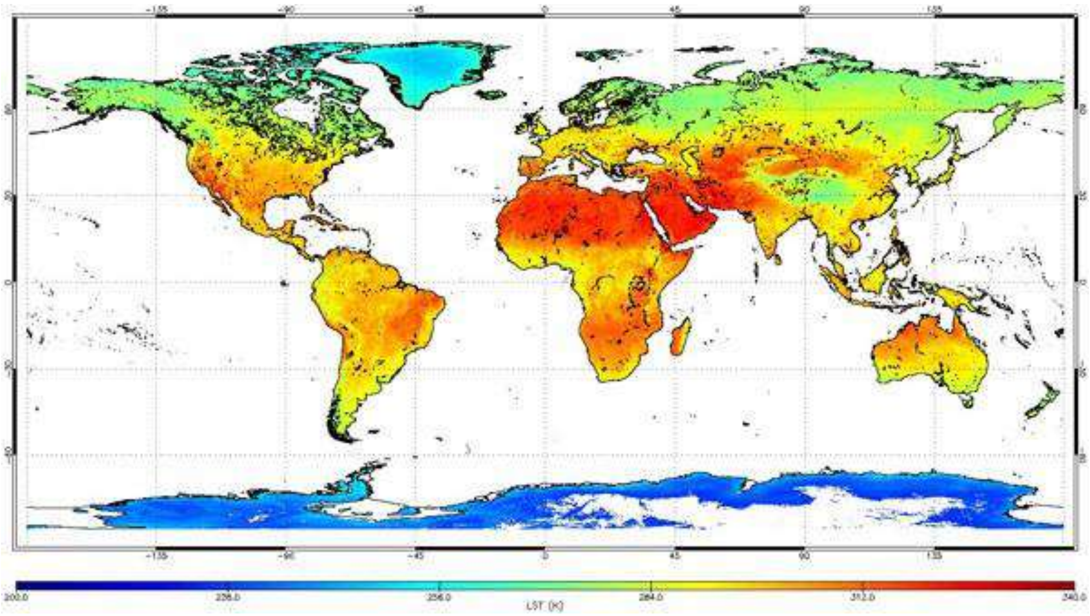
Research Report

On

"ANALYZING WARD LEVEL LAND SURFACE TEMPARATURE DYNAMICS IN MUNICIPAL CORPORATION OF DELHI BETWEEN 2000-2022"

M.Sc. Semester-IV, Practical Examination 2023



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HALDIA GOVERNMENT COLLEGE

DEPARTMENT OF GEOGRAPHY (UG & PG)

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To Whom It May Concern

This is to certify that Somashree Mondal, Roll: PG/VUEGG19-GEO-IVS, No: 015 has happened the Field Report **on "ANALYZING WARD LEVEL LAND SURFACE TEMPARATURE DYNAMICS IN MUNICIPAL CORPORATION OF DELHI BETWEEN 2000-2022"** for M.Sc Semester-IV Examination in Geography 2023 as a partial fulfilment of Paper-GEO 496.2. It is also certified that the present dissertation is her own work and may be placed before the Examiner for evaluation.

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Date: Signature of the candidate

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INTRODUCTION

Land Surface Temperature (LST) is the temperature of the surface which can be measured when the land surface is in direct contact to the measuring instrument. LST is nothing but the skin temperature of the land surface. Worldwide urbanization has significantly reshaped the landscape, which has important climatic implications across all scales due to the simultaneous transformation of natural land cover and introduction of urban materials i.e. anthropogenic surfaces. Identification and characterization of Urban Heat Island (UHI) is typically based on LST that varies spatially, due to the no homogeneity of land surface cover and other atmospheric factors. Ground surveys would permit a highly accurate Land Use Land Cover (LULC) classification, but they are time-consuming, burdensome and expensive, which highlights remote sensing an evident and preferred alternative. Medium spatial resolution data, such as that from the LANDSAT and SPOT are suitable for land cover or vegetation mapping at regional local scale. LANDSAT 8 carries two sensors, i.e., the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). OLI collects data at a 30m spatial resolution with eight bands located in the visible and near-infrared and the shortwave infrared regions of the electromagnetic spectrum, and an additional panchromatic band of 15m spatial resolution. TIRS senses the TIR radiance at a spatial resolution of 100m using two bands located in the atmospheric window between 10 and 12 μm.

Land Surface Temperature (LST) is an important climate variable, related to surface energy balance and the integrated thermal state of the atmosphere within the planetary boundary layer. Traditionally, LST was referred to standard surface-air temperature measured by a sheltered thermometer 1.5–3.5 m above a flat grassy, well-ventilated surface. With satellite technology, another type of LST, satellite-based surface temperature called skin temperature, is becoming available globally. Satellite LST products provide an estimate of the kinetic temperature of the earth’s surface skin, i.e., the aggregate surface medium viewed by the sensor to a depth of about 12 μm. Skin temperature is inferred from the thermal emission of the earth surface and is generally some average effective radioactive temperature of various canopy and soil surfaces.

LST is a key parameter in land surface processes, not only acting as a indicator of climate change, but also due to its control of the upward terrestrial radiation, and consequently, the control of the surface sensible and latent heat flux exchange with the atmosphere. For example, energy exchanges at the land-surface boundary are largely controlled by the difference between

the skin temperature and the surface air temperature, the air and the surface reacting with different time and space scales to external forcing while still being complexly interconnected. And the surface temperature responds more rapidly to changes of the local balance of energy than the air temperature. On the other hand, surface heat fluxes can induce local convection in the boundary layer, producing changes in air temperature, surface winds, cloudiness, and (potentially) precipitation. Estimates of the surface temperature diurnal cycle can yield information about the soil moisture via an estimate of the thermal inertia. Matsui et al found that there is relationship between LST and rainfall variability in the North American Monsoon. The substantial variability of skin temperature may modulate the temperature gradient between land and ocean. In additional, skin temperature can be used for monitoring vegetation water stress, assessing surface energy balance, detecting land surface disturbance, and monitoring condition suitability for insect–vector disease proliferation, among other uses.

However, despite the recognized importance of land surface temperature, accurate measurements of LST over continents are not yet available for the whole globe, for clear and cloudy skies, with a time sampling adequate to resolve the diurnal cycle and to analyse synoptic, seasonal, and inter annual variability. The National Research Council and the Intergovernmental Panel on Climate Change pointed out the urgent need for long-term remote sensing–based land surface skin temperature (LST) data in global warming studies to improve the limits of conventional 2-m World Meteorological Organization (WMO) surface air temperature observations. Currently, the long-term surface skin temperature dataset is only available over the ocean, i.e., sea surface temperature (SST). Over land, developing such a dataset has proved more difficult due to the land’s high surface heterogeneities, unknown surface emissivity and cloud contamination.

1.1 Remote Sensing in LST:

Satellite-based Land surface temperature can be determined from thermal emission at wavelengths in either infrared or microwave which is “atmospheric windows”. However, there are many uncertainties involved in the retrieval of LST from radiance which is directly measured by sensors on board. Thermal infrared (TIR)-based LST retrievals are less uncertain

(1-2K) than microwave-based ones because of the smaller range of variation of surface emissivity's in the TIR domain and the stronger dependence of the radiance on temperature (workshop, 2008). The range of surface emissivities in the microwave is much larger and the

temperature dependence is essentially linear leading to LST uncertainties that can be as large as 10K. Infrared measurements are very much more sensitive to cloud contamination than are microwave measurements. Strict cloud detection can reduce the uncertainty of infrared temperature determinations to 2-3K, whereas the remaining cloud effects on microwave determinations are similar though much less frequent. However, the need for a strict cloud detection severely limits the space-time sampling of infrared measurements; in fact, the "clear-sky" bias of infrared results is significant and varies systematically with location, time of day and season. In fact, the correlation of temperature variations and cloudiness in weather events precludes an accurate determination of the synoptic variations as well. Microwave measurements are much less limited in this regard but are much more uncertain because of the complex and large variations of surface emissivity (including angle dependence).

The most popular remote sensed data used to derive LST is Advanced Very High Resolution Radiometer AVHRR and Moderate Resolution Imaging Spectro radiometer MODIS. For the sensor AVHRR, on board National Oceanic and Atmospheric Administration NOAA polar-orbiting satellite, is a cross-track scanning system with five spectral channels. Each channel has a nominal spatial resolution of 1.1 km at nadir. The NOAA polar-orbiting satellites have unique advantages for the LST dataset development because of a long observation period, global coverage, easy data access, an abundance of excellent research, and operational efforts to promote a retrieval process of the highest quality possible. NOAA's AVHRR uses thermal infrared channels to measure the radiative emission of the surface. LST can be derived from AVHRR radiances after removing atmospheric and surface emissivity effects.

MODIS is an EOS instrument on board Terra (EOS AM) and Aqua (EOS PM) that serves as the keystone for global studies of atmosphere, land, and ocean processes (Running, 1994; Wan, 1996). It scans ±55° from nadir in 36 bands, with bands 1-19 and band 26 in the visible and near infrared range, and the remaining bands in the thermal infrared from 3-15 µm. It will provide images of daylight reflection and emission of the Earth every 1-2 days, with continuous duty cycle. The thermal infrared bands have an IFOV (instantaneous field-of-view) of about 1km at nadir. MODIS will view cold space and a full-aperture blackbody before and after viewing the Earth scene in order to achieve calibration accuracy of better than 1% absolute for thermal infrared bands. MODIS is particularly useful because of its global coverage, radiometric resolution and dynamic ranges, and accurate calibration in multiple thermal

infrared bands designed for retrievals of SST, LST and atmospheric properties. Specifically bands 3-7, 13, and 16-19 will be used to classify land-cover to infer emissivity's, band 26 will detect cirrus clouds, and thermal infrared bands 20, 22, 23, 29, 31, and 32 correct for atmospheric effects and retrieve surface emissivity and temperature. The atmospheric sounding channels of MODIS retrieve atmospheric temperature and water vapour profiles.

1.2 Example of LST Application:

LST products have been extensively used as inputs into assimilation routines to help improve the estimate of model state and prognostic variables. These are in turn used to improve the understanding and quantifications of surface fluxes, water availability, to aid resources management and improve weather forecasts. Through improved estimates of soil moisture and evapotranspiration, LST products are also outside of assimilation schemes to monitor drought at continental and regional scales. Following are some examples. The first example demonstrates the use of satellite-derived observations of land surface temperature (LST), from the SEVRI sensor, as inputs in a data assimilation scheme, aims at retrieving parameters that describe the energy balance at the land surface .The approach uses a parsimonious 1-D multi scale variational assimilation procedure. This assimilation scheme has been coupled with the non-hydrostatic limited area atmospheric model RAMS, in order to improve the quality of the energy budget at the surface in RAMS by replacing the lower boundary condition of the atmospheric domain.

Another example demonstrates the use of thermal infrared (TIR) data (GOES) as a valuable remote indicator of both evapotranspiration (ET) and the surface moisture status.

Ensemble filters and LST assimilation in basin-scale hydrological models for flood forecasting: This study evaluates the fundamental differences (threshold process, preferential trajectories for convection and diffusion, low observability of the main state variables and high parametric uncertainty) between distributed hydrologic models and other geo-fluid-dynamics models, and explores them through some numerical experiments on a continuous hydrologic model, MOBIDIC.

The research on operational regional-scale soil moisture with assimilation of satellite LST describes the operational implementation over the Italian territory of an experimental operational system of soil moisture monitoring, based on the assimilation of LST and other

satellite-derived products. The assimilation scheme is based on the surface energy balance.

The study Vegetation monitoring through retrieval of NDVI and LST time series from NOAA-AVHRR historical databases simultaneously analyses the annual evolutions of NDVI and LST, with the purpose of a better mapping of the vegetation than when only NDVI parameter is used.

❖ The main challenges associated with the use of LST products for applications:

The workshop specifies the challenges that hinder the widely application of LST products, as listed below.

1) Limited number of products available

2) Difficult to ascertain exactly what is available

3) No comprehensive "catalog" of all products In addition, for those products available:

4) Not many are operational (systematic; long-term continuation assured)

5) The majority is insufficiently validated (stratification approaches required: land cover types, climate regimes, day vs. night)

6) Show discontinuous in space and time (cloud, orbital characteristics)

7) Insufficiently long term records

8) Inadequate latency

9) Spatial resolution/ temporal resolution dichotomy

10) May be sensor – or algorithm-specific specifically, when the application involves the use of models, additional challenges are:

11) Remote Sensing products and model state variables are inherently inconstant (vertical scale): satellite sees "skin" temperature in thin layer, whereas model "surface" temperature is typically a mixture of temperatures of thicker layers.

12) Satellite skin temperature and model surface temperature may be inherently inconsistent (horizontal scale): Satellite “sees” a great variety of spatial heterogeneity, whereas a model is limited in the spatial variability it can represent.

❖ Main concerns regarding the LST products that will and will not become available in the future:

1) Lack of longevity and consistency of products

2) Lack of adequate cover of diurnal cycle

3) Lack of inter-calibrated data from data from satellite to satellite to get uniform long term global data

4) Inadequate spatial resolution (high resolution required)

5) Limited availability of products

6) Existence of systematic biases in products

7) Lack of consistency of instrument or spectral channels across platforms

8) Inadequate accuracy to meet user needs

9) Most products are clear-sky biased

10) Inadequate cloud mask

11) Combination of polar orbiters and geostationary provides real opportunities.

12) Feasibility of multi-sensor multi-platform LST products.

❖ Solutions to bridge the gap between science and community:

1) Expand Table 4 to include the other criteria/requirements/issues and reach a final agreement on what are the acceptable requirements

2) Determine the feasibility of generating satellite LST products for all-sky conditions.

3) Demonstrate the usefulness of LST versus air temperature for operational systems. Identify what additional information is provided by LST compared with Tair.

4) How can we reliably accommodate differences between LST and the aerodynamic temperature (Taerodynamic) for energy balance calculations and to compare with land surface model simulations.

LITERATURE REVIEW

Land surface temperature (LST), land surface changes, vegetation cover and other land parameters are a significant dynamic in worldwide climate change researcher's structure. Land surface changes have brought essential changes on to the vegetation on to the vegetation cover for cities. This study tries to look at land surface temperature dynamic in Delhi Municipal Corporation based on thermal remote sensing Landsat data and sentinel data. This paper is mainly focusing the land surface temperature changes in last 22 year in Delhi city. Here land use/land cover and land surface temperature and to access the thermal response pattern of land cover types studied through remote sensing techniques. The results shows that dominated importance of urban land cover expansion in the changes in heat island intensity and surface temperature patterns. Urban development was also related to continual population increases in Delhi city. For the planning application in Delhi city the combine use of satellite derived vegetation and land cover distribution with surface temperature maps provides a very useful tool. For the temperature control in Delhi city more green campaigns and landscaping designs is very important. And for that planners should focus on forest, green lawns and water bodies which make cooling effect in city.

Remote sensing and GIS is useful tools for deriving information regarding of land use and land cover land surface temperatures and for examining the thermal effect of urban development. The urban built up area of Delhi is increased 5.63% to 8.16% in last 10 years. Application of Landsat TM thermal infrared data to the study of land surface temperatures suggests that different land cover types have distinctive thermal responses. The spatial variability and land surface temperature is increased due to the conversion of natural and vegetated surface into urban uses. Effective city's Green campaign planning is possible by combining Satellite-derived land use/cover maps showing the vegetation distribution with land surface temperature maps. Forest, water body, green lawns showing cooling effect, so urban planners can use this knowledge to managing the temperature.

This study observe that the LST has increased over the years from 2000 till 2022 on some specific areas where there is more anthropogenic activities happen and for the build-up areas (settlements and industrial areas). Evaluations of land surface temperature provide significant contribution for UHI restoration initiatives. Based on the results, it has been concentration, frequency of heat island occurring, and period of UHI, on the other hand, the climatic events

under different climate change scenarios. This research shows sub-district UHI; therefore, highest heat stress needs particular attention. Regardless of the growth of green after sometimes cause urban heat island focus. In difference vegetation areas known as green which is very vital for sustainable urban planning.

Thermal Infrared (TIR) Landsat 8 proved that it is possible observing land temperature which has been touched by different microclimate conditions in the cities. Satellite data has a vital role in the land observation of the surface changes across the world, mainly wherever necessary knowledge isn’t accessible for such observations. This study used Landsat 8 images to observe unique patterns of land surface temperature and heat island growth in Delhi during 2000 & 2022. This study proved that the central part of Delhi facing a low temperature, which is starting from 28°C for and 49°C for suburban part of Delhi which has been covered by rock and new growth settlements areas. Moderately, a low temperature has recorded in vegetation cover and water bodies in the middle part of the Delhi. A central part covered by enough density of vegetation cover and tree cover. The higher temperature has recorded for high dance build-up areas ranges between 48°C and 52°C. The results show that urban heat island growth has transferred from the central part of the city to surrounding areas from 2000-2022. The heat-trapping in the South, South West and North West part of the city due to the high concentration of building and grown societies and industrial units over Delhi caused an It recommended that development authority should consider environmental concern before planning industrial land use and urban growth must be regulated and perpetually monitored.

OBJECTIVES

The present dissertation attempts to study on spatio-temporal dynamics in Delhi Municipal Corporation with the following objectives:

1. Studying minimum, median and maximum LST in Delhi Municipal Corporation in 2000 & 2022.
2. Studying the difference in ward level minimum, median and maximum LST between 2000 -2022.
3. Analyzing spatial variability of LST with respect to present build-up growth.

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STUDY AREA

The study was carried out over Delhi and surroundings areas situated between latitude 28°14’57”N to 28°52’18”N and longitude between 77°35’34”E to 76°57’38”E and altitude lies between 213m and 305m covering an area of 5160.00 km². Delhi climatic type is a monsoon-influenced humid sub-tropical (Koppen climate classification CWA).

One of the most characteristics features of the Delhi climate is extreme low and high temperature ranging to as high as 47°C during summer while reaching as low as 0.6°C during winter. January being the coldest, May/June the hottest and mean annual total rainfall is around 70 cm.

Physically Delhi can be divided into three segments: The Yamuna flood plain, The ridge and the plain. The Yamuna flood plain is somewhere low-lying and sandy. The ridge constitutes the most dominating physiographic features of the territory. It originates from the Aravali Hills of Rajasthan and enter Delhi from the south, Extent in north-eastern direction and the rest of Delhi is categorized as a plain. Yamuna is the main river that passes through Delhi. Apart from the flood channels of Yamuna there are three canals, i.e. portion of Agra canal, Hindu canal and western Yamuna canal. The vegetation in the ridge is predominantly thorny scrub type, which is usually founding in arid and semi-arid Zone. Ridge forest of Delhi falls in the category of ‘Tropical thorn Forest’ as per the forest type classification of champion and Seth (1968), and more espatially as semi-arid and open scrub and among trees that are dominant Acacias.

Delhi is the biggest commercial center in northern India and one of the fastest emerging cities in the region. The most developed of all economy branches is the service sector, information technology, telecommunications, hotels, banking, media and tourism.

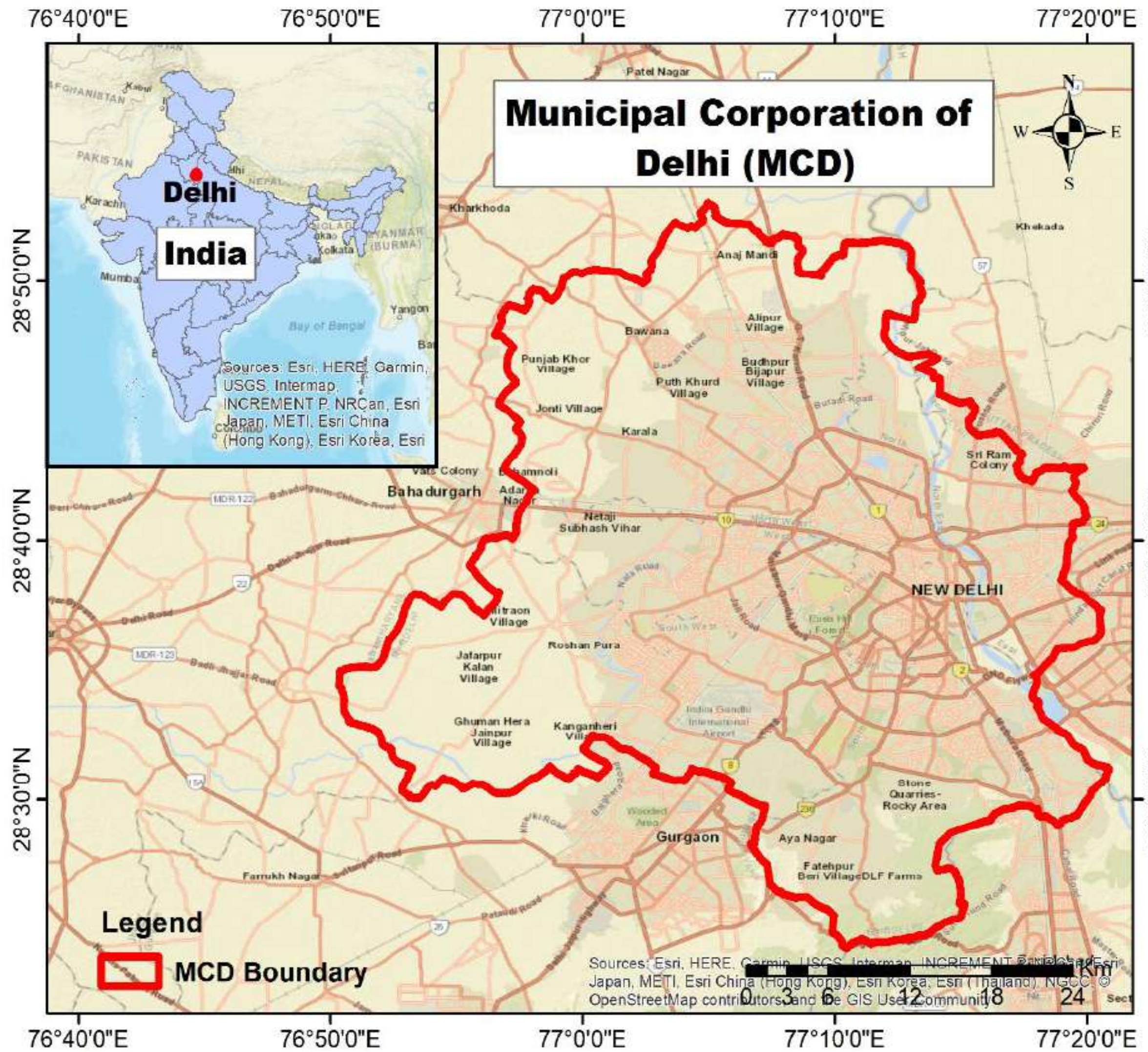


Fig: Location map of the Municipal Corporation of Delhi

Municipal Corporation of Delhi (MCD) is the municipal corporation that governs most of Delhi, India. The MCD is among the largest municipal bodies in the world providing civic services to a population of about 20 million citizens in the capital city Delhi. MCD is one of three municipalities in the National Capital Territory of Delhi, the others being New Delhi Municipal Council, and Delhi Cantonment Board. The annual budget of the corporation is above ₹16,000 crore (~US$1.95 billion). The municipal corporation covers an area of 1,397.3 km² (539.5 mi²). It is the only municipality of Delhi which is elected by people.

DATABASE AND METHODOLOGY

1.6 Database:

This study is based on satellite images. Satellite images have been collected from the United States Global Survey on various dates, shows detailed information about the satellite images used for this study. For the analysis cloud, free images of the same time period have been chosen to minimize the errors. For the analysis, ground verification has been done for some ground truth information. Some information regarding the growth and development of Delhi and its surrounding information has been collected from the various offices like Delhi Municipal Corporation, Delhi Municipal Development Authority etc.

The following geospatial dataset have been used in the present study:

- Landsat 8 Operational Land Imager in 2000 & 2022 for the Delhi Municipal Corporation.
- Sentinel 2 LULC of Delhi (2022).

1.7 Methodological Framework:

- Landsat 8 Thermal Infrared satellite data were used to derive ward wise LST in the municipality for 2000 and 2022 respectively.
- Lastly, the flow chat used to investigate the differences of temperature between ward wise LST in 2000 & 2022 in Delhi.

The data processing workflow consist of several steps:

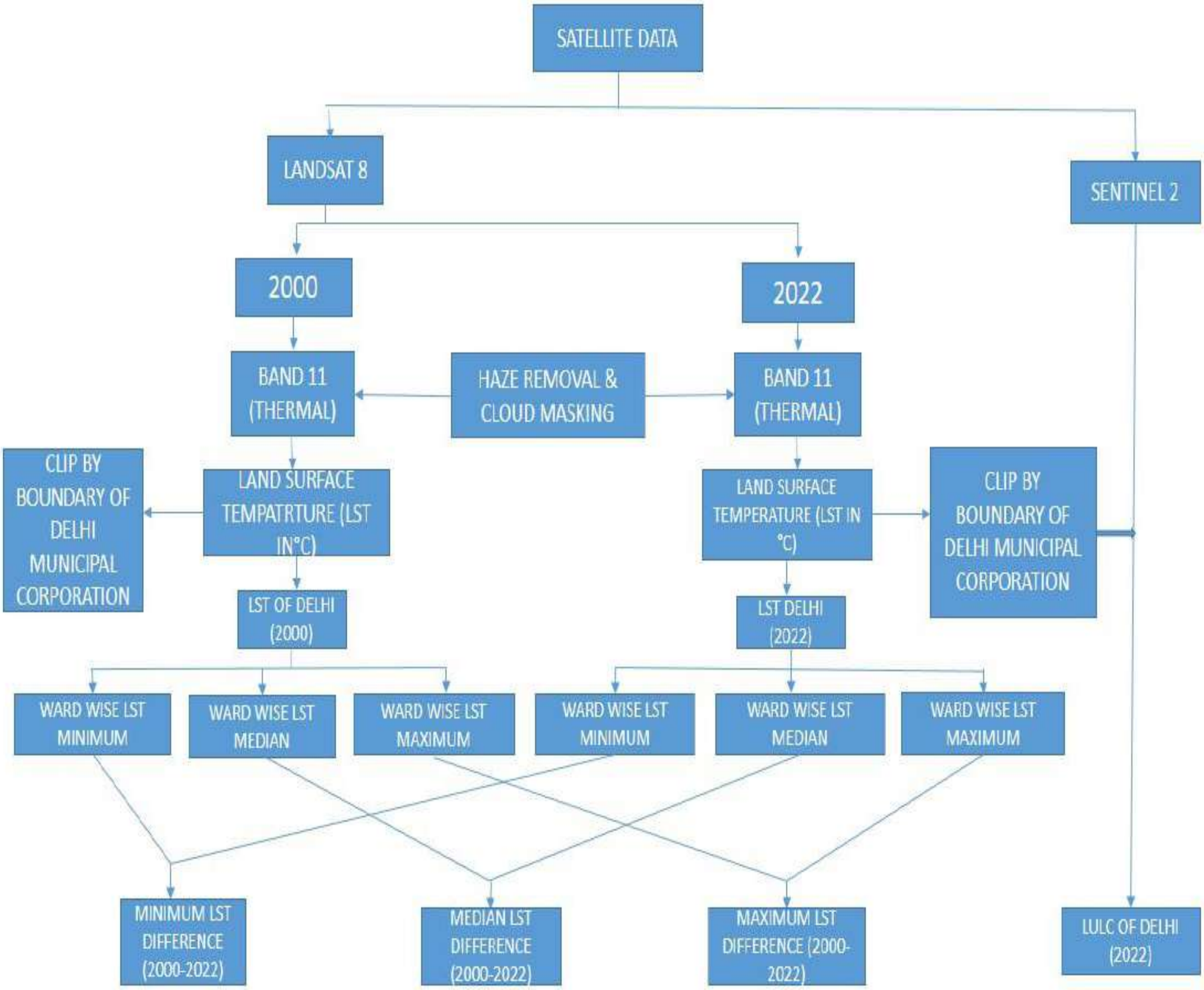


Fig: Methodological Workflow

1.8 Software Used:

- Google Earth Engine web portal for necessary data extraction.
- ArcGIS 10.8 for thematic mapping.
- MS Excel for statistical analysis.

RESULTS & DISCUSSIONS

1.9 Land Use Land Cover (LULC)

Municipal Corporation of Delhi (MCD) is the municipal corporation that governs most of Delhi, India. The MCD is among the largest municipal bodies in the world providing civic services to a population of about 20 million citizens in the capital city Delhi. MCD is one of three municipalities in the National Capital Territory of Delhi, the others being New Delhi Municipal Council, and Delhi Cantonment Board. The annual budget of the corporation is above ₹16,000 crore (~US$1.95 billion). The municipal corporation covers an area of 1,397.3 km² (539.5 mi²). It is the only municipality of Delhi which is elected by people.

In the present study, LANDSAT 8 image was used to prepare Standard False Colour Composite (SFCC) of Delhi Municipal Corporation for 2022 as given in the figure below.

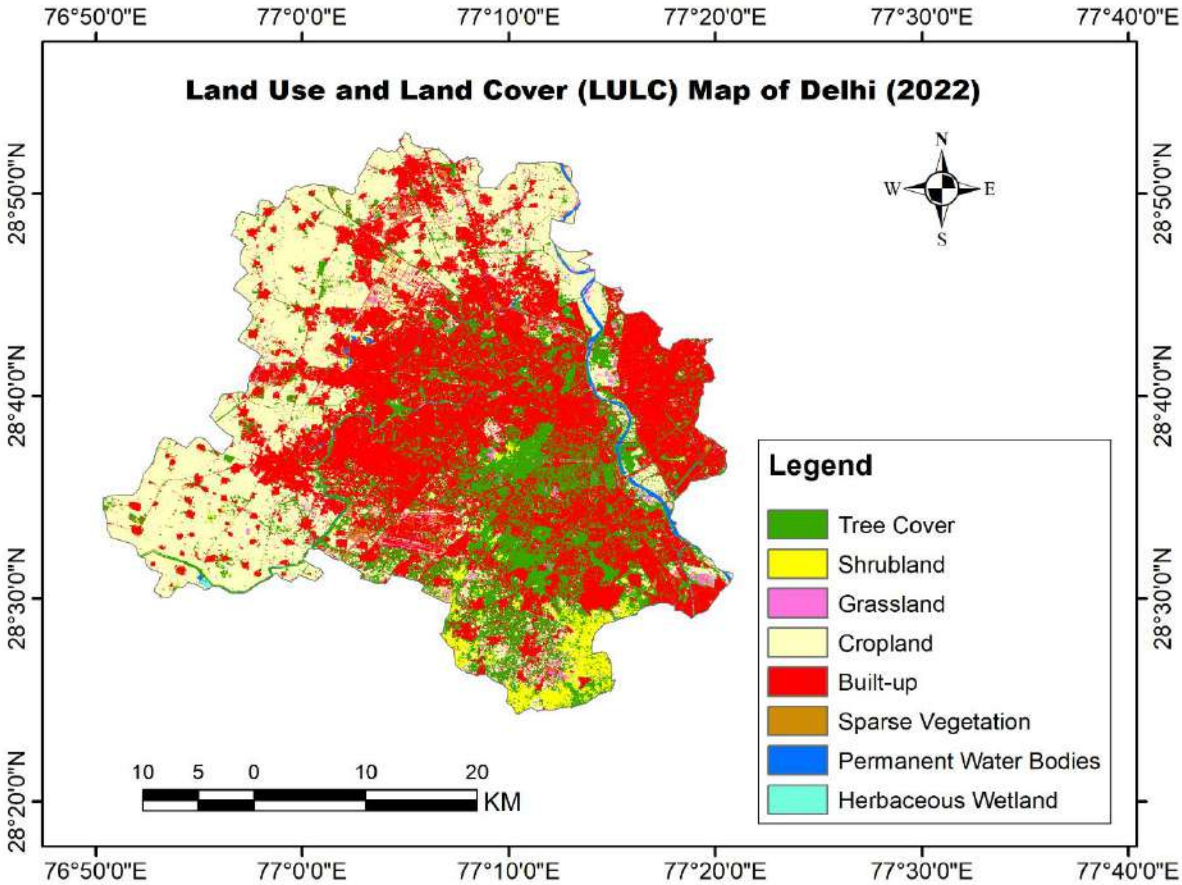


Fig 1.9: Land Use and Land Cover (LULC) Map of Delhi (2022)

LAND SURFACE TEMPARATURE (LST)

2.0 Introduction:

Land surface temperature is defined as the temperature felt when the land surface is touched with the hands or the skin temperature of the ground. As one of the most important aspects of the land surface, LST has been a main topic for developing methodologies to be measured from space. LST is an important factor in many areas of studies, such as global climate change, hydrological and agricultural processes, and urban land use/land cover. Calculating LST from remote sensed images is needed since it is an important factor controlling most physical, chemical, and biological processes of the Earth. There is a growing awareness among environmental scientists that remote sensing can and must play a role in providing the data needed to assess ecosystems conditions and to monitor change at all special scales.

2.1 LST Minimum of 2000 & 2022:

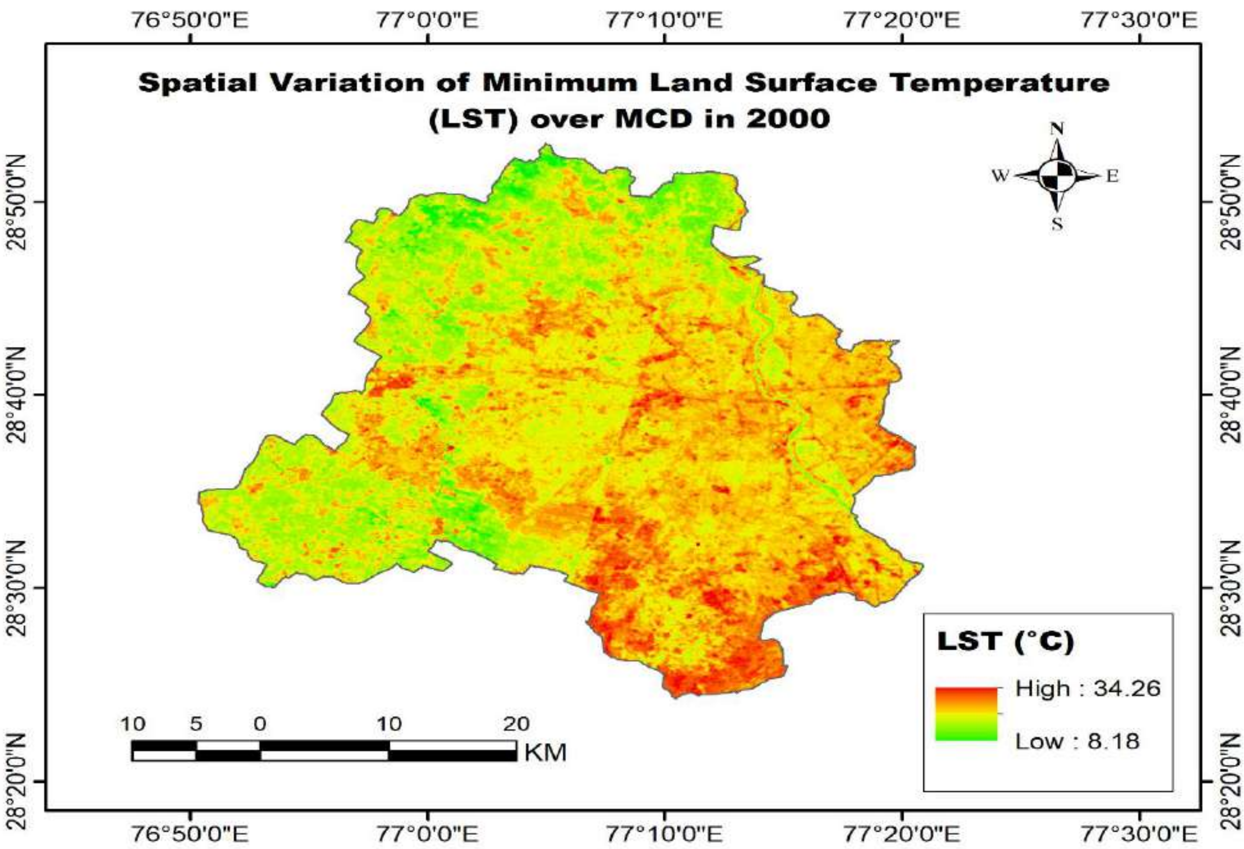


Fig 2.1.1: Spatial Variation of Minimum LST over MCD in 2000

It can be seen that from 2000, the overall spatial distribution of LST was generally high in the southern, eastern and central regions, while low in the northern, western, south-west regions in Municipal corporation of Delhi (Fig 2.1.1). The high value areas (LST 34.26°C) were mainly distributed in the southern part of the MCD. This regions have flat terrain, obvious urban expansion, large human disturbance and prominent social and economic development. The low value areas (LST 8.18°C) were mainly distributed in the northern and western part of the MCD. These areas have wide water coverage, dence cropland , weak human activities with small urban areas.

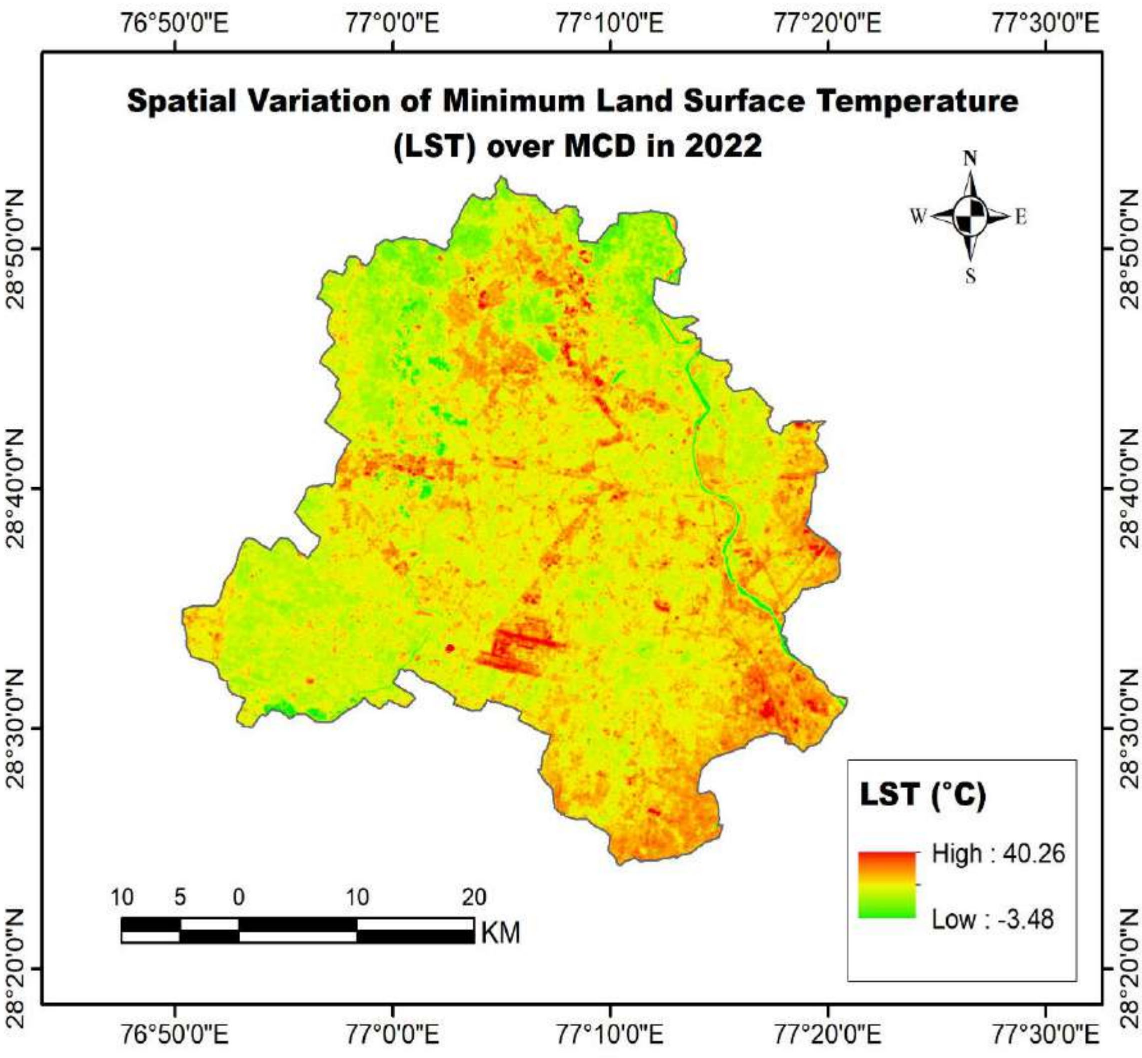
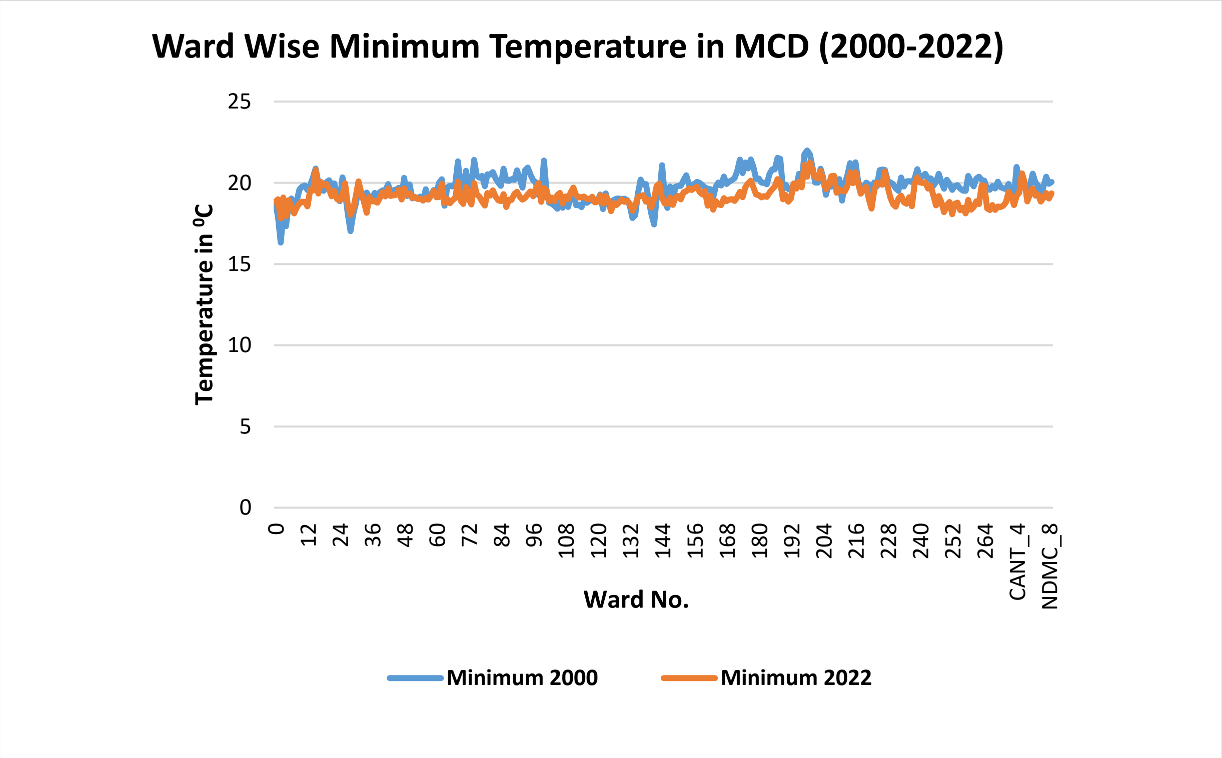


Fig 2.1.2: Spatial Variation of LST over MCD in 2022

It can be seen that from 2022, the overall spatial distribution of LST was generally high in the southern, eastern and central regions, while low in the northern, western, eastern regions in Municipal corporation of Delhi (Fig2.1.2). The high value areas (LST 40.26°C) were mainly distributed scattered in the central part and south east part of the MCD. This regions have flat terrain, obvious urban expansion, large human disturbance and prominent social and economic development. The low value areas (LST -3.48°C) were mainly distributed in the northern and western part of the MCD. These areas have wide water coverage, dence cropland , weak human activities with small urban areas. Landscape pattern, biophysical parameters and anthropogenic urban growth forces have significant effects on determining minimum land surface temparature in MCD.



The ward wise figure for 2000 depicts that the minimum LST in a very few wards was above 20°C, which has substantially decreased in 2022.

2.2 LST Median of 2000 & 2022:

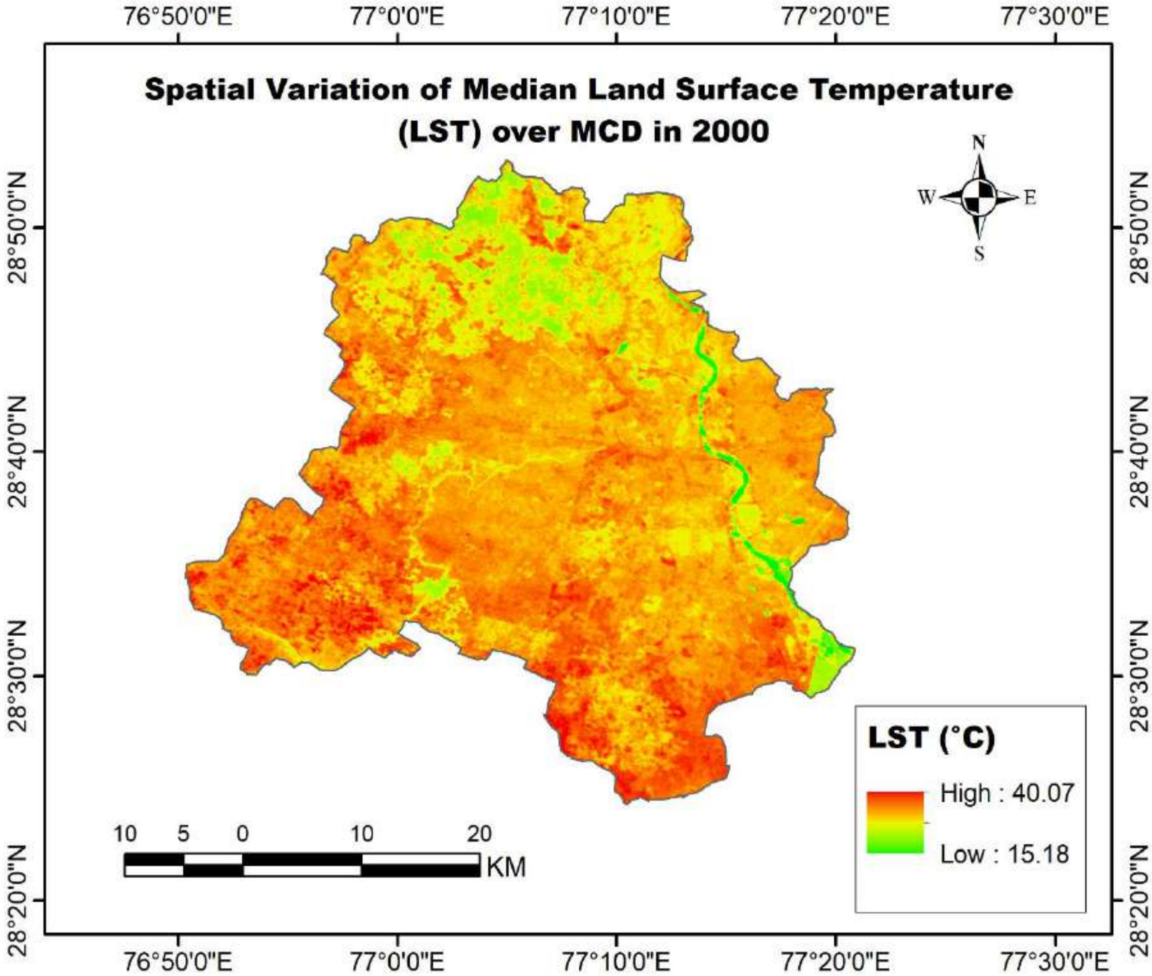


Fig 2.2.1: Spatial Variation of Median LST over in 2000

It can be seen that from 2000, the overall spatial distribution of LST was generally high in the overall MCD regions, while low in the northern and some parts of south-eastern regions in Municipal corporation of Delhi (Fig 2.2.1). The high value areas (LST 40.07°C) were mainly distributed in the overall part of the MCD. This regions have flat terrain, obvious urban expansion, large human disturbance and prominent social and economic development. The low value areas (LST 15.18°C) were mainly distributed in the northern part of the MCD. These areas have wide water coverage, dence cropland , weak human activities with small urban areas.

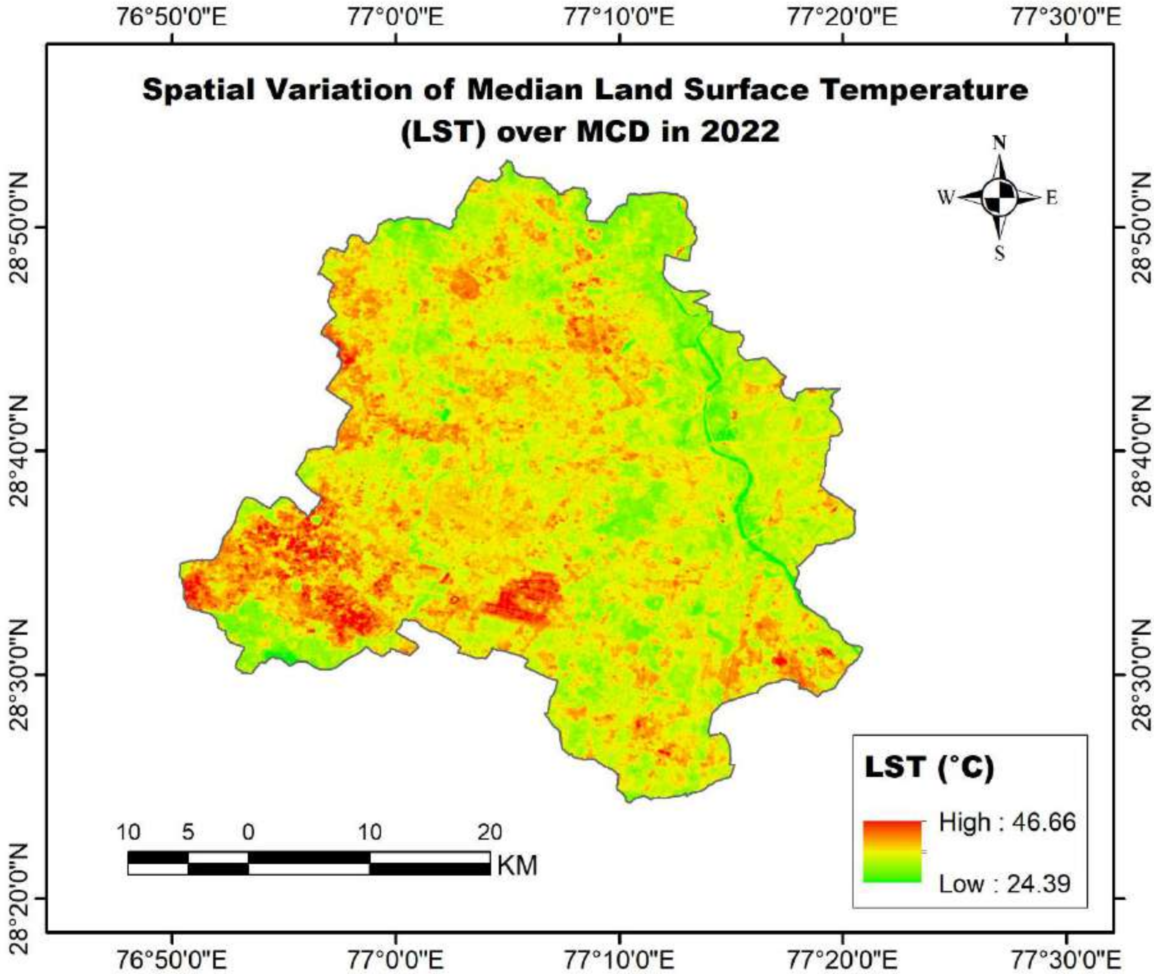
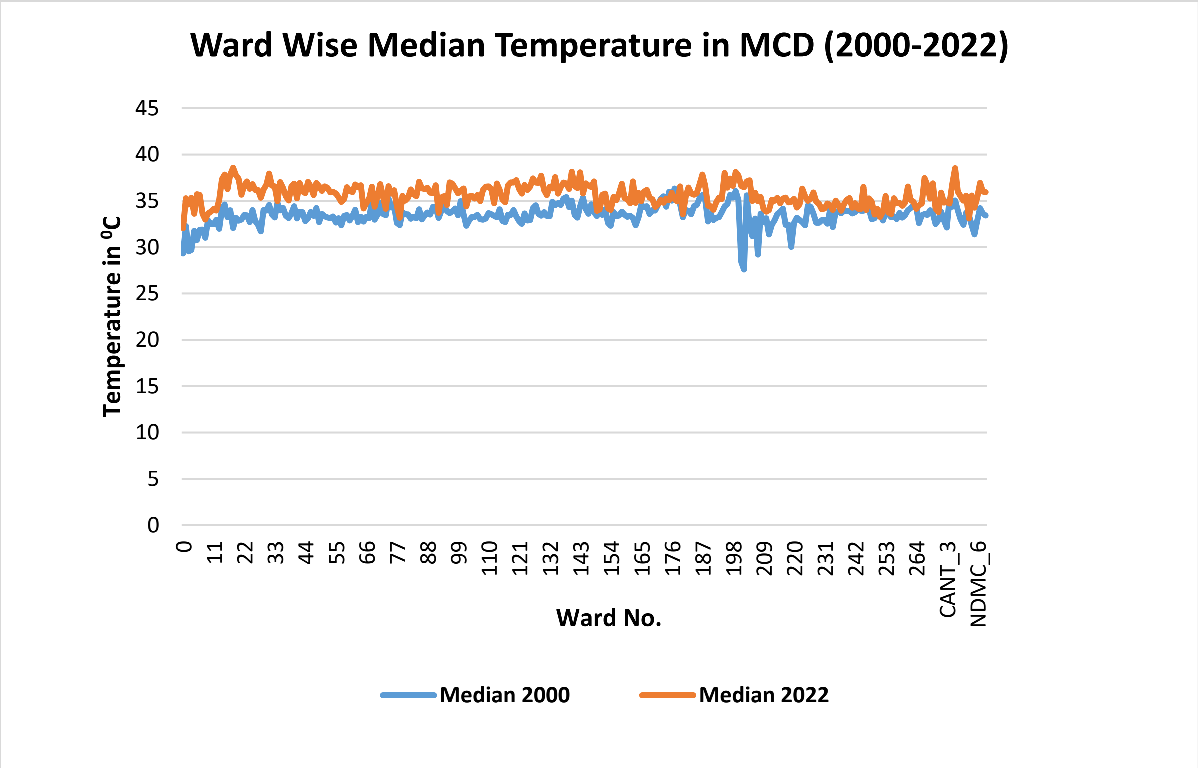


Fig 2.2.2: Spatial Variation of Median LST over MCD in 2022

It can be seen that from 2022, the overall spatial distribution of LST was generally high in the western,some part of the northern and south eastern regions, while low in the eastern, southern and some part of the western part of the regions in Municipal corporation of Delhi (Fig2.2.2). The high value areas (LST 46.66°C) were mainly distributed scattered in the central part and south-west and north-west part of the MCD. This regions have flat terrain, obvious urban expansion, large human disturbance and prominent social and economic development. The low value areas (LST 24.39°C) were mainly distributed in the northern and western part of the MCD. These areas have wide water coverage, dence cropland , weak human activities with small urban areas. Landscape pattern, biophysical parameters and anthropogenic urban growth forces have significant effects on determining minimum land surface temparature in MCD.



The ward wise figure for 2000 depicts that the Median LST in a few wards was above 35°C, which has substantially increased in 2022.

2.3 LST Maximum of 2000 & 2022:

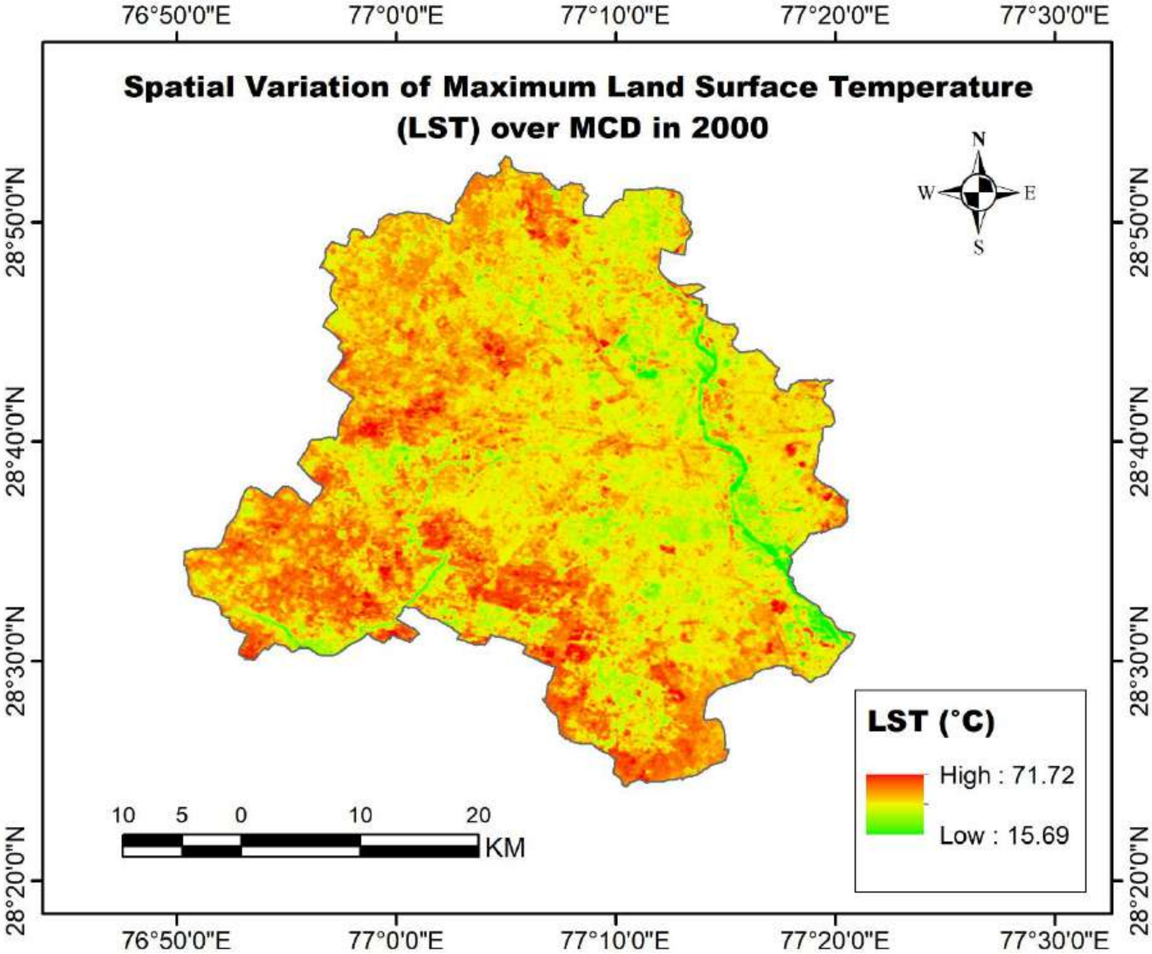


Fig 2.3.1: Spatial Variation of Maximum LST over MCD in 2000

It can be seen that from 2000, the overall spatial distribution of LST was generally high in the north-west,western and south-west regions, while low in the nort-east parts and south-eastern regions in Municipal corporation of Delhi (Fig 2.3.1). The high value areas (LST 71.72°C) were mainly distributed in the overall part of the MCD. This regions have flat terrain, obvious urban expansion, large human disturbance and prominent social and economic development. The low value areas (LST 15.69°C) were mainly distributed in the north-eastrrn part of the MCD. These areas have wide water coverage, dence cropland , weak human activities with small urban areas.

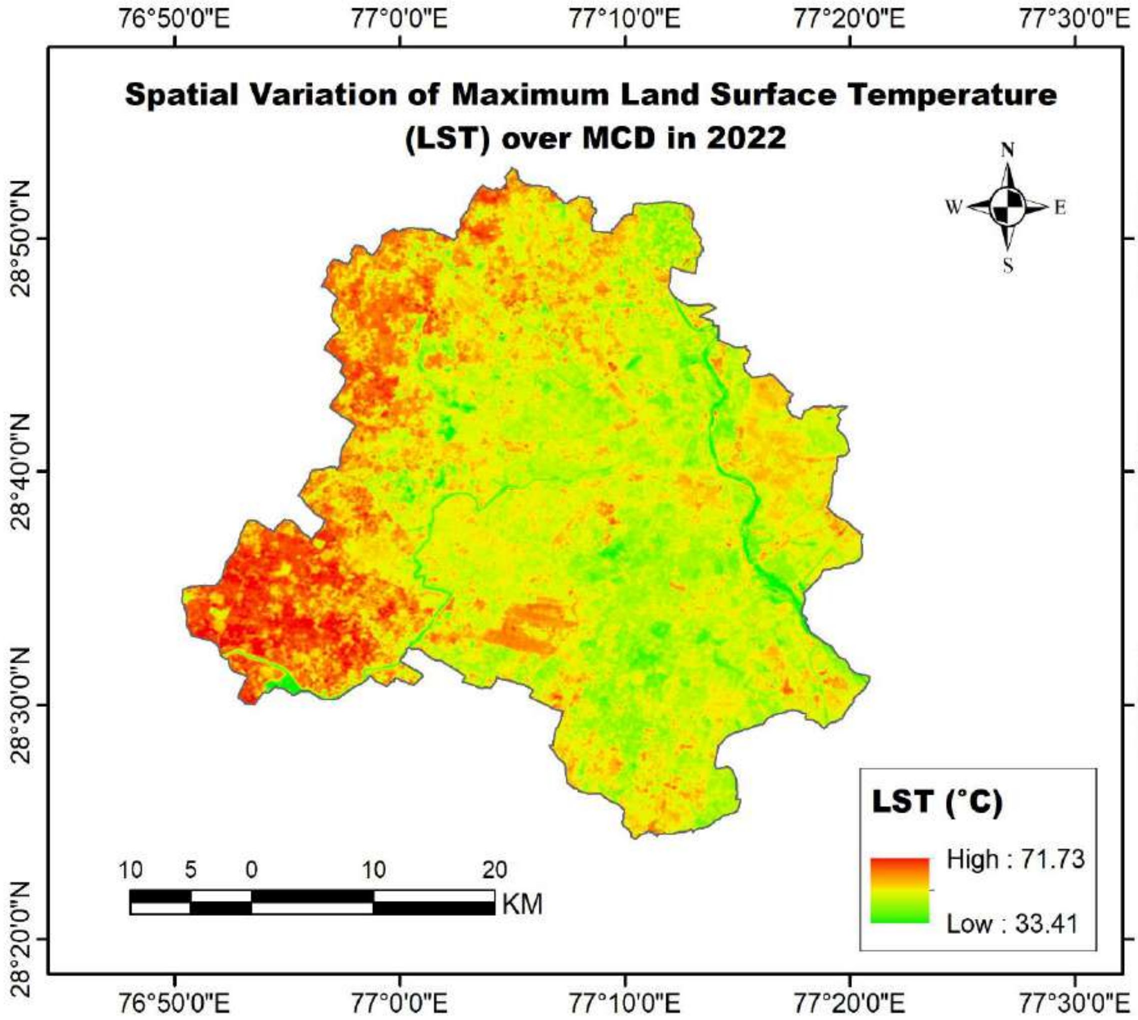
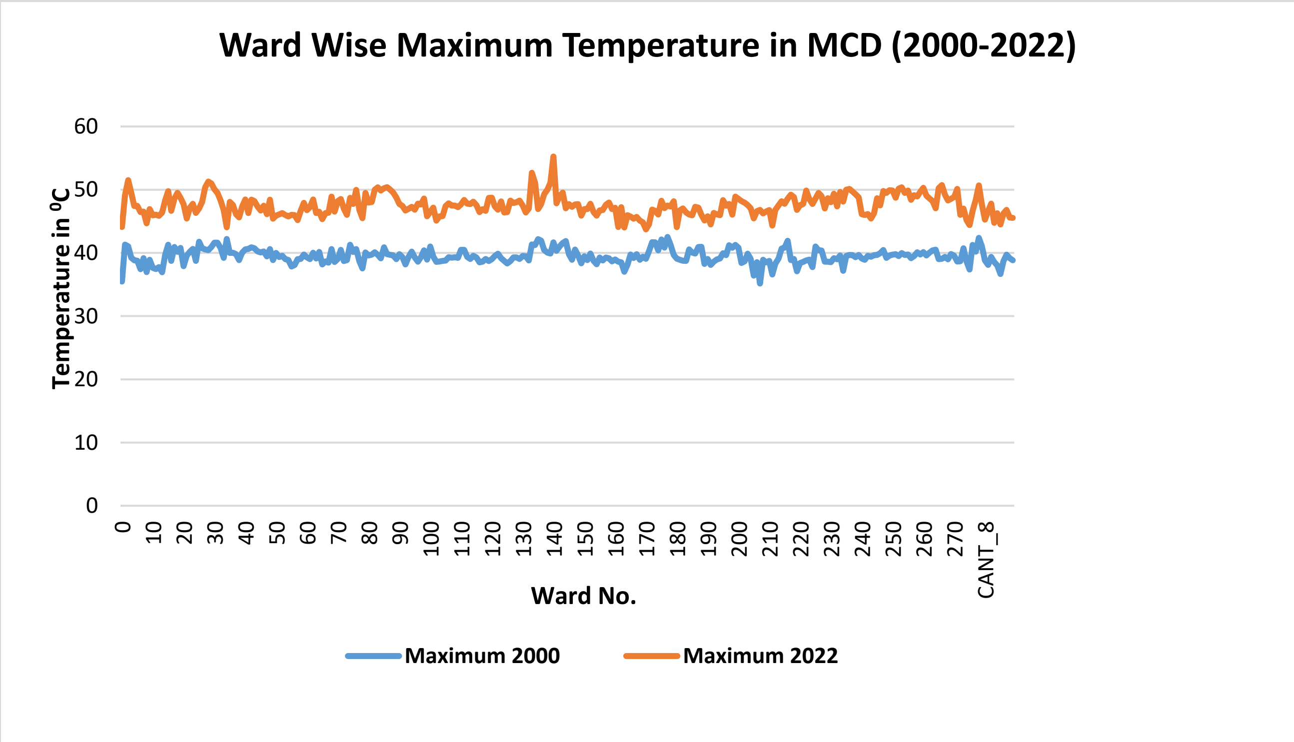


Fig 2.3.2: Spatial Variation of Maximum LST over MCD in 2022

The following map represents spatial variation of maximum LST over MCD in the year of 2022. Land surface temperature of the MCD ranges from 33.41°C to 71.73°C. The north-western and south-western part of the MCD has higher temperature due to urbanization and human disturbance, while central, north-eastern and eastern, south and south-eastern part of the MCD has lower temperature due to the wide water coverage, vegetation and weak human activities with small urban areas. There for it is clear from Fig 2.3.2.



The ward wise figure for 2000 depicts that the Maximum LST in a few wards was above 40°C, which has substantially increased in 2022, temperature was 50°C.

2.4 Minimum LST Difference (2000-2022):

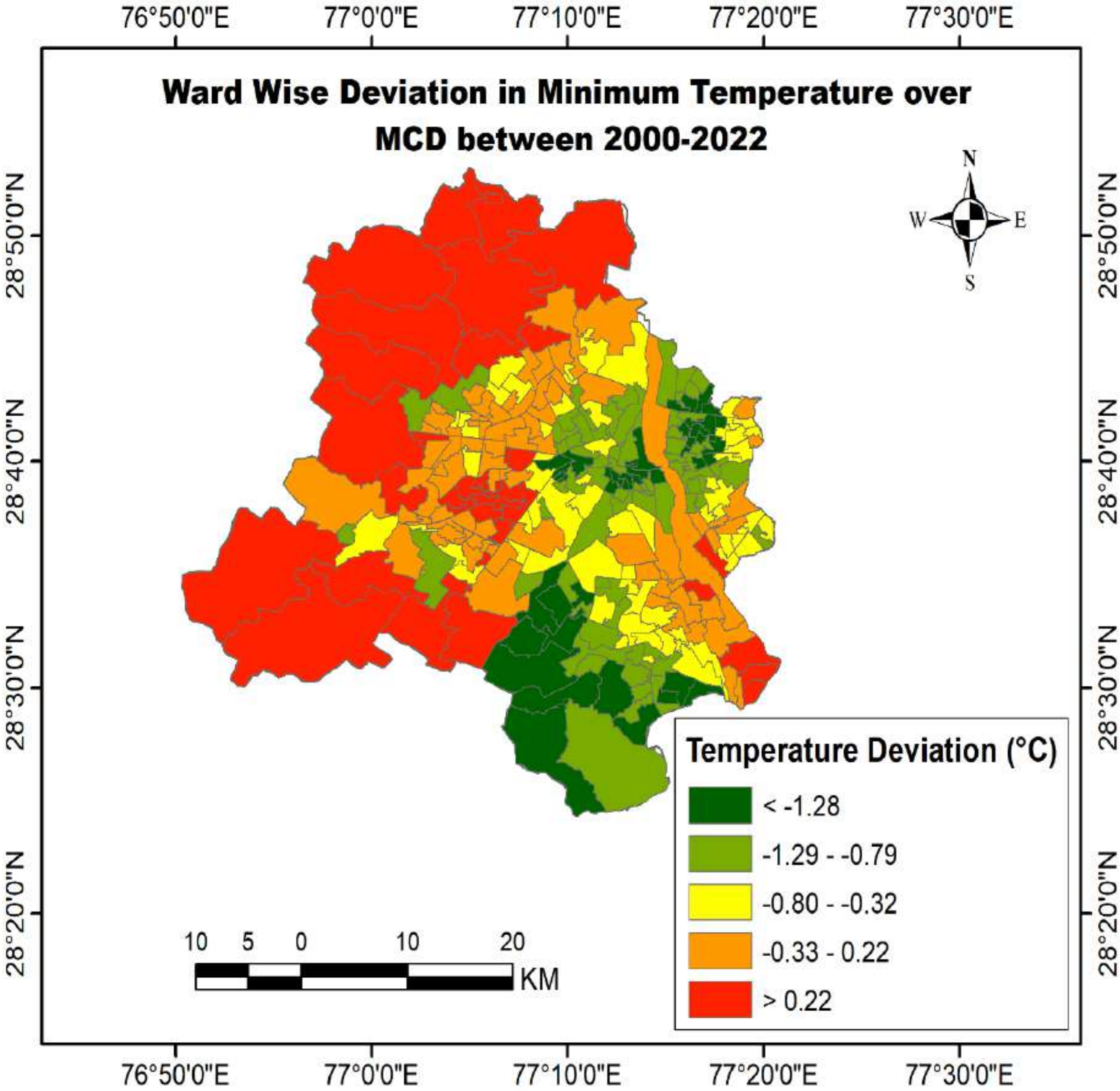
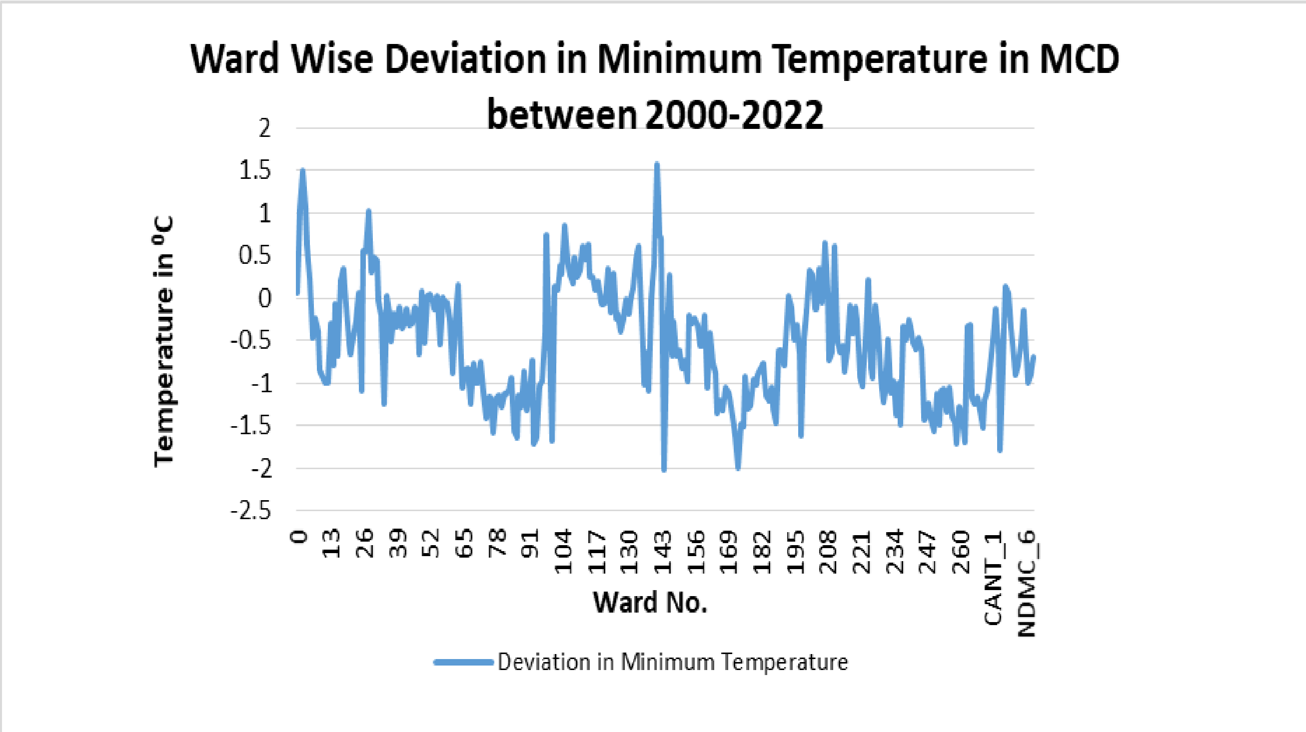


Fig 2.4.1: Ward wise deviation in Minimum Temparature over MCD between 2000-2022

The following map represents the ward wise deviation in minimum temparature over MCD between 2000-2023. From the figure 2.4.1 shows that the highest tempareture is north and south-west in part of the MCD due to the over build-up, bare soil and fello land and low values observed over water body, forest and open space with grass. If we concentrate on urban built-up area which is mainly combine of residencial area and industrial area is showing much higher minimun temparature.


Ward Wise Deviation in Minimum Temperature in MCD between 2000-2022
Temperature in ⁰C
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
0
13
26
39
52
65
78
91
104
117
130
143
156
169
182
195
208
221
234
247
260
CANT_1
NDMC_6
Ward No.
Deviation in Minimum Temperature

2.5 Median LST Difference (2000-2022):

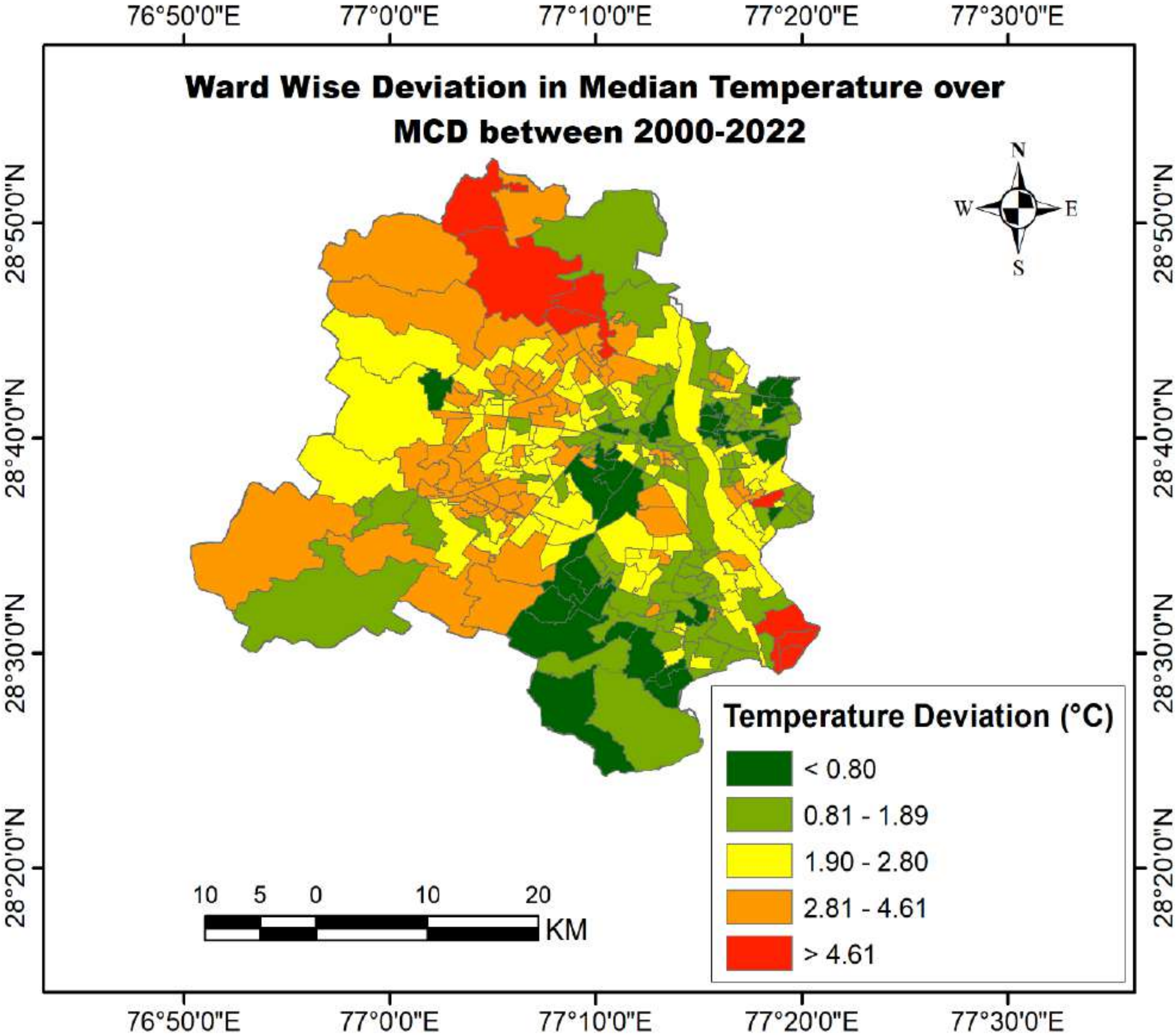
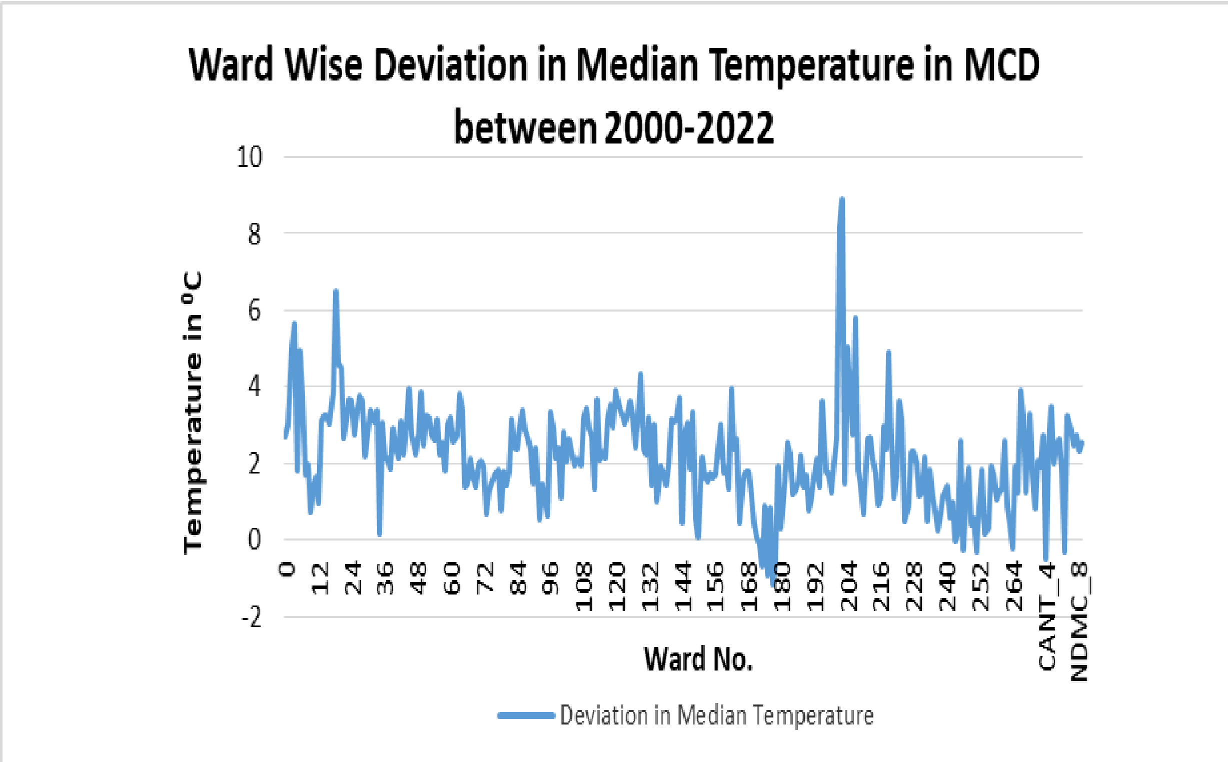


Fig 2.5.1: Ward wise deviation in Median Temperature over MCD between 2000-2022

The following map represents the ward wise deviation in median temparature over MCD between 2000-2023. From the figure 2.5.1 shows that the highest tempareture is some of the ward in north side of the MCD due to the over build-up, bare soil and fello land and low values observed central part of the MCD over water body, forest and open space with grass.


Ward Wise Deviation in Median Temperature in MCD between 2000-2022
10
8
6
4
2
0
-2
Temperature in °C
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
192
204
216
228
240
252
264
CANT_4
NDMC_8
Ward No.
Deviation in Median Temperature

2.6 Maximum LST Difference (2000-2022):

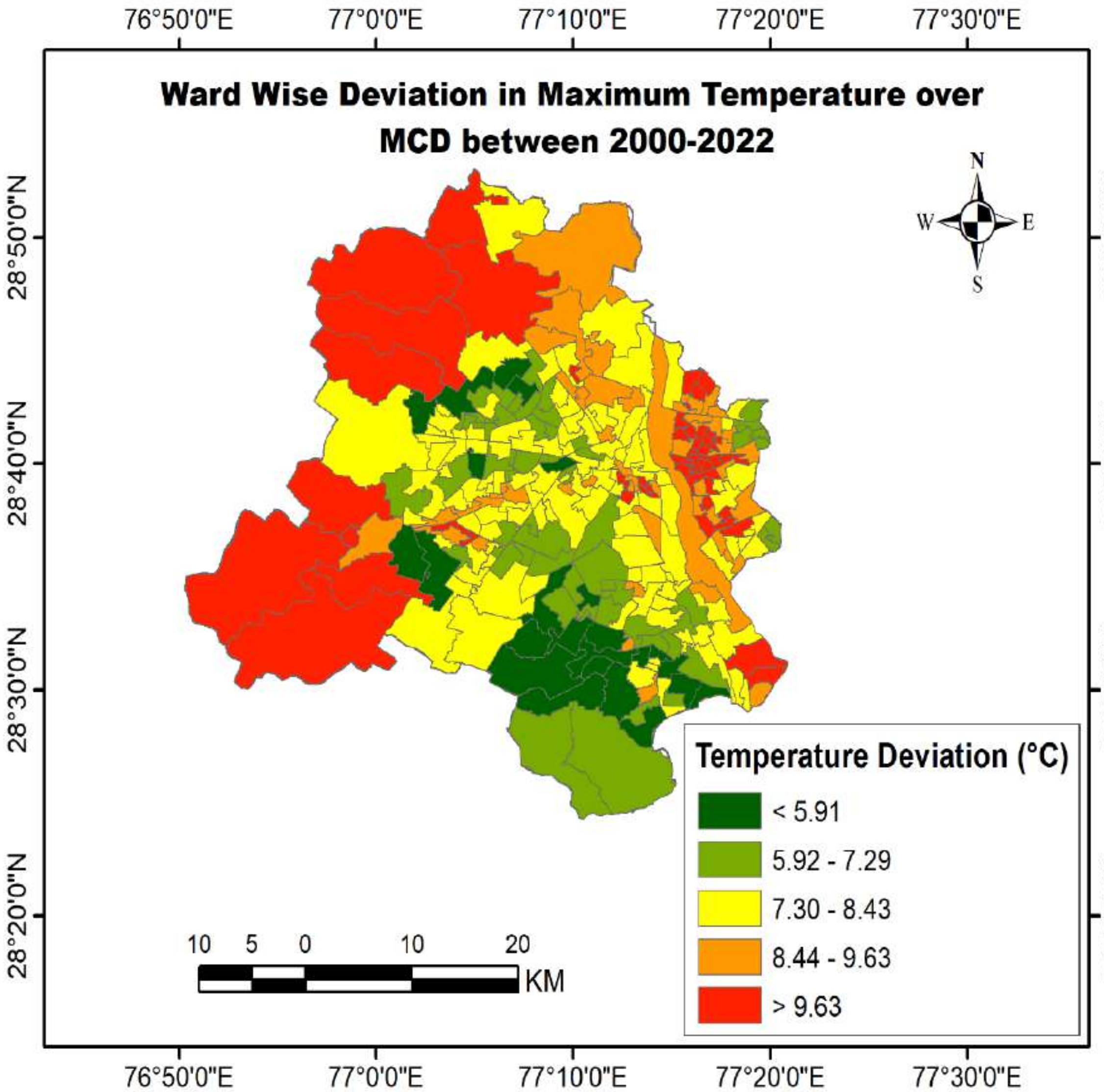
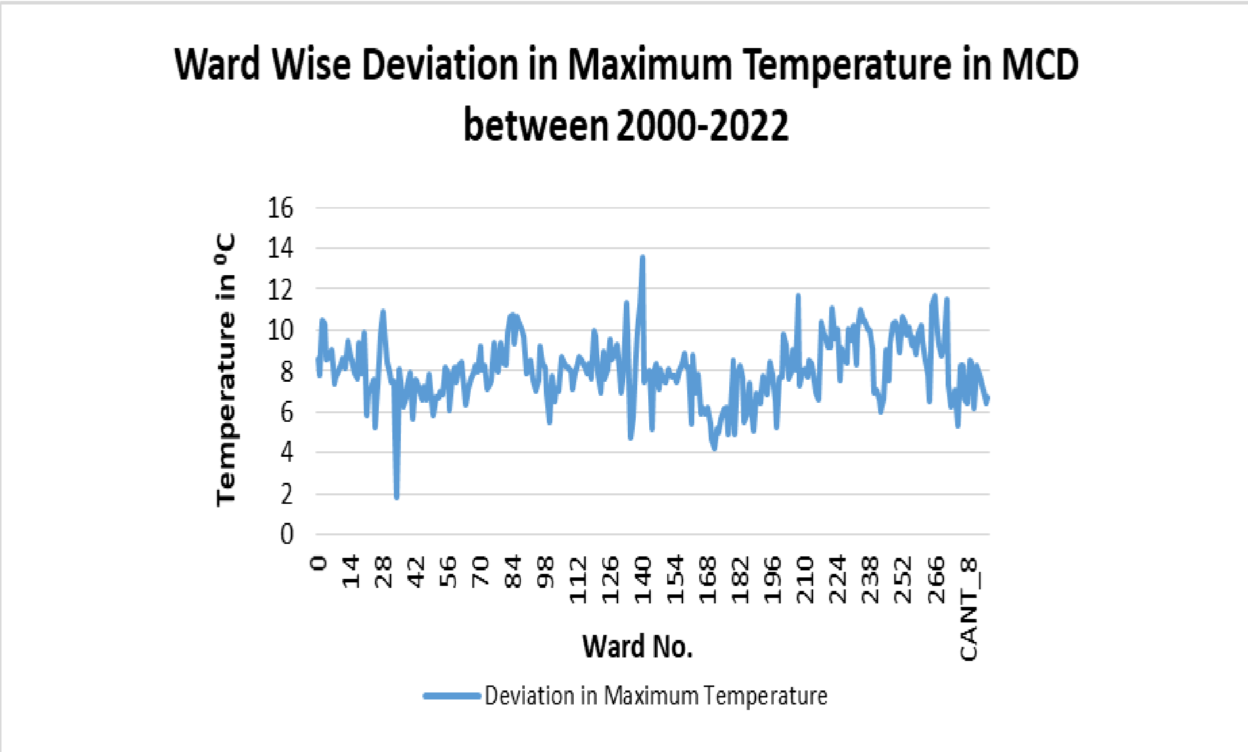


Fig 2.6.1: Ward wise deviation in Maximum Temperature over MCD between 2000-2022

The following map represents the ward wise deviation in maximum temparature over MCD between 2000-2023. From the figure 2.6.1 shows that the highest tempareture is some of the ward in north and west side of the MCD due to the over build-up, bare soil and fello land and low values observed central part of the MCD over water body, forest and open space with grass.


Ward Wise Deviation in Maximum Temperature in MCD between 2000-2022
Temperature in ºC
16
14
12
10
8
6
4
2
0
0
14
28
42
56
70
84
98
112
126
140
154
168
182
196
210
224
238
252
266
CANT_8
Ward No.
Deviation in Maximum Temperature

MAJOR FINDINGS

In the present study Land surface temparature dynamics have been studied in Municipal Corporation of Delhi. LST dynamic analysis include LST minimum, median and maximum in 2000 & 2022 and minimum, median & maximum LST differences 2000-2022. The studied anthropogenic parameters comprise LULC dynamics, LST dynamics analysis. All the parameters and analysis performed well. The major findings of the present study are listed below,

- It can be seen that from 2000, the overall spatial distribution of minimum LST was generally high in the southern, eastern and central regions, while low in the northern, western, south-west regions in Municipal corporation of Delhi. It can be seen that from 2022, the overall spatial distribution of LST was generally high in the southern, eastern and central regions, while low in the northern, western, eastern regions in Municipal corporation of Delhi.
- It can be seen that from 2000, the overall spatial distribution of median LST was generally high in the overall MCD regions, while low in the northern and some parts of south-eastern regions in Municipal corporation of Delhi. It can be seen that from 2022, the overall spatial distribution of LST was generally high in the western,some part of the northern and south eastern regions, while low in the eastern, southern and some part of the western part of the regions in Municipal corporation of Delhi.
- It can be seen that from 2000, the overall spatial distribution of LST was generally high in the north-west,western and south-west regions, while low in the nort-east parts and south-eastern regions in Municipal corporation of Delhi. Land surface temperature of the MCD ranges from 33.41°C to 71.73°C. The north-western and south-western part of the MCD has higher temperature and central, north-eastern and eastern, south and south-eastern part of the MCD has lower temperature.
- The following map represents the ward wise deviation in minimum temparature over MCD between 2000-2023. From the figure 2.4.1 shows that the highest tempareture is north and south-west in part of the MCD due to the over build-up, bare soil and fello land and low values observed over water body, forest and open space with grass.
- The following map represents the ward wise deviation in median temparature over MCD between 2000-2023. From the figure 2.5.1 shows that the highest tempareture is

some of the ward in north side of the MCD due to the over build-up, bare soil and fello land and low values observed central part of the MCD over water body, forest and open space with grass.

- The following map represents the ward wise deviation in maximum temparature over MCD between 2000-2023. From the figure 2.6.1 shows that the highest tempareture is some of the ward in north and west side of the MCD due to the over build-up, bare soil and fello land and low values observed central part of the MCD over water body, forest and open space with grass.

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