DISSERTATION

ON

"Analyzing the pattern of Vegetation Change in Asansol Urban Area using Geospatial Technology"

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

Paper-496 (Under Vidyasagar University)

Supervised by-

Sarbeswar Haldar

Asst. Professor in Geography

Submitted by-

Shantashree Mandal

Roll: - PG/VUEGG19-GEO-IVS No: - 004

Reg. No: -1291057 of 2018– 2019

DEPARTMENT OF GEOGRAPHY

HALDIA GOVERNMENT COLLEGE

SUPERVISOR'S CERTIFICATE

This to certify that Mr/Ms. Shantashree Mandal, Roll PG/VUEGG-No 19-GEO-IVS 004 has prepared this dissertation on "*Analyzing the pattern of Vegetation Change in Asansol Urban Area 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

14.08.23

Sarbeswar Haldar

Assistant Professor and Head

Department of Geography

Haldia Government College

Assistant Professor, WBES
Department of Geography
Haldia Government College
Debhog-721657

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 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.

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.

Shantashree Mandal.

Date : 14.08.23

Signature

LIST OF FIGURES

LIST OF TABLES

CONTENTS

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 distributional pattern of vegetation in Asansol Urban Area
2. To understand the intra annual and inter annual nature of vegetation cover change in Asansol Urban Area.
3. To find out the probable causes of decreasing vegetation cover 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).

Preparation of NDVI Map

Normalized Difference Vegetation Index (NDVI) is a popular technique for estimating the density of vegetation on the basis of the difference between visible and near infrared reflectance of vegetation cover which has been extracted by the following method in ArcGIS 10.3(Townshend & Justice, 1986).[7](Fig.5).

$$\mathrm{NDVI} = \frac{(NIR\ Band - R\ Band)}{(NIR\ Band + R\ Band)} \qquad [7]$$

The NDVI value cover the range of +1 to -1 where positive value indicates healthy vegetation.

Methods for calculating rate of change of Surface Water Bodies

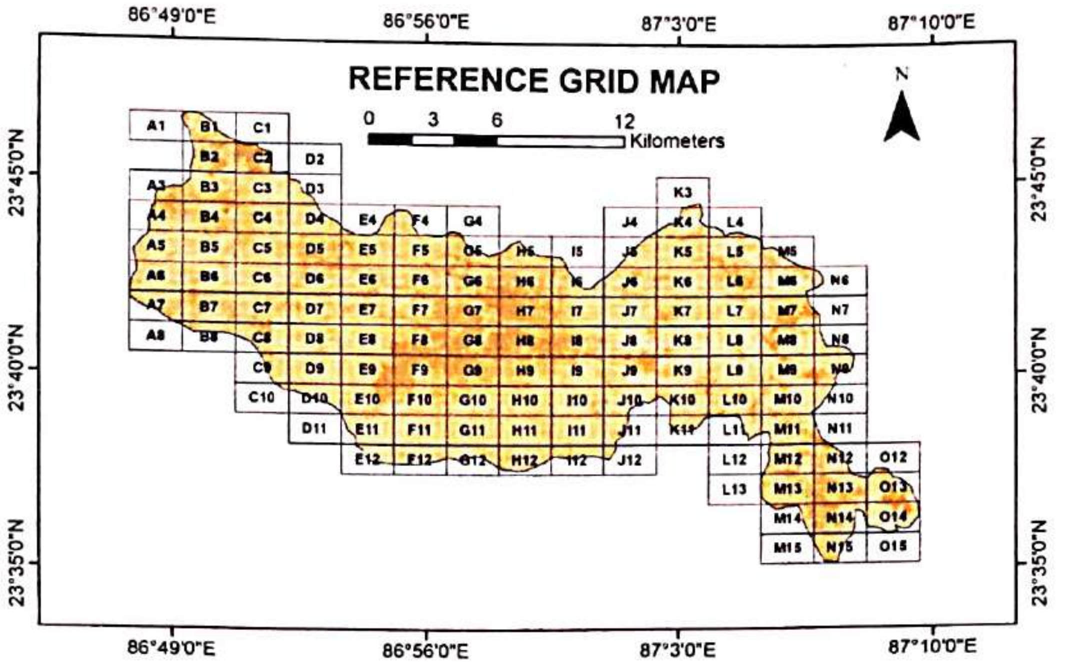
For analysing the change of surface water bodies, vegetation and built up area, single feature supervised image classification techniques incorporating the associated spatial indices (MNDWI for water bodies, NDBI for built up area and NDVI for vegetation) for each year have been performed separately for surface water bodies, vegetation and built up area using Erdas Imagine 2014(ESRI) software (Fig.9, 10, 11). Accuracy assessment (Kappa Co-efficient) has been done using Google earth for each year separately (Table.2). Finally, on the basis of these maps aerial changes have been computed

ArcGIS and MS-Excel both have been used for correlation and regression analysis between LST and spatial indices. Following two steps have been performed-1. Firstly values of LST, NDVI, NDBI and MNDWI have been extracted using a reference grid (Fig.8) in ArcGIS utilizing the extract multi values to point tools from the extraction tool under Spatial Analyst Tools. 2. Finally, grid wise extracted values of LST, NDVI, NDBI and MNDWI from the respective attribute table have been used for calculating correlation and regression in the MS-Excel environment (Fig.12).

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

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.

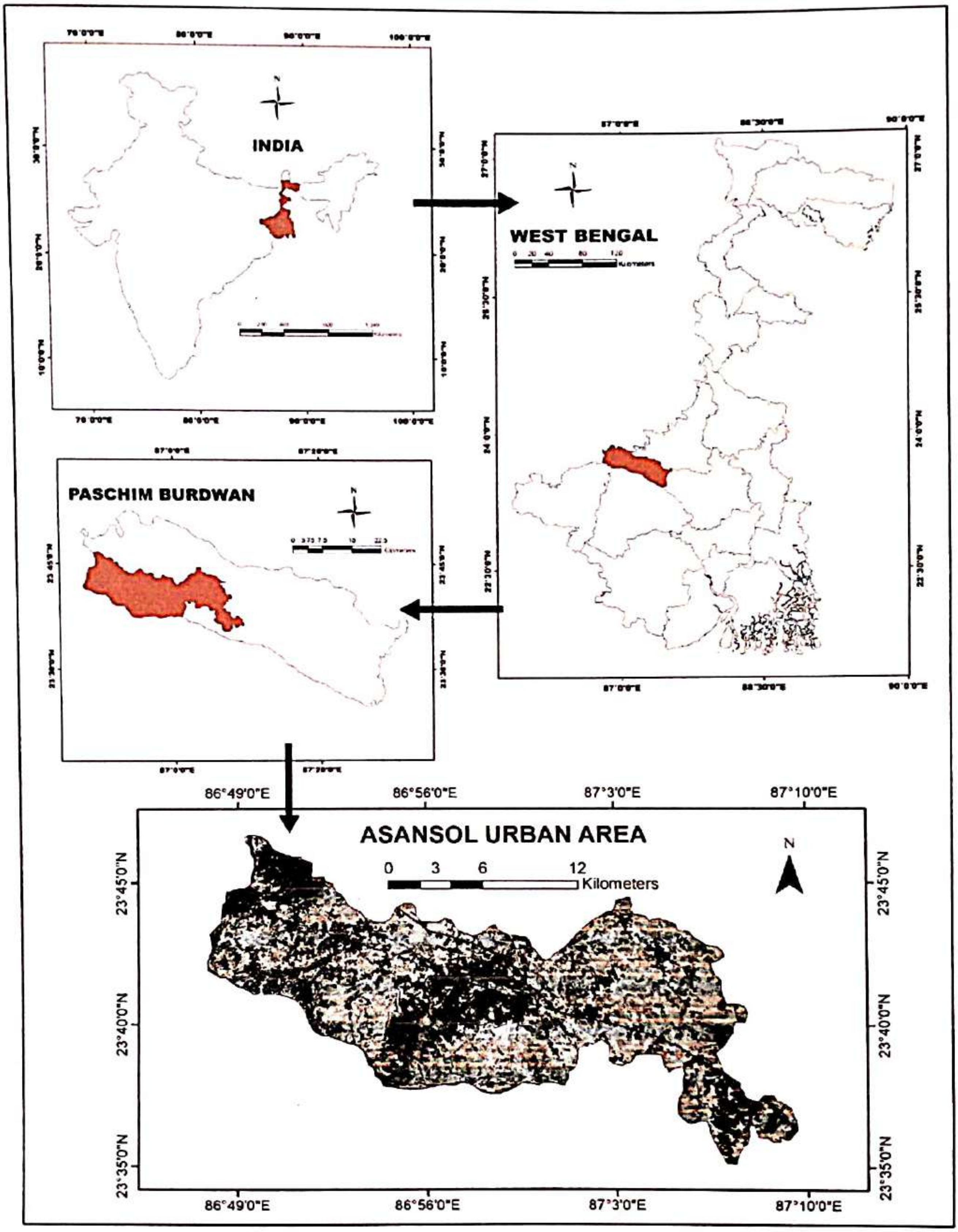


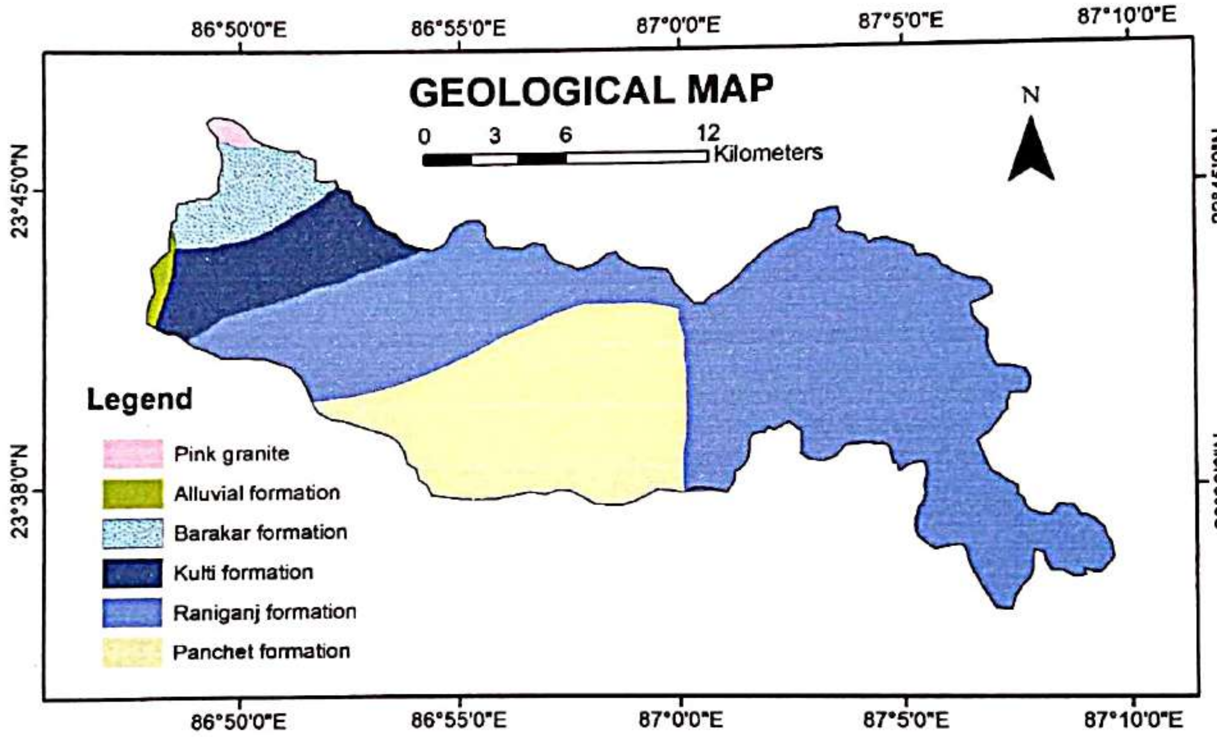
Fig.1: Location of the Study Area

Physical Background of the Study Area

Physical Background of the Study Area

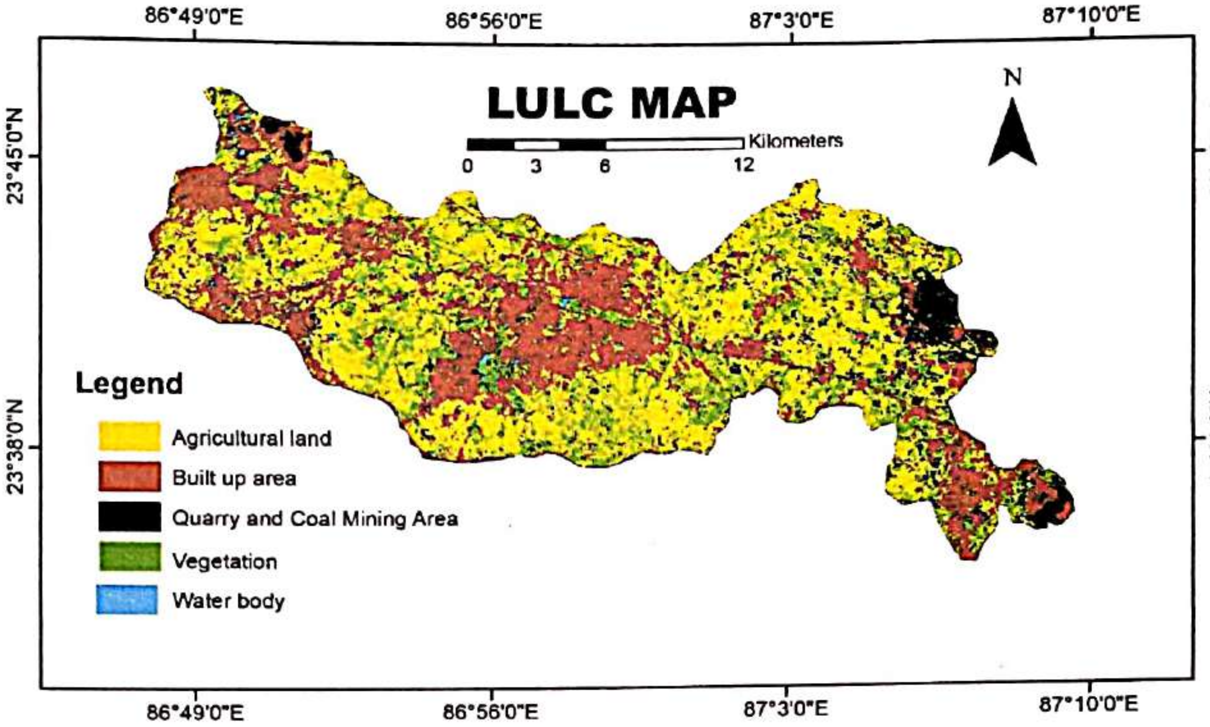
Geology

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.



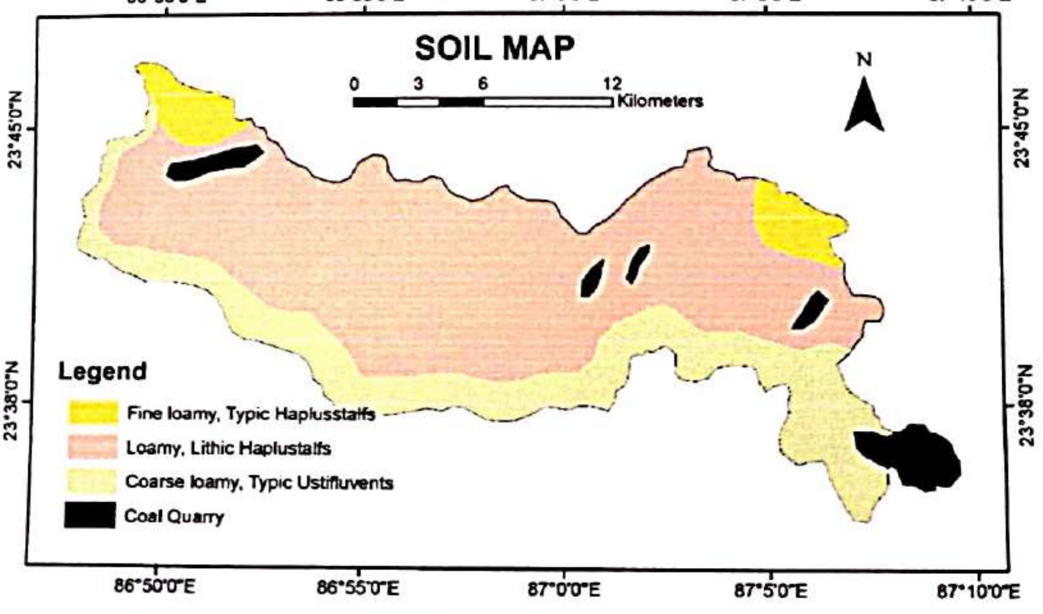
Land use land cover

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.



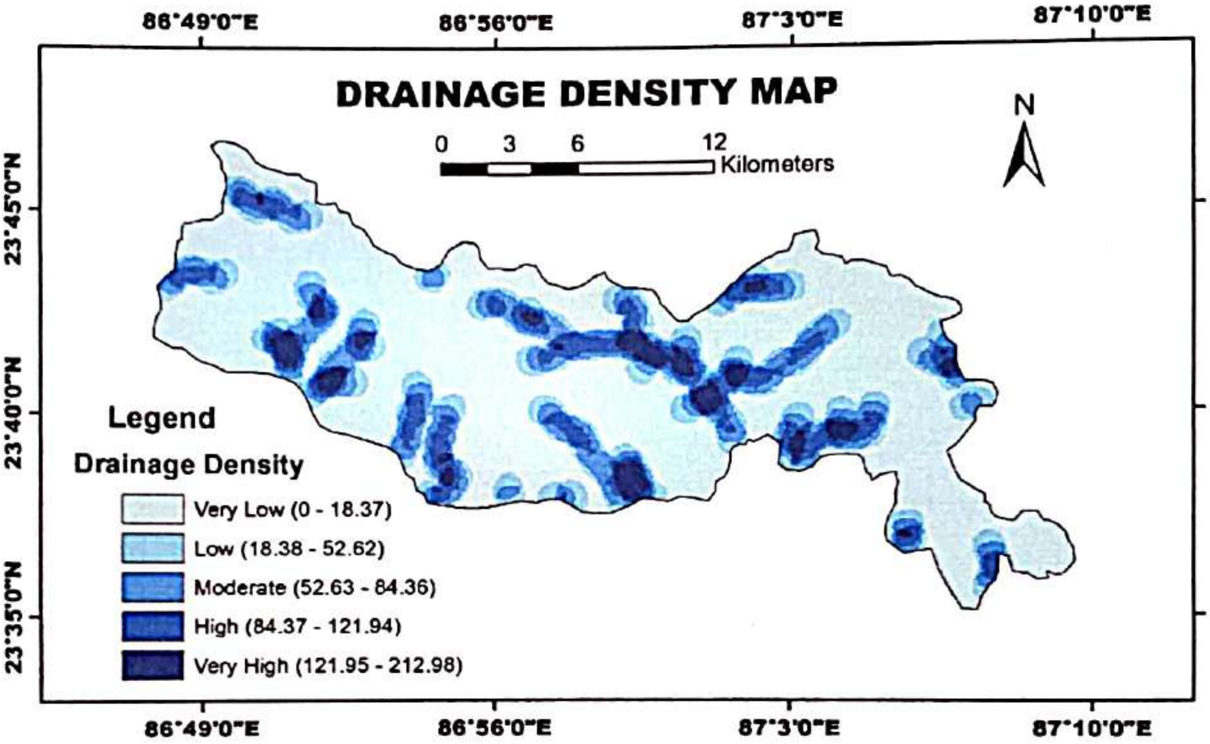
Soil

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.



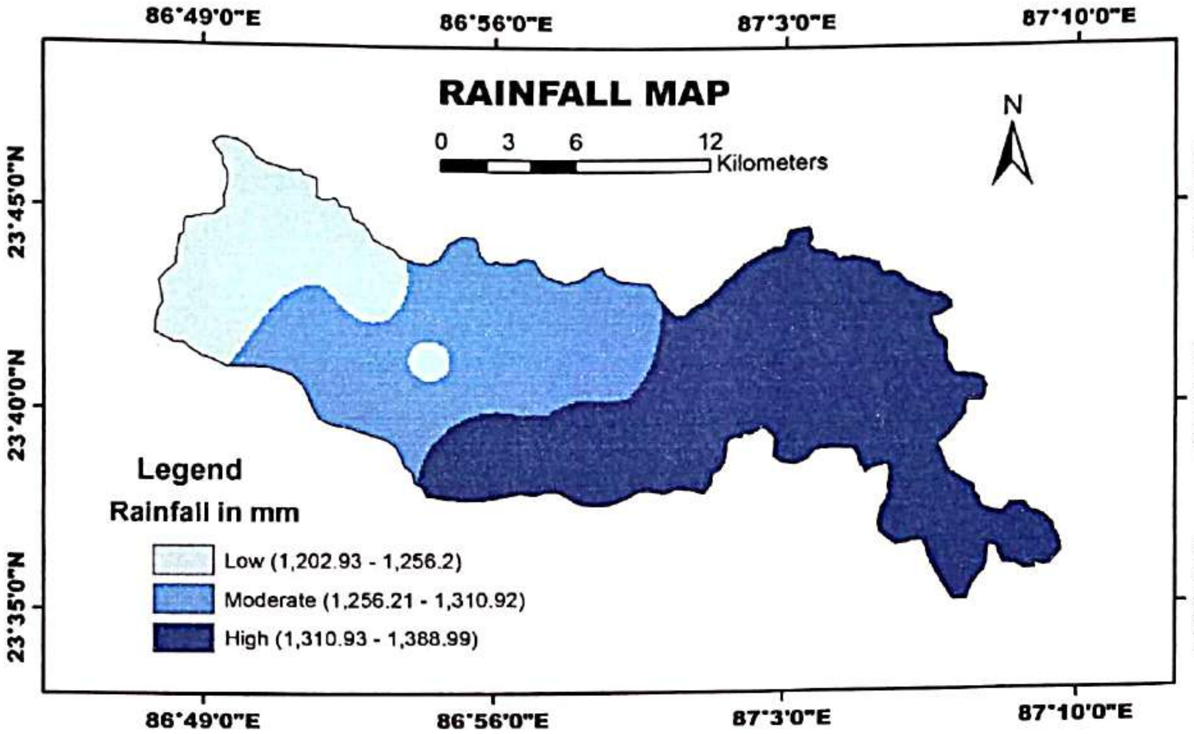
Drainage and Lineament Density

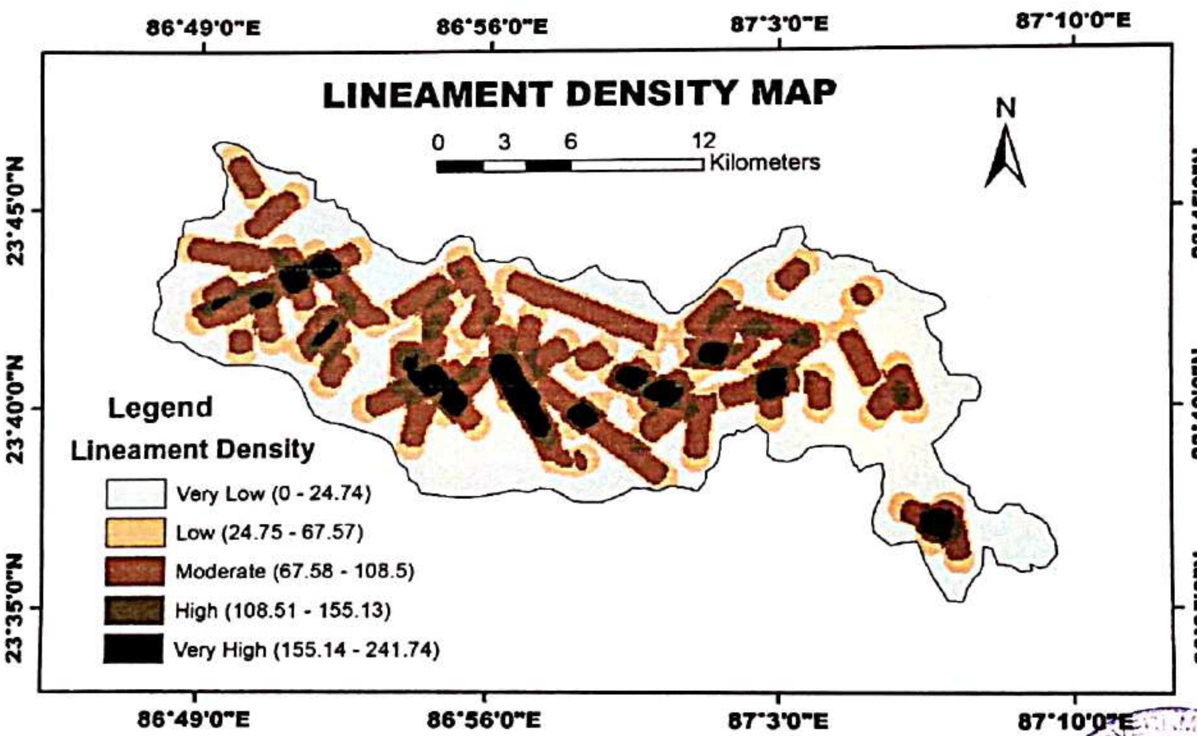
Drainage density and RWH potentiality is negatively associated, higher the DD lower the RWH potentiality and lower the DD higher the RWH potentiality (Jha et al., 2014; Karimi & Zeinivand, 2021). Drainage and lineament density both have similar effects on surface rainwater harvesting. Lineament and drainage 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.


86°49'0"E
86°56'0"E
87°3'0"E
87°10'0"E
RAINFALL MAP
0 3 6 12 Kilometers
N
23°45'0"N
23°40'0"N
23°35'0"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
LINEAMENT DENSITY MAP
0 3 6 12 Kilometers
N
23°45'0"N
23°40'0"N
23°35'0"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)

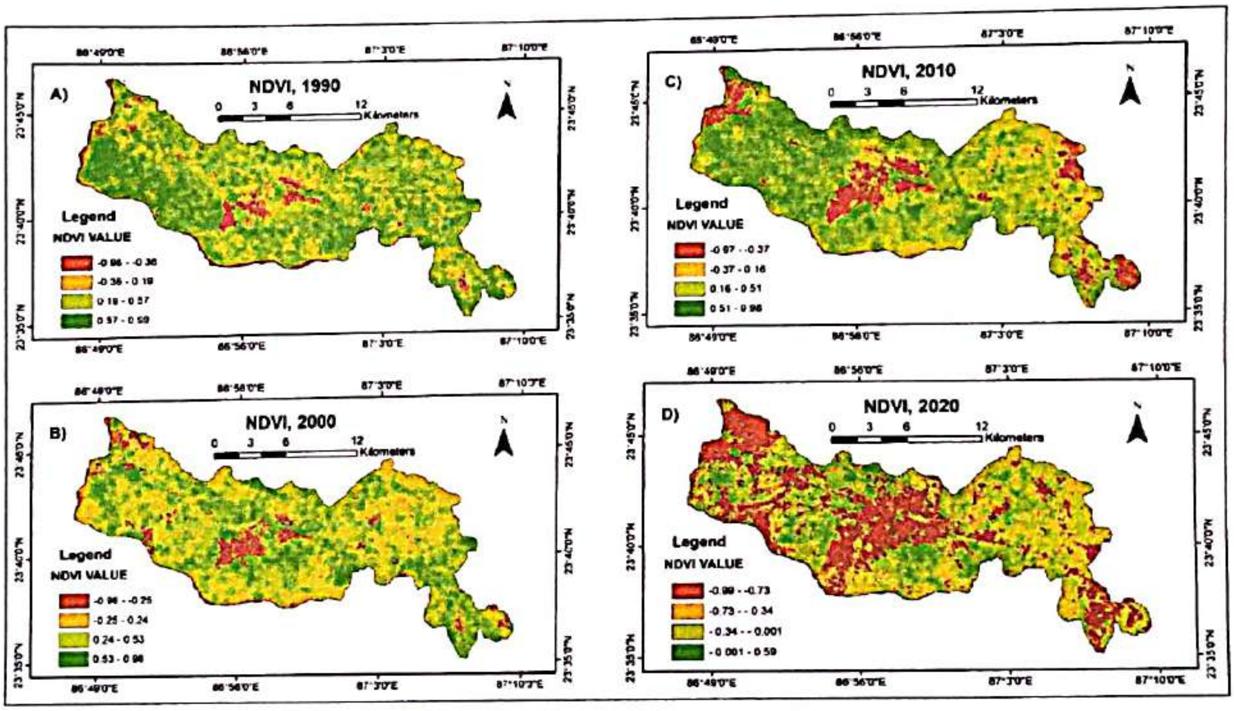
Analysis of Vegetation Cover Change

Results and Discussion

Analysis of Surface Water bodies change

For identifying the temporal change of surface water bodies four separate post monsoon (October) maps for the year 1990, 2000, 2010 and 2020 (Fig.9) have been prepared incorporating the algorithms of MNDWI (Fig.6) in software environment. Finally, area under surface water coverage has been calculated for each year. It is observed that surface water bodies are constantly decreasing which indicates the severe transformation of water bodies. In the first decade, the rate of decreasing surface water bodies is 0.62km^2/year whereas in the second decade, the rate is 0.41km^2/year. Ultimately, in the last decade it is reduced to 0.25km^2/year (Table.4). In 1990 total area under surface water bodies was 17.32km^2 whereas in 2020 only 4.58km^2 is found which is very alarming in the context of maintain urban ecology, specifically water resource management.

Similar techniques have been applied also for the preparation of vegetation cover map of October, 1990, 2000, 2010, and 2020(Fig.10) followed by the preparation of built up area maps (Fig.11). A decreasing trend of vegetation cover is observed comparing the calculated area under vegetation in different year) (Table.4). In the first decade, vegetation cover has decreased at 1.59km^2/year whereas in second decade the rate is 0.75km^2/year. Ultimately in last decade transforming rate is 0.49km^2/year



Area under Vegetation(Km^2)		Change (km^2)	Area under Water bodies(km^2)		Change (km^2)	Built up area(Km^2)		Change (km^2)
1990	2000	-15.88	1990	2000	-6.16	1990	2000	9.68
48.54	32.66		17.32	11.16		25.59	35.27	
Decreasing at 1.59km^2/year			**Decreasing at 0.62 km^2/year**			**Increasing at 0.96 km^2/year**		
1990	2010	-7.54	2000	2010	-4.09	2000	2010	17.08
32.66	25.12		11.16	7.07		35.27	52.35	
Decreasing at 0.75km^2/year			**Decreasing at 0.41km^2/year**			**Increasing at 1.71 km^2/year**		
2010	2020	-4.87	2010	2020	-2.49	2010	2020	24.94
25.12	20.25		7.07	4.58		52.35	77.29	
Decreasing at 0.49km^2/year			**Decreasing at 0.25km^2/year**			**Increasing at 2.49 km^2/year**		

Table.2: Calculation of Surface water bodies change

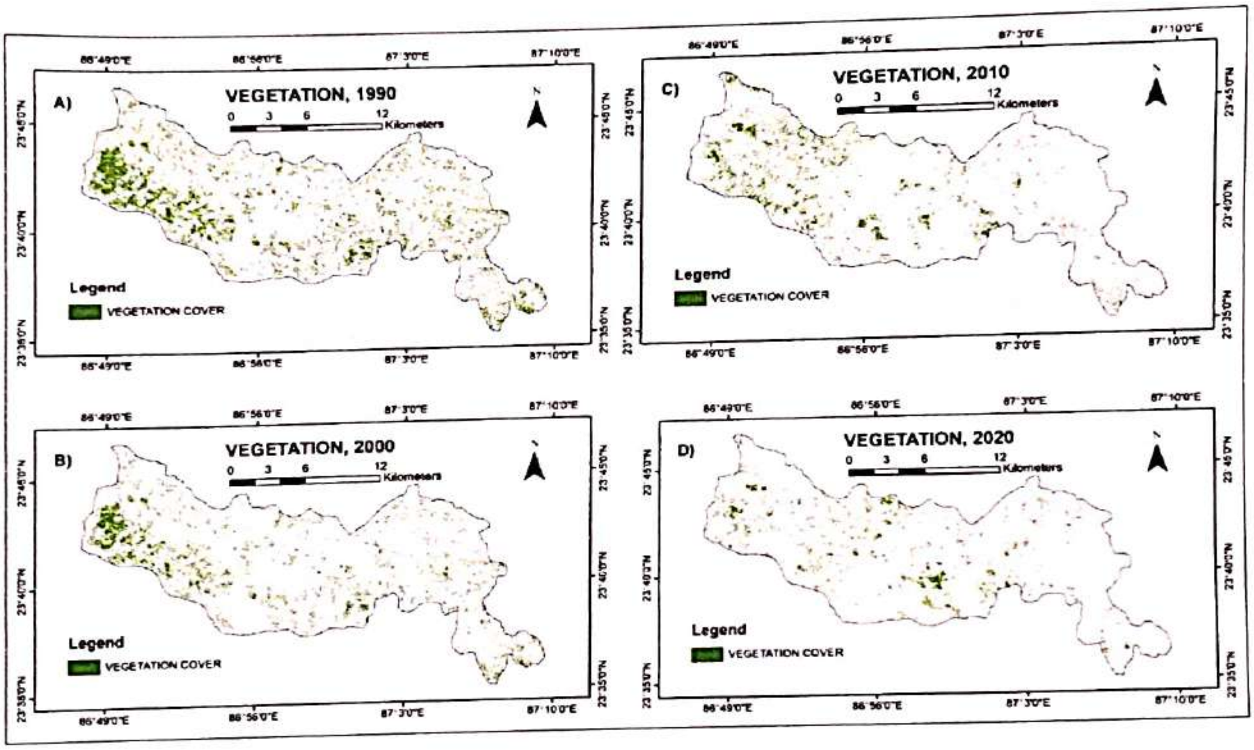


Fig.10. A) Vegetation covers map of October, 1990 B) October, 2000 C) October, 2010 D) October, 2020

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.

References

Alexander, C. (2020). Normalised difference spectral indices and urban land cover as indicators of land surface temperature (LST). *International Journal of Applied Earth Observation and Geoinformation*, *86*(October 2019), 102013. https://doi.org/10.1016/j.jag.2019.102013

Amiri, R., Weng, Q., Alimohammadi, A., & Alavipanah, S. K. (2009). Spatial-temporal dynamics of land surface temperature in relation to fractional vegetation cover and land use/cover in the Tabriz urban area, Iran. *Remote Sensing of Environment*, *113*(12), 2606–2617. https://doi.org/10.1016/j.rse.2009.07.021

Arnfield, A. J. (2003). Two decades of urban climate research: A review of turbulence, exchanges of energy and water, and the urban heat island. *International Journal of Climatology*, *23*(1), 1–26. https://doi.org/10.1002/joc.859

Asansol Municipal Corporation. (2020). http://www.asansolmunicipalcorporation.com/aboutus/2. Accessed at 2nd January, 2020

Asgarian, A., Amiri, B. J., & Sakieh, Y. (2015). Assessing the effect of green cover spatial patterns on urban land surface temperature using landscape metrics approach. *Urban Ecosystems*, *18*(1), 209–222. https://doi.org/10.1007/s11252-014-0387-7

Bhattacharya, B. K., Mallick, K., Patel, N. K., & Parihar, J. S. (2010). Regional clear sky evapotranspiration over agricultural land using remote sensing data from Indian geostationary meteorological satellite. *Journal of Hydrology*, *387*(1–2), 65–80. https://doi.org/10.1016/j.jhydrol.2010.03.030

Census of India. (2011). Registrar General and Census Commissioner of India, http://www.census2011.co.in/city.phpn

Choudhury, D., Das, K., & Das, A. (2019). Assessment of land use land cover changes and its impact on variations of land surface temperature in Asansol-Durgapur Development Region. *Egyptian Journal of Remote Sensing and Space Science*, *22*(2), 203–218. https://doi.org/10.1016/j.ejrs.2018.05.004

Das, N., Mondal, P., Sutradhar, S., & Ghosh, R. (2020). The Egyptian Journal of Remote Sensing and Space Sciences Assessment of variation of land use / land cover and its impact on land surface temperature of Asansol subdivision. *The Egyptian Journal of Remote Sensing and Space Sciences*, *24*(1), 131–149. https://doi.org/10.1016/j.ejrs.2020.05.001

Das, S., & Angadi, D. P. (2020). Remote Sensing Applications : Society and Environment Land use-land cover (LULC) transformation and its relation with land surface temperature changes : A case study of Barrackpore Subdivision ,. *Remote Sensing Applications: Society and Environment*, *19*(July 2019), 100322. https://doi.org/10.1016/j.rsase.2020.100322

Ding, H., & Shi, W. (2013). Land-use/land-cover change and its influence on surface temperature: a case study in Beijing City. *International Journal of Remote Sensing*, *34*(15), 5503–5517. https://doi.org/10.1080/01431161.2013.792966

Fall, S., Niyogi, D., Gluhovsky, A., Pielke, R. A., Kalnay, E., & Rochon, G. (2010). Impacts of land use land cover on temperature trends over the continental United States: Assessment using the North American Regional Reanalysis. *International Journal of Climatology*, *30*(13), 1980–1993. https://doi.org/10.1002/joc.1996

Fan, C., Myint, S. W., Kaplan, S., Middel, A., Zheng, B., Rahman, A., Huang, H. P., Brazel, A., & Blumberg, D. G. (2017). Understanding the impact of urbanization on surface urban heat Islands-A longitudinal analysis of the oasis effect in subtropical desert cities. *Remote Sensing*, *9*(7). https://doi.org/10.3390/rs9070672

Foody, G. (1992). On the compensation for chance agreement in image classification accuracy assessment. *Photogrammetric Engineering and Remote Sensing*, *58*(10), 1459–1460.

Govind, N. R., & Ramesh, H. (2019). The impact of spatiotemporal patterns of land use land cover and land surface temperature on an urban cool island: a case study of Bengaluru. *Environmental Monitoring and Assessment*, *191*(5). https://doi.org/10.1007/s10661-019-7440-1

Guha, S., Govil, H., & Diwan, P. (2020). Monitoring LST-NDVI Relationship Using Premonsoon Landsat Datasets. *Advances in Meteorology*, *2020*(1). https://doi.org/10.1155/2020/4539684

Jupp, D. L. B. (1989). The stability of global estimates from confusion matrices. *International Journal of Remote Sensing*, *10*(9), 1563–1569. https://doi.org/10.1080/01431168908903990

Khan, A., Govil, H., Taloor, A. K., & Kumar, G. (2020). Identification of artificial groundwater recharge sites in parts of Yamuna River basin India based on Remote

Sensing and Geographical Information System. *Groundwater for Sustainable Development*, *11*(February), 100415. https://doi.org/10.1016/j.gsd.2020.100415

Kuang, W., Liu, Y., Dou, Y., Chi, W., Chen, G., Gao, C., Yang, T., Liu, J., & Zhang, R. (2015). What are hot and what are not in an urban landscape: quantifying and explaining the land surface temperature pattern in Beijing, China. *Landscape Ecology*, *30*(2), 357–373. https://doi.org/10.1007/s10980-014-0128-6

Landis, J. R., & Koch, G. G. (1977). Landis amd Koch1977_agreement of categorical data. *Biometrics*, *33*(1), 159–174.

Li, J., Song, C., Cao, L., Zhu, F., Meng, X., & Wu, J. (2011). Impacts of landscape structure on surface urban heat islands: A case study of Shanghai, China. *Remote Sensing of Environment*, *115*(12), 3249–3263. https://doi.org/10.1016/j.rse.2011.07.008

Luck, M., & Wu, J. (2002). A gradient analysis of urban landscape pattern: A case study from the Phoenix metropolitan region, Arizona, USA. *Landscape Ecology*, *17*(4), 327–339. https://doi.org/10.1023/A:1020512723753

Mathew, A., Sreekumar, S., Khandelwal, S., Kaul, N., Kumar, R., & Member, S. (2016). *Prediction of Land-Surface Temperatures of Jaipur City Using Linear Time Series Model*. 1–7.

Mathew, A., Sreekumar, S., Khandelwal, S., & Kumar, R. (2019). Prediction of land surface temperatures for surface urban heat island assessment over Chandigarh city using support vector regression model. *Solar Energy*, *186*(March), 404–415. https://doi.org/10.1016/j.solener.2019.04.001

Memon, R. A., Leung, D. Y. C., & Chunho, L. I. U. (2008). *Review of Generation, Determination, Mitigation UHI*. *20*, 120–128.

Mirzaei, P. A. (2015). Recent challenges in modeling of urban heat island. *Sustainable Cities and Society*, *19*, 200–206. https://doi.org/10.1016/j.scs.2015.04.001

Pal, S., & Ziaul, S. (2017). Detection of land use and land cover change and land surface temperature in English Bazar urban centre. *Egyptian Journal of Remote Sensing and Space Science*, *20*(1), 125–145. https://doi.org/10.1016/j.ejrs.2016.11.003

Peng, J., Xie, P., Liu, Y., & Ma, J. (2016). Urban thermal environment dynamics and associated landscape pattern factors: A case study in the Beijing metropolitan region. *Remote Sensing of Environment*, *173*, 145–155. https://doi.org/10.1016/j.rse.2015.11.027

Pu, R., Gong, P., Michishita, R., & Sasagawa, T. (2006). Assessment of multi-resolution and multi-sensor data for urban surface temperature retrieval. *Remote Sensing of Environment*, *104*(2), 211–225. https://doi.org/10.1016/j.rse.2005.09.022

Rahman, M. T., Aldosary, A. S., & Mortoja, M. G. (2017). Modeling future land cover changes and their effects on the land surface temperatures in the Saudi Arabian eastern coastal city of Dammam. *Land*, *6*(2). https://doi.org/10.3390/land6020036

Ramachandra, T. V. (2012). Land Surface Temperature Analysis in an Urbanising Landscape through Multi-Resolution data Land Surface Temperature Analysis in an Urbanising Landscape through Multi- Resolution Data Centre for infrastructure , Sustainable Transportation and Urban Plannin. *Journal of Space Science & Technology*, *1*(1), 1–10.

Rinner, C., & Hussain, M. (2011). Toronto's urban heat island-exploring the relationship between land use and surface temperature. *Remote Sensing*, *3*(6), 1251–1265. https://doi.org/10.3390/rs3061251

Shafizadeh-Moghadam, H., Weng, Q., Liu, H., & Valavi, R. (2020). Modeling the spatial variation of urban land surface temperature in relation to environmental and anthropogenic factors: a case study of Tehran, Iran. *GIScience and Remote Sensing*, *57*(4), 483–496. https://doi.org/10.1080/15481603.2020.1736857

Siddique, G., Roy, A., Hasan, M., Ghosh, S., Basak, A., Singh, M., & Mukherjee, N. (2020). An assessment on the changing status of urban green space in Asansol city , West Bengal. *GeoJournal*, *2*. https://doi.org/10.1007/s10708-020-10312-2

Song, J., Du, S., Feng, X., & Guo, L. (2014). The relationships between landscape compositions and land surface temperature: Quantifying their resolution sensitivity with spatial regression models. *Landscape and Urban Planning*, *123*, 145–157. https://doi.org/10.1016/j.landurbplan.2013.11.014

Story, M., & Congalton, R. G. (1986). Remote Sensing Brief Accuracy Assessment: A User's Perspective. *Photogrammetric Engineering and Remote Sensing*, *52*(3), 397–399.

Townshend, J. R. G., & Justice, C. O. (1986). Analysis of the dynamics of african vegetation using the normalized difference vegetation index. *International Journal of Remote Sensing*, *7*(11), 1435–1445. https://doi.org/10.1080/01431168608948946

Xu, H. (2005). A Study on information extraction of water body with the Modified Normalized Difference Water Index(MNDWI). *Journal of Remote Sensing*, 9, 589-595.

Zha, Y., Gao, J., & Ni, S. (2003). Use of normalized difference built-up index in automatically mapping urban areas from TM imagery. *International Journal of Remote Sensing*, *24*(3), 583–594. https://doi.org/10.1080/01431160304987

Zhao, M., Cai, H., Qiao, Z., & Xu, X. (2016). Influence of urban expansion on the urban heat island effect in Shanghai. *International Journal of Geographical Information Science*, *30*(12), 2421–2441. https://doi.org/10.1080/13658816.2016.1178389