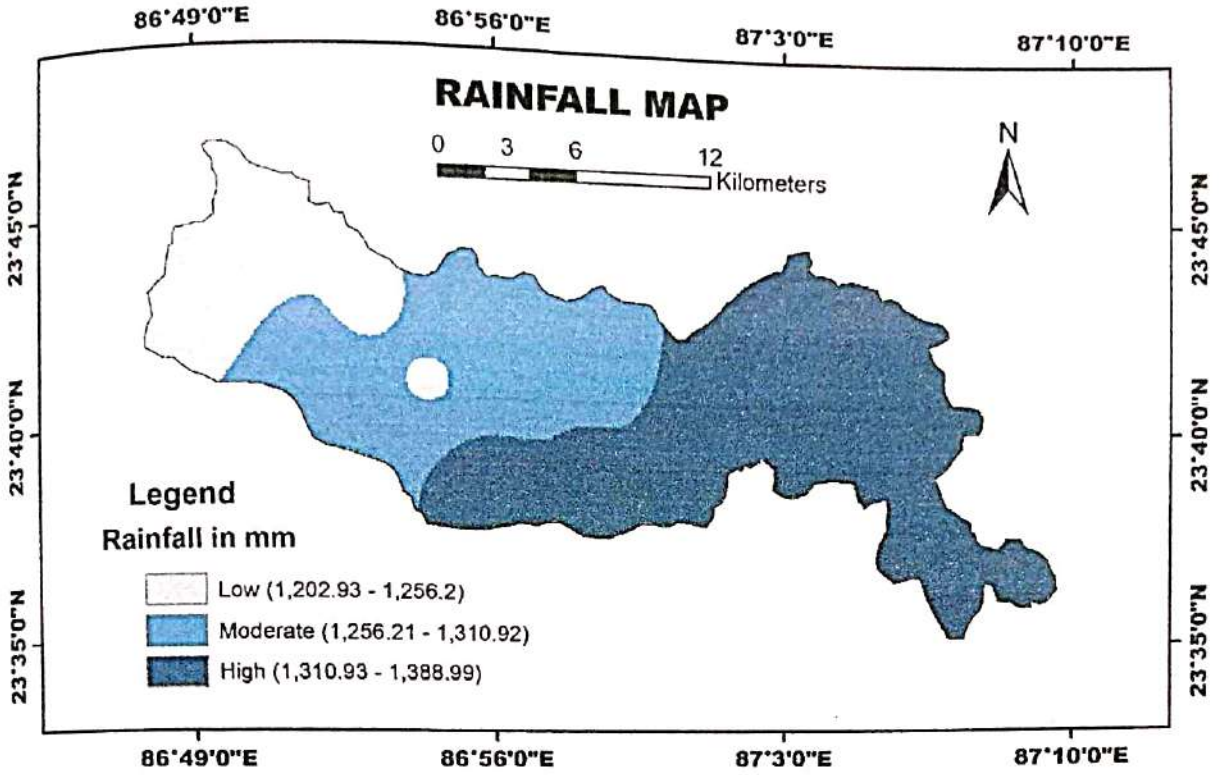
### *Drainage and Lineament Density*

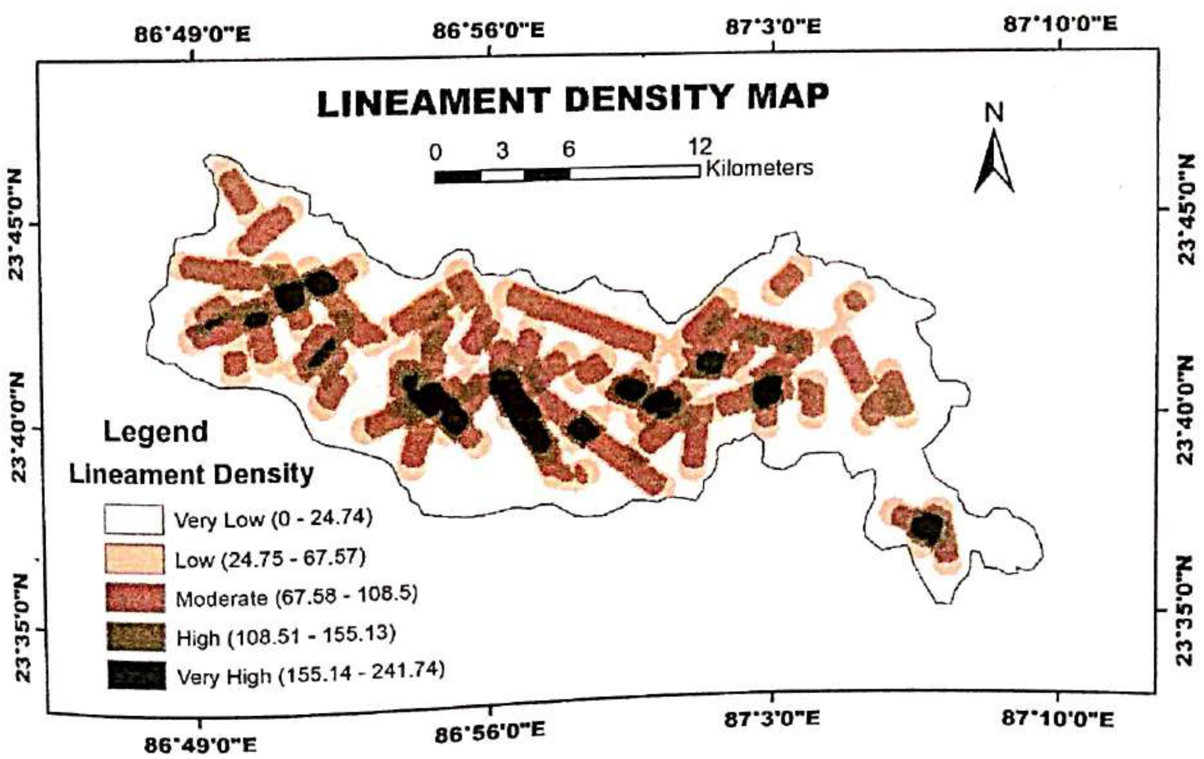
Drainage density and RWH potentiality is negatively associated, higher the DD lower the RWH potentiality and lower the DD higher the RWH potentiality (Jha et al., 2014; Karimi & Zeinivand, 2021). Drainage and lineament density both have similar effects on surface rainwater harvesting. Lineament and drainage density acts as a barrier for storing water on the surface by increasing infiltration capacity. For lineament and drainage density study, five categories are prepared base on their density. Considering the negative effects of LD and DD low weights have been allotted for the areas having high DD and LD, similarly high weightage has been given for the areas having low DD and LD.




### *Rainfall*

Without rainfall it is impossible to think about any kind of RWH. Slight variation is observed in rainfall distribution in AUA. Comparatively high precipitation is perceived in south west part of AUA whereas low precipitation is observed in north to north east area. The average precipitation of AUA is more than 1200 millimetre and the variation is under 100 millimetre. Considering the contribution of rainfall to RWH maximum weightage has been given to the area receiving high rainfall and vice versa.

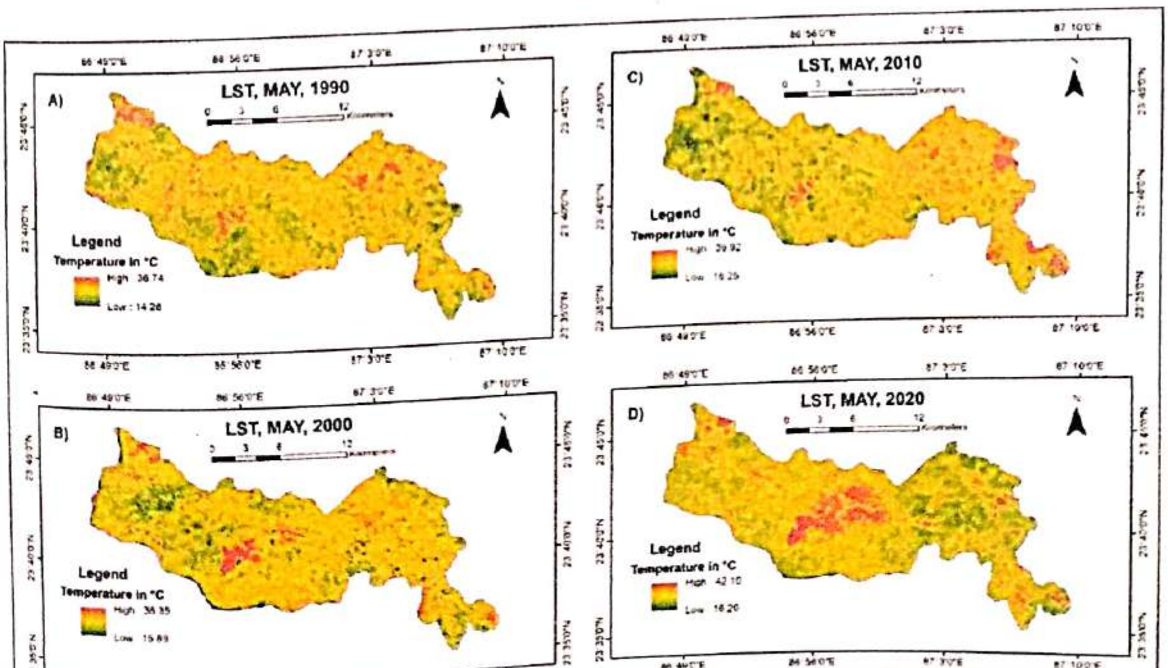

RAINFALL MAP
0 3 6 12 Kilometers
N
Legend
Rainfall in mm
Low (1,202.93 - 1,256.2)
Moderate (1,256.21 - 1,310.92)
High (1,310.93 - 1,388.99)
86°49'0"E
86°56'0"E
87°3'0"E
87°10'0"E
23°45'0"N
23°40'0"N
23°35'0"N


LINEAMENT DENSITY MAP
0 3 6 12 Kilometers
N
Legend
Lineament Density
Very Low (0 - 24.74)
Low (24.75 - 67.57)
Moderate (67.58 - 108.5)
High (108.51 - 155.13)
Very High (155.14 - 241.74)
86°49'0"E
86°56'0"E
87°3'0"E
87°10'0"E
23°45'0"N
23°40'0"N
23°35'0"N

## Results and Discussion

### *Analysis of Land surface Temperature change*

For the analysis of the nature of land surface temperature change in last five years of Asansol Urban Area(AUA) LST maps have been prepared of winter(January), summer(May) and end monsoon(September) for the year 2015 and 2020(Fig.3). In general a rising trend of temperature is found for each period. It is cleared from the maps of LST (Fig.4) that maximum range of temperature has changed from 24.85°C to 26.79°C in winter, 36.53°C to 39.15°C in summer and from 33.35°C to 34.44°C in end monsoon periods. Minimum range of temperature is also increased except the end monsoon period. Minimum range for the winter period was 15.75°C in 2015 which has changed to 16.10°C in 2020. In case of summer it has changed from 23.18°C to 24.29°C. For calculating the rate of increasing temperature a reference grid map (Fig.8) has been used for extracting the temperature values in Arc GIS platform. Yearly temperature increasing rate for winter period and summer have been calculated separately using Arc GIS 10.3 Software incorporating the grid wise extracted temperature values (Table.2). It is observed that rate of rising temperature slightly varies between winter and summer season. In summer temperature has increased 0.59°C per year, whereas increasing rate of temperature is 0.56°C yearly. It is evident from previous literature that land use/land cover transformation associated with urban-industrialization processes is highly responsible for rising temperature (Choudhury, et al., 2018; Das, et al., 2020). For analysing the nature of temperature change with surface coverage mainly vegetation, water bodies and build up areas a comparative analysis has been done with the help of series of maps prepared based on different spatial indices( NDVI, NDWI, MNDWI, NDBI)( Fig. 4,5,6,7) which has been discussed in later section.



## Table.3 Calculation of Land Surface Temperature Change

| Temperature change | 1990 -2000 | | | 2000-2010 | | 2010-2020 | |
|---|---|---|---|---|---|---|---|
| Grid | LST in °C May,1990 | LST in °C May,2000 | Difference | LST in °C May,2010 | Difference | LST in °C May. 2020 | Difference |
| A5 | 22.603 | 24.294 | 1.691 | 25.145 | 0.851 | 31.663 | 6.518 |
| A6 | 21.470 | 21.712 | 0.242 | 25.254 | 3.542 | 31.775 | 6.521 |
| B4 | 20.368 | 22.184 | 1.815 | 22.956 | 0.772 | 30.339 | 7.383 |
| B5 | 21.905 | 24.123 | 2.218 | 24.001 | -0.122 | 26.554 | 2.553 |
| B6 | 22.110 | 22.265 | 0.155 | 23.125 | 0.860 | 24.254 | 1.129 |
| C4 | 19.416 | 21.187 | 1.771 | 22.520 | 1.333 | 30.557 | 8.037 |
| C5 | 20.116 | 22.801 | 2.685 | 23.652 | 0.851 | 30.857 | 7.205 |
| C6 | 18.904 | 21.119 | 2.215 | 23.257 | 2.138 | 29.995 | 6.738 |
| C7 | 19.648 | 23.009 | 3.361 | 26.552 | 3.543 | 29.850 | 3.298 |
| D6 | 20.439 | 23.689 | 3.250 | 26.536 | 2.847 | 30.599 | 4.063 |
| D7 | 20.782 | 22.480 | 1.698 | 27.100 | 4.620 | 30.457 | 3.357 |
| D8 | 21.446 | 22.790 | 1.343 | 26.996 | 4.206 | 29.214 | 2.218 |
| E6 | 19.627 | 23.705 | 4.078 | 25.025 | 1.320 | 30.859 | 5.834 |
| E7 | 19.866 | 23.588 | 3.722 | 27.569 | 3.981 | 30.786 | 3.217 |
| E8 | 19.932 | 24.107 | 4.175 | 28.253 | 4.146 | 31.120 | 2.867 |
| E9 | 19.658 | 23.193 | 3.536 | 28.352 | 5.159 | 31.254 | 2.902 |
| F6 | 19.842 | 23.290 | 3.447 | 27.254 | 3.964 | 31.225 | 3.971 |
| F7 | 27.025 | 29.125 | 2.100 | 31.210 | 2.085 | 33.257 | 2.047 |
| F8 | 28.124 | 29.453 | 1.329 | 31.215 | 1.762 | 34.125 | 2.910 |
| F9 | 19.847 | 23.748 | 3.901 | 24.102 | 0.354 | 24.200 | 0.098 |
| F10 | 19.249 | 23.099 | 3.849 | 23.000 | -0.099 | 25.254 | 2.254 |
| G6 | 27.420 | 29.235 | 1.815 | 30.544 | 1.309 | 34.352 | 3.808 |
| G7 | 29.125 | 30.254 | 1.129 | 30.589 | 0.335 | 34.201 | 3.612 |
| G8 | 28.125 | 31.100 | 2.975 | 31.100 | 0.000 | 35.125 | 4.025 |
| G9 | 19.797 | 22.642 | 2.845 | 30.995 | 8.353 | 33.254 | 2.259 |
| G10 | 19.790 | 22.284 | 2.493 | 30.554 | 8.270 | 34.335 | 3.781 |
| H6 | 21.703 | 24.520 | 2.817 | 29.425 | 4.905 | 34.334 | 4.909 |
| H7 | 22.320 | 23.746 | 1.426 | 29.245 | 5.499 | 34.320 | 5.075 |
| H8 | 23.024 | 24.123 | 1.099 | 29.112 | 4.989 | 33.995 | 4.883 |
| H9 | 24.254 | 23.050 | -1.204 | 28.996 | 5.946 | 33.558 | 4.562 |
| H10 | 23.025 | 23.588 | 0.563 | 23.550 | -0.038 | 28.298 | 4.748 |
| I7 | 27.200 | 29.420 | 2.220 | 31.123 | 1.703 | 33.997 | 2.874 |
| I8 | 27.120 | 28.890 | 1.770 | 31.100 | 2.210 | 33.989 | 2.889 |
| I9 | 19.425 | 22.778 | 3.353 | 30.235 | 7.457 | 33.994 | 3.759 |
| I10 | 19.285 | 22.079 | 2.794 | 30.998 | 8.919 | 33.457 | 2.459 |
| J7 | 19.662 | 22.163 | 2.501 | 28.995 | 6.832 | 31.547 | 2.552 |
| J8 | 19.811 | 22.642 | 2.831 | 28.856 | 6.214 | 32.869 | 4.013 |
| J9 | 20.276 | 24.269 | 3.993 | 28.556 | 4.287 | 32.854 | 4.298 |
| K6 | 21.302 | 25.377 | 4.075 | 28.253 | 2.876 | 31.995 | 3.742 |
| K7 | 21.325 | 24.752 | 3.427 | 27.998 | 3.246 | 30.998 | 3.000 |
| K8 | 19.755 | 22.716 | 2.961 | 27.126 | 4.410 | 30.587 | 3.461 |
| K9 | 19.016 | 22.010 | 2.993 | 26.996 | 4.986 | 26.998 | 0.002 |
| L7 | 21.749 | 25.311 | 3.562 | 26.268 | 0.957 | 29.532 | 3.264 |
| L8 | 19.967 | 22.311 | 2.344 | 24.247 | 1.936 | 29.996 | 5.749 |
| L9 | 20.432 | 24.429 | 3.997 | 26.876 | 2.447 | 29.887 | 3.011 |
| M9 | 19.280 | 22.935 | 3.655 | 28.500 | 5.565 | 29.220 | 0.720 |
| M10 | 19.107 | 21.975 | 2.868 | 28.560 | 6.585 | 31.956 | 3.396 |
| N13 | 26.143 | 26.452 | 0.309 | 28.254 | 1.802 | 31.254 | 3.000 |
| N14 | 26.035 | 26.500 | 0.465 | 28.548 | 2.048 | 30.998 | 2.450 |
| O14 | 19.145 | 22.550 | 3.405 | 25.480 | 2.930 | 29.254 | 3.774 |
| Rate of increased | 0.24°C/Year | | | 0.33°C/Year | | 0.37°C/Year | |

Computed by the author using Arc GIS 10.3 and MS-Excel

# Summary and Conclusion

## Conclusion

Surface water bodies and vegetation are two essential part of ecosystem for any area both of which are under threat along with rising land surface temperature at alarming rate. The surface water bodies and vegetation have been converted into build up area which is strongly associated with increasing temperature. Land surface temperature is rising at 0.59°C/year in summer and 0.56°C/year in winter which is really a warning for the ecological health of Asansol Urban Area as well as for the people of Asansol (Table.2). Conversion of surface water bodies into build up or any others form is another menace followed by the conversion of vegetative land in regular basis. From the trend of land conversion it is concluded that major part of surface water bodies and vegetative land have been converted into build up areas ( settlement, industry, commercial complex etc.) as build up area increased at 18.08Km$^2$/year(Table.4). It is very important to mention here coal mining activities also has significant influence on land transformation as it is a part of mining area. From the correlation and regression analysis it is evidenced NDVI and NDWI are negatively associated to LST, which indicates that a significant portion of vegetation and surface water body is required to control the surface temperature. On the other hand as NDBI is positively associated with LST, there should at least some control over urban industrial expansion within the premises of Asansol Urban Area. In summary it is evidenced from over all discussion that land surface temperature of AUA in last five years is increasing at distressing rate. In last five year rate of transforming surface water bodies and vegetation are also shocking. The association between LST and others spatial indices indicate positive relation between LST and NDBI, negative between LST and NDVI and NDWI. Land transformation accompanying with rapid urbanisation is mainly responsible for mounting land surface temperature in last five year.

Escalating land surface temperature and disorganised land alteration is a potential threat for the sustainable future of Asansol. There is a urgent need to review the existing policies regarding land transformation considering the growing land surface temperature and associated problems. It should be better to include the nature of LST, conversion of vegetation and water bodies as essential part of urban planning.

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