RESEARCH ARTICLE

A QGIS Grid-Based Study to Understand the Relationship Between Land Surface Temperature and Greenness in Urban Areas

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Abstract

This study is an attempt to understand the relationship between greenness and land surface temperature using a specific QGIS plugin. The city is divided into equally sized grids, and temperature and NDVI values are obtained from the centre of each grid. Before that, the NDVI and LST maps are reclassified using QGIS. The result shows that although there is a general declining trend of temperature with greenness, the trend is not statistically significant.

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Introduction

Many studies worldwide are suggesting that the surface temperature in urban areas depends on vegetation. Although there are studies that indicate different factors affecting this relationship, such as elevation, built-up area, climate change, etc., the present work is an attempt to understand the relationship between these two factors in Delhi. For that, a remote sensing method using a Landsat image is applied. QGIS has a plugin named RSGIS, which is effective in calculating the land surface temperature and NDVI and is being used for this study. The entire region is divided into equal-sized grids, and the geometrical centroid of these grids is considered a sampling site. From these sampling sites, both the LST and NDVI values are noted and are correlated with simple statistics. The LST and NDVI maps were reclassified using the Raster calculator method provided in QGIS.

Methodology

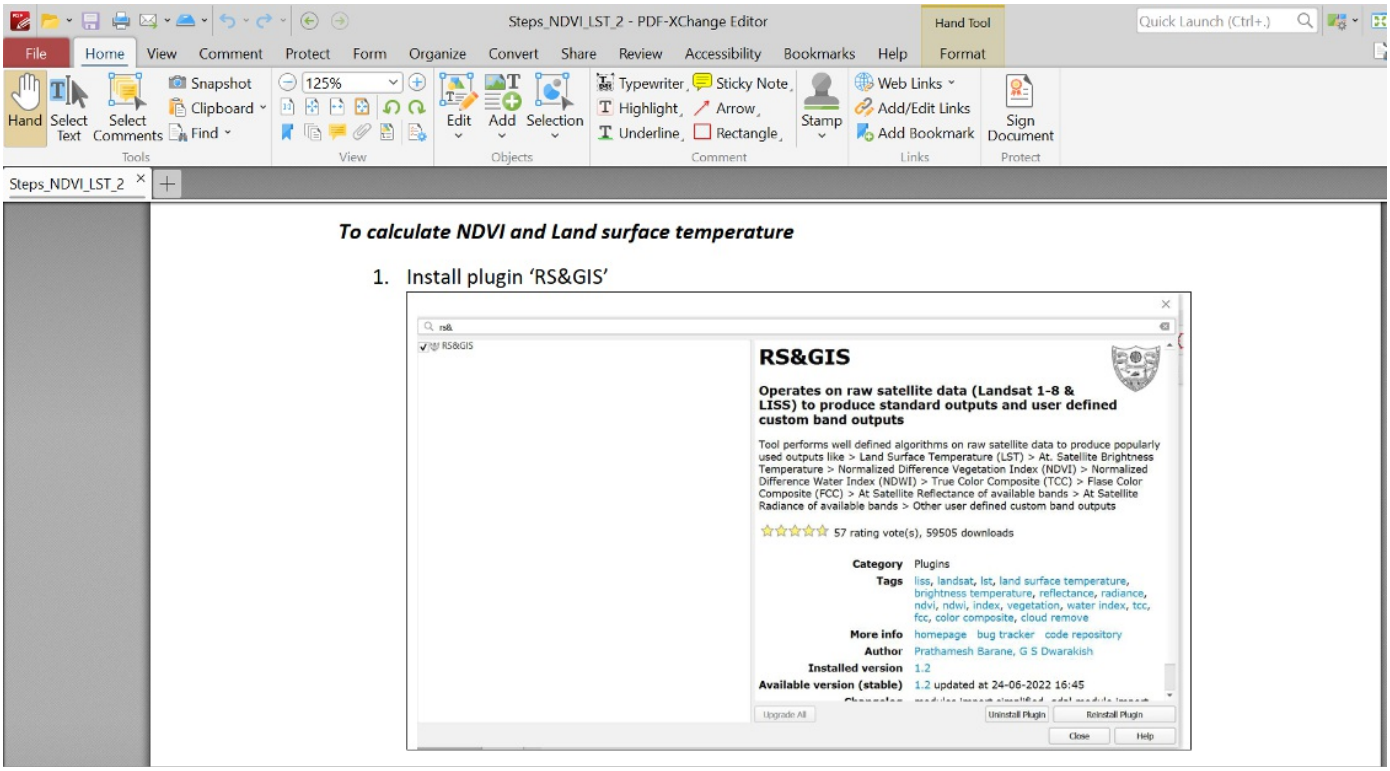
Landsat image

A Landsat image is used in this study. The details of the image are as follows:

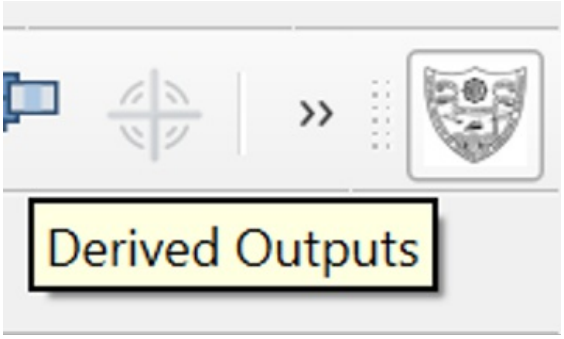
Scene number: LC81460402020089LGN00; SPACECRAFT_ID = "LANDSAT_8"; NUMBER_OF_BANDS = 11; BAND_LIST = (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11); GROUP = PROJECTION; ELLIPSOID_AXES = (6378137.000000, 6356752.314200); MAP_PROJECTION = "UTM"; PROJECTION_UNITS = "METERS"; DATUM = "WGS84"; ELLIPSOID = "WGS84"; EPHEMERIS_EPOCH_YEAR = 2020; EPHEMERIS_EPOCH_DAY = 089; EPHEMERIS_EPOCH_SECONDS = 19088.716065; DATA_TYPE = "L1TP"; COLLECTION_CATEGORY = "T1"; ELEVATION_SOURCE = "GLS2000"; OUTPUT_FORMAT = "GEOTIFF"; SPACECRAFT_ID = "LANDSAT_8"; SENSOR_ID = "OLI_TIRS"; WRS_PATH = 146; WRS_ROW = 40; NADIR_OFFNADIR = "NADIR"; TARGET_WRS_PATH = 146; TARGET_WRS_ROW = 40; DATE_ACQUIRED = 2020-03-29; SCENE_CENTER_TIME = "05:18:34.6911930Z"

Calculation of Land surface temperature and NDVI

1. Install the plugin ‘RSGIS’



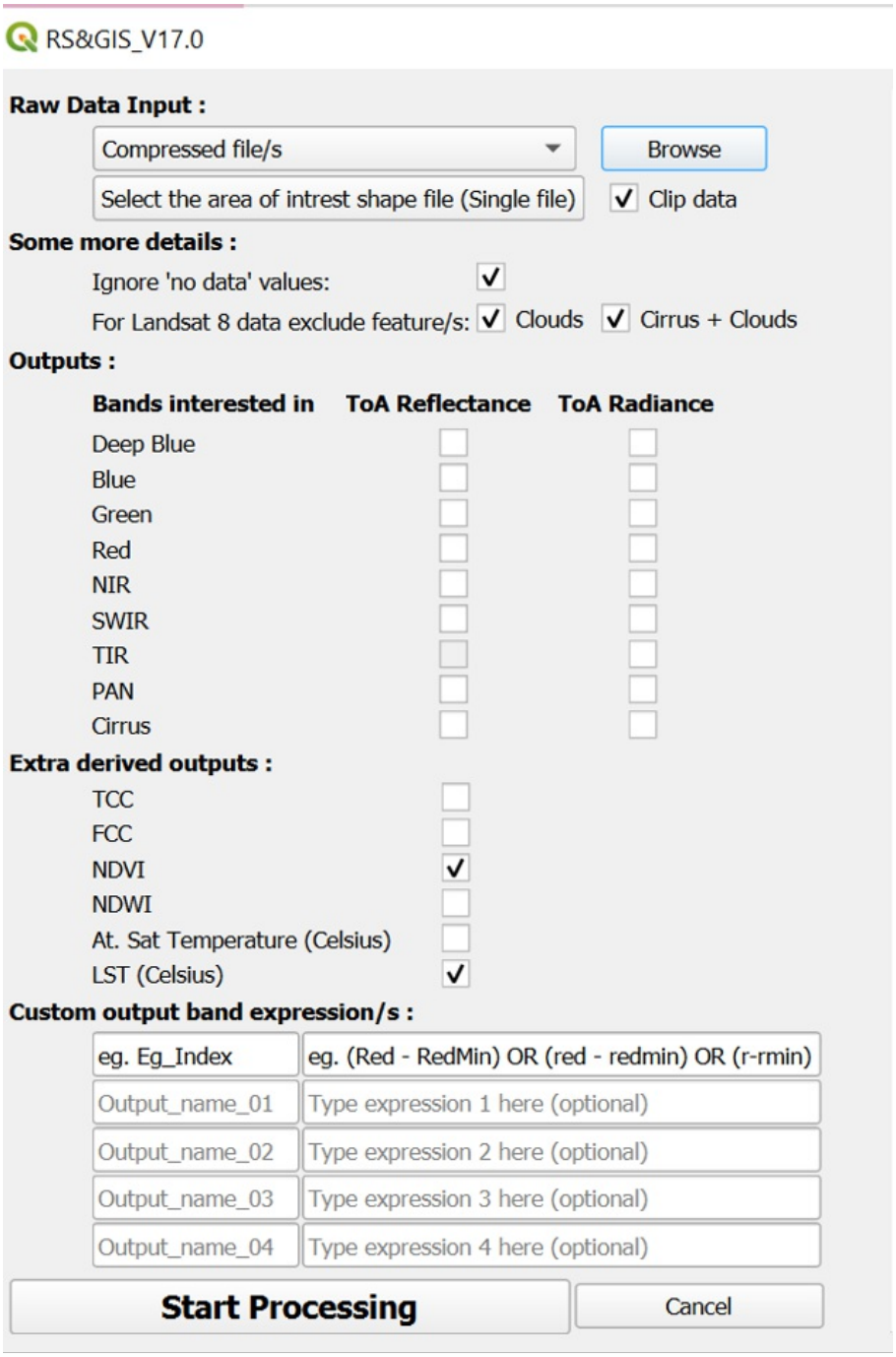
2. Click ‘Derived Outputs’



a. Fill in the following

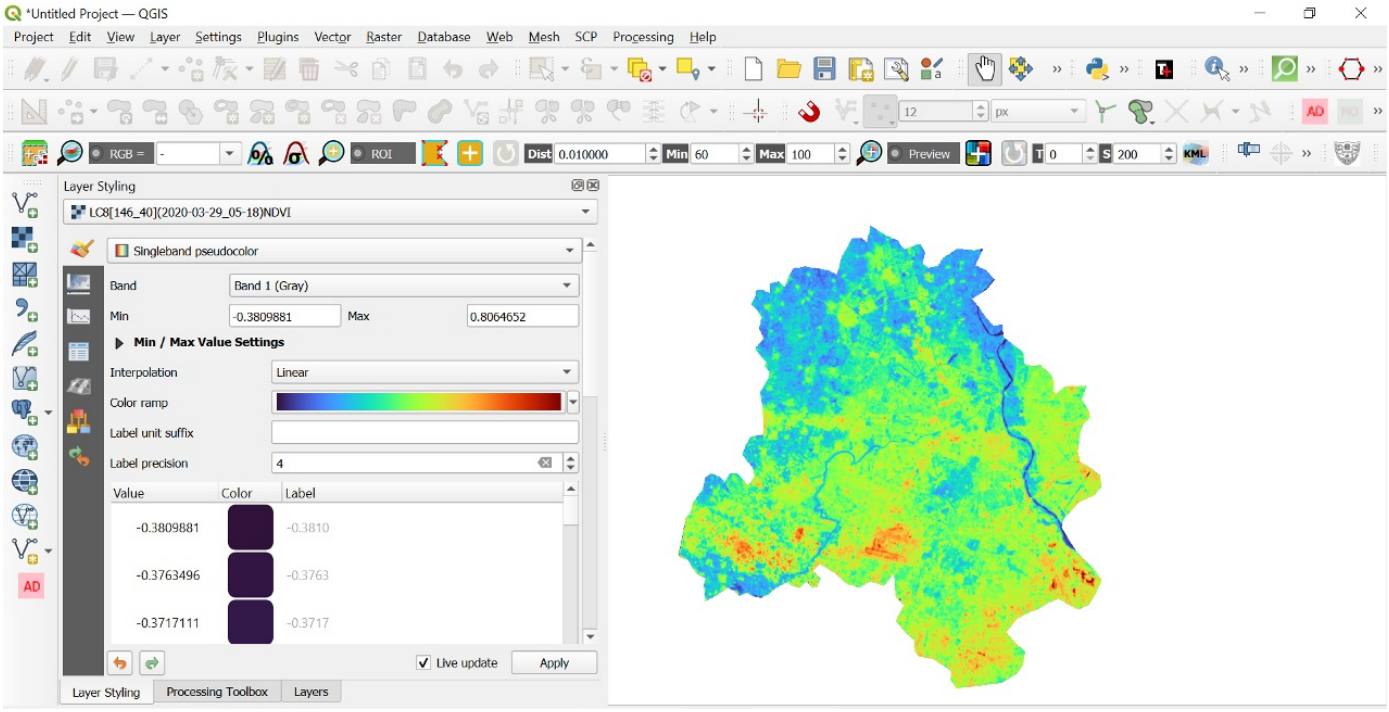
   i. Under ‘Raw Data Input’:
   ii. ‘Compressed file/s’ – Select the Landsat8 TAR file supplied separately (LC08_L1TP_146040_20200329_20200409_01_T1.tar)
   iii. ‘Under Select the area of interest shape file (Single file)’ – Select the Delhi Shape file provided earlier

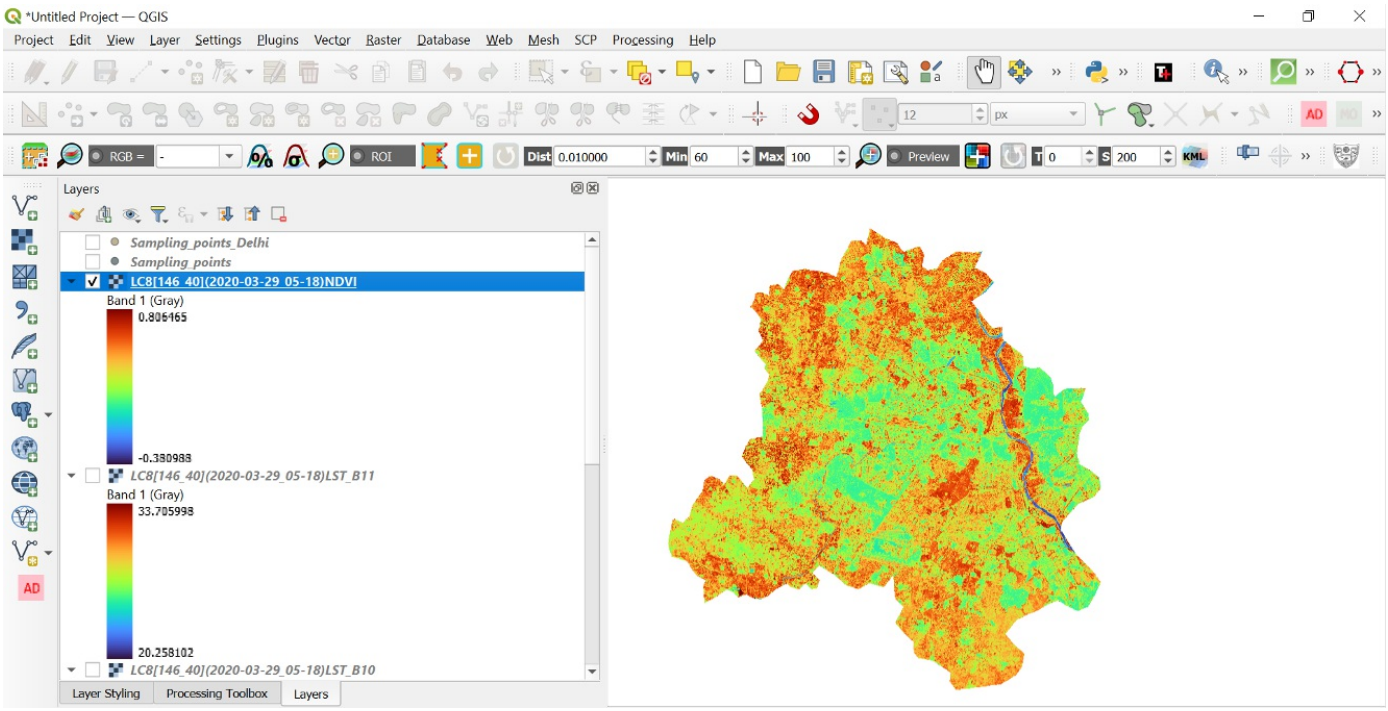
b. Ignore the no data value – Check the box
c. For Landsat8 Data exclude – Check the Clouds and Cirrus clouds box
d. Check the box NDVI and LST (Celsius) under ‘Extra derived outputs:’
e. Click Start Processing



3. Three folders will be created, where the ‘Output’ folder consists of images of Land surface temperature and NDVI

4. Open the NDVI and LST maps from the ‘Output’ Folder





5. Open the NDVI and LST maps from the ‘Output’ Folder

6. Now extract Delhi_NDVI and Delhi_LST using the Delhi shape file

a. Raster – Extraction – Clip Raster by Mask Layer (this is required if not clipped earlier)

Analysing the relation between temperature and Greenness variables in Delhi

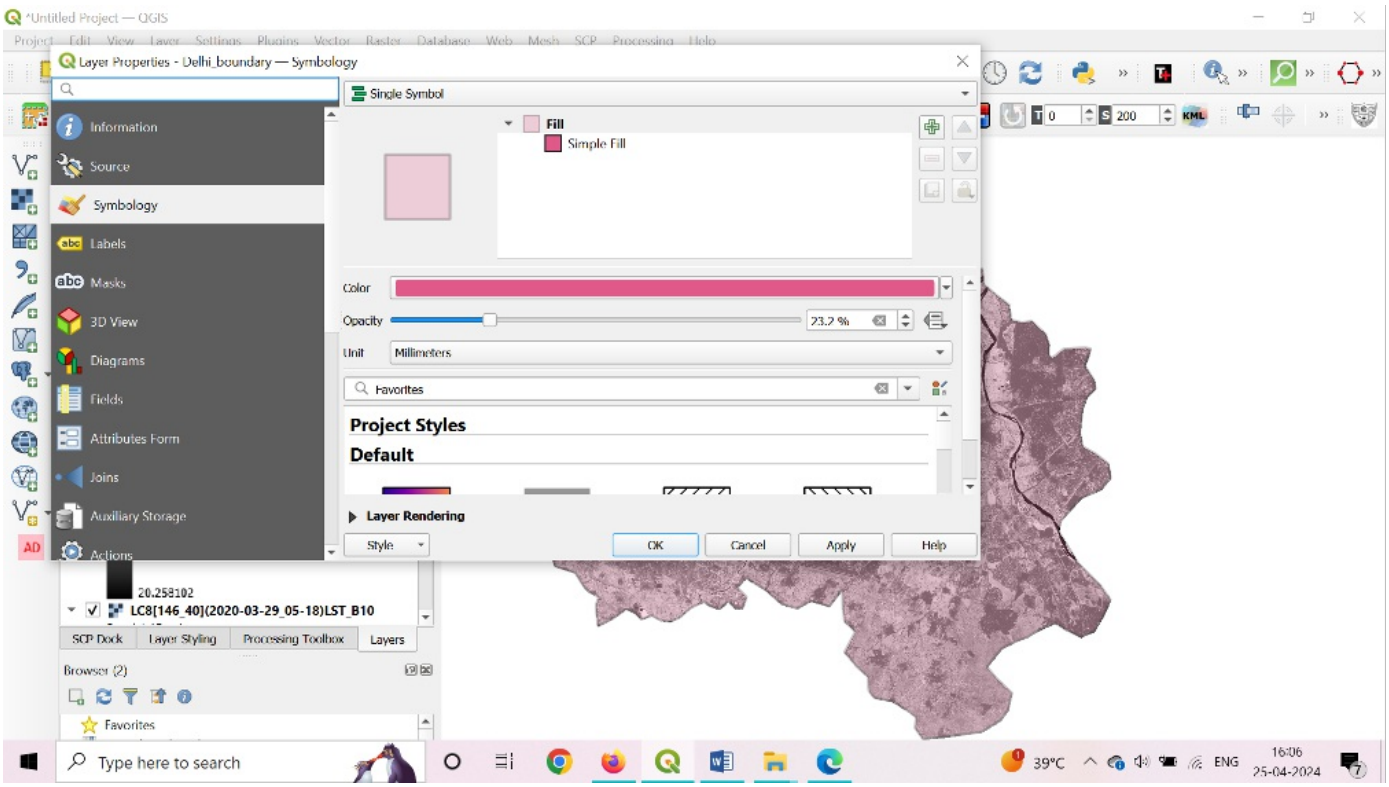
1. Open the files

a. Open Delhi Shape file, Delhi NDVI, Delhi LST

2. We will compare the relationship between urban green space and the land surface temperature. For that, we will create sampling points (for the two variables)

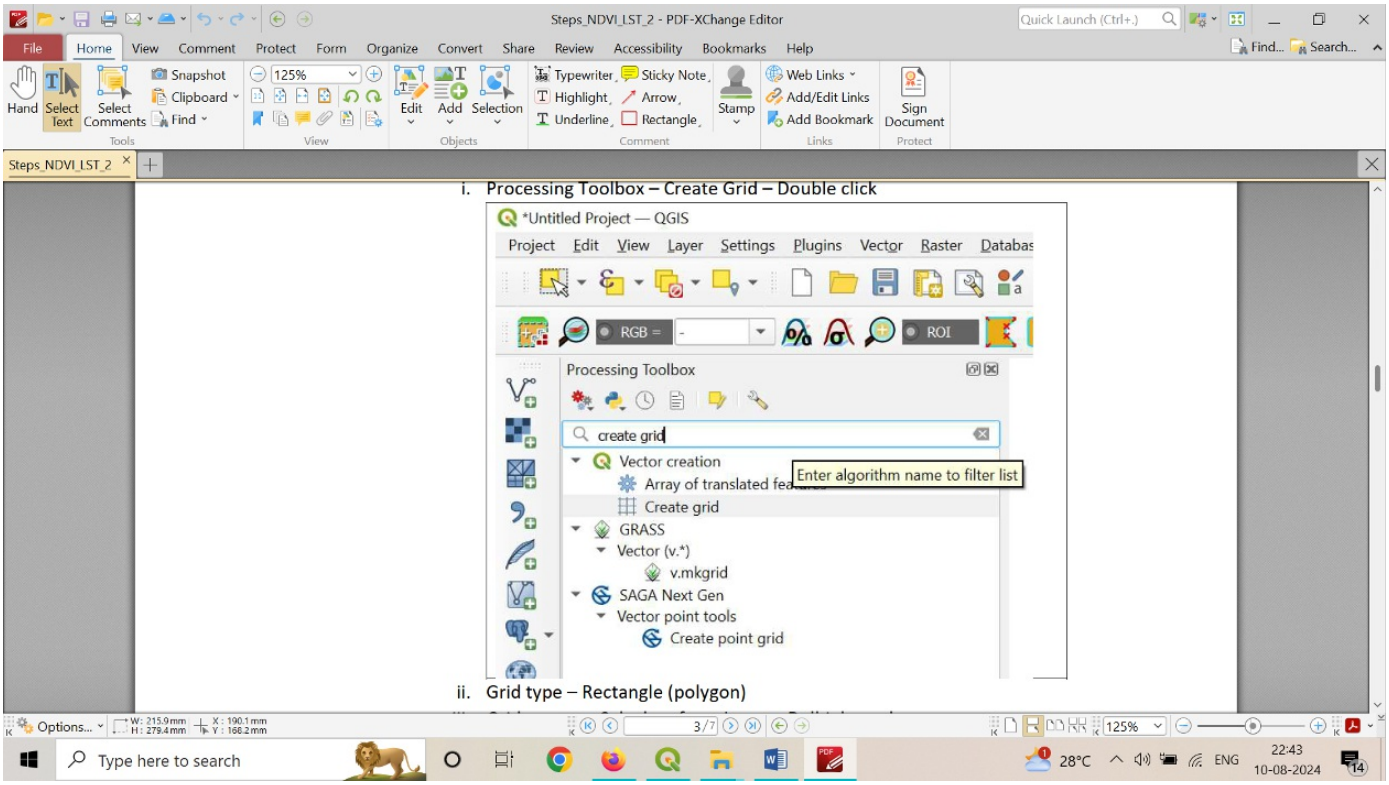
3. Create sampling points (for the two variables)

a. Make the Delhi shape file transparent (Reduce the opacity through symbology)



b. Create Grid

i. Processing Toolbox – Create Grid – Double click



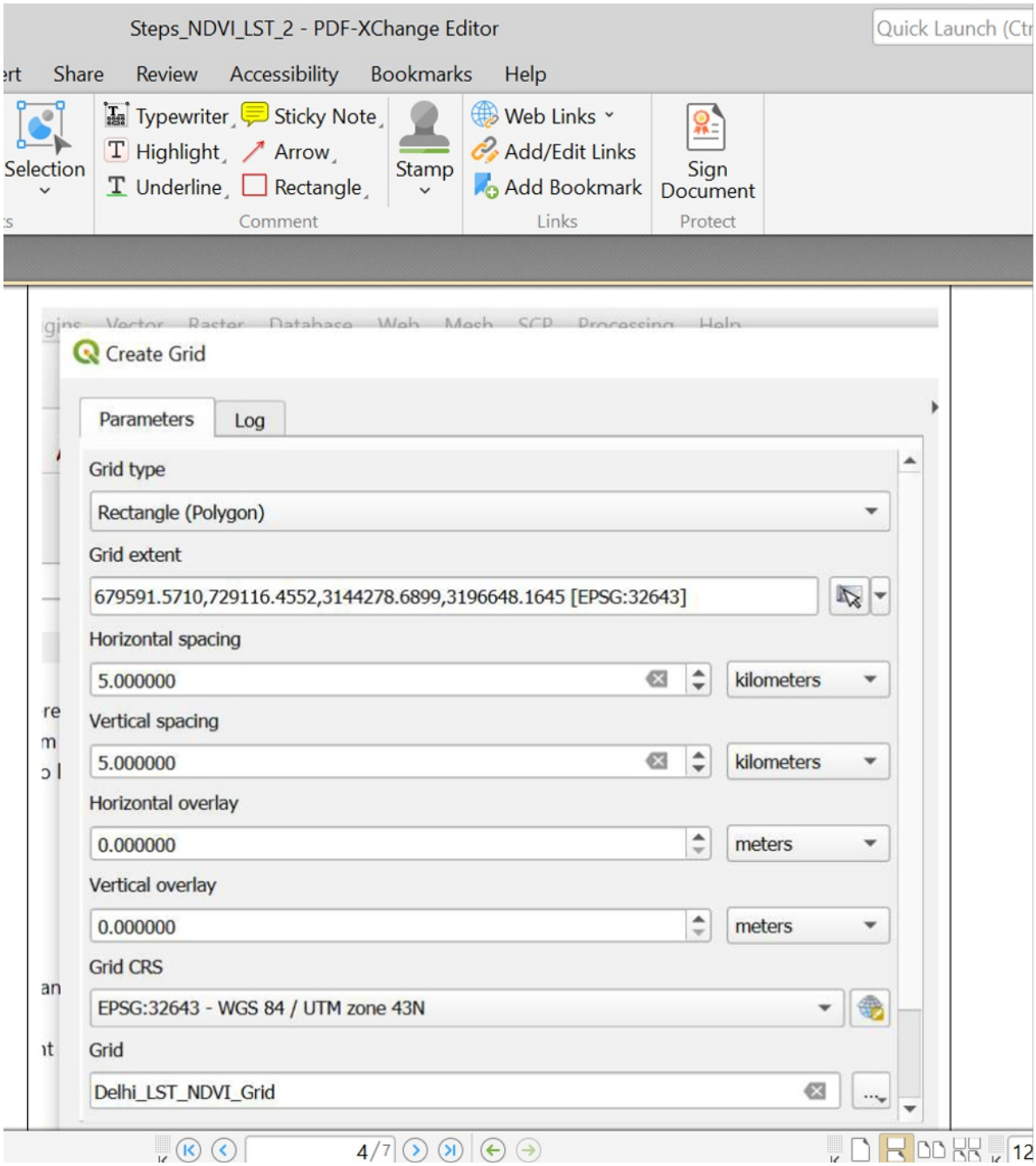
ii. Grid type – Rectangle (polygon)

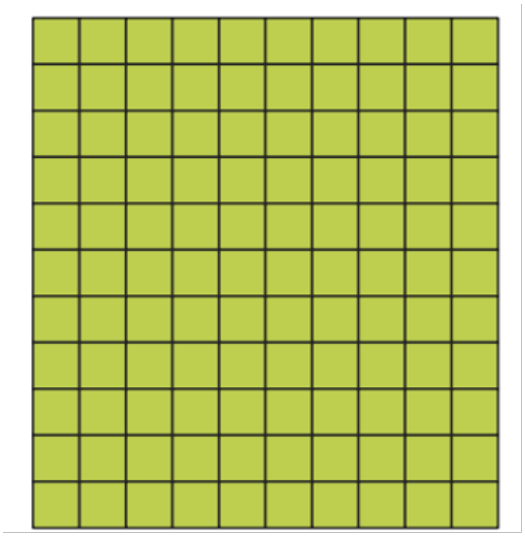
iii. Grid extent – Use layer extent

iv. Horizontal spacing – 5 km

v. Vertical spacing – 5 km

vi. Grid – Save it in a folder

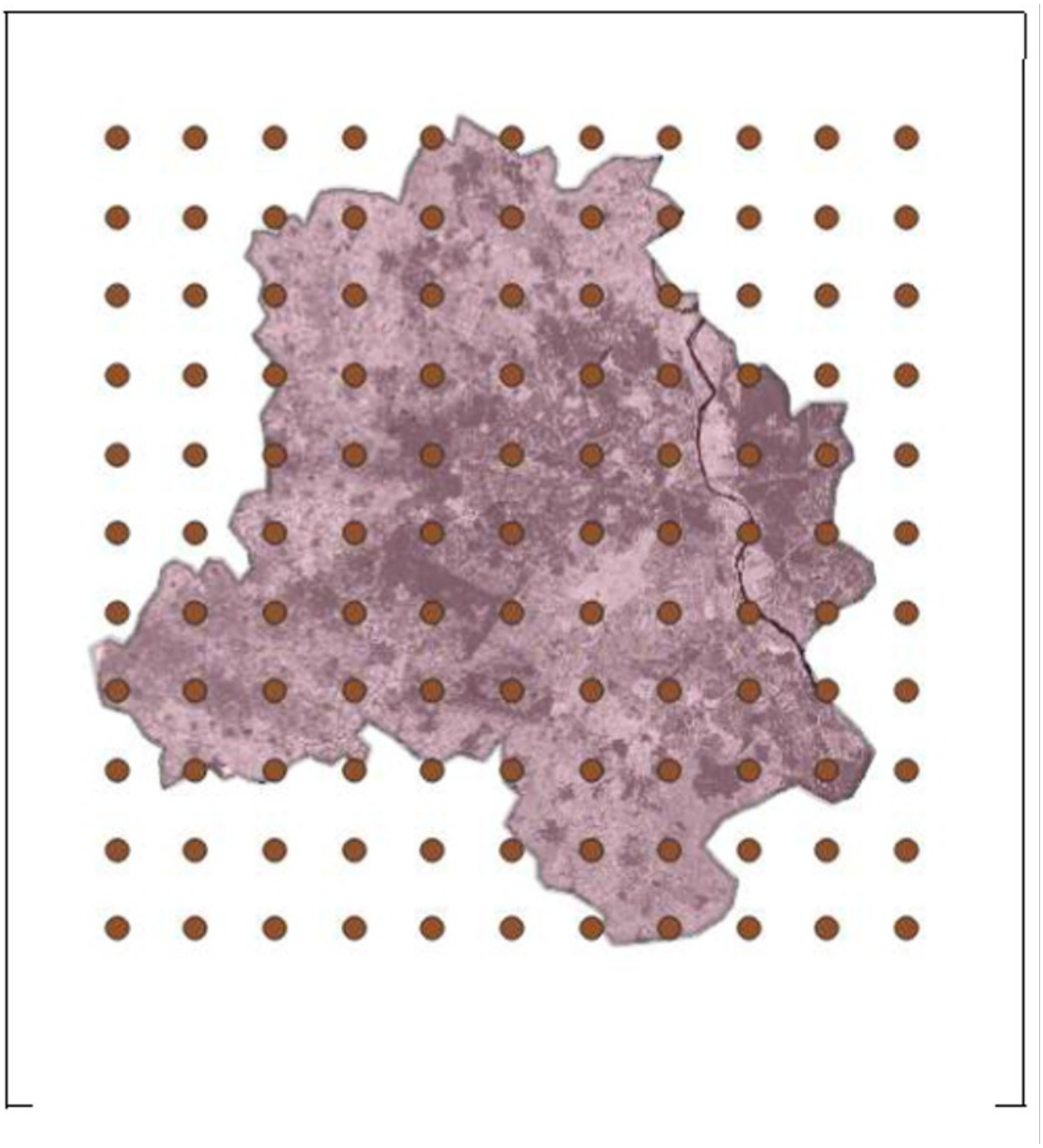

Steps_NDVI_LST_2 - PDF-XChange Editor
Quick Launch (Ctr
Share
Review
Accessibility
Bookmarks
Help
Selection
Typewriter
Sticky Note
Highlight
Arrow
Underline
Rectangle
Comment
Stamp
Web Links
Add/Edit Links
Add Bookmark
Links
Sign Document
Protect
Create Grid
Parameters
Log
Grid type
Rectangle (Polygon)
Grid extent
679591.5710,729116.4552,3144278.6899,3196648.1645 [EPSG:32643]
Horizontal spacing
5.000000
kilometers
Vertical spacing
5.000000
kilometers
Horizontal overlay
0.000000
meters
Vertical overlay
0.000000
meters
Grid CRS
EPSG:32643 - WGS 84 / UTM zone 43N
Grid
Delhi_LST_NDVI_Grid
4/7



c. Create Points

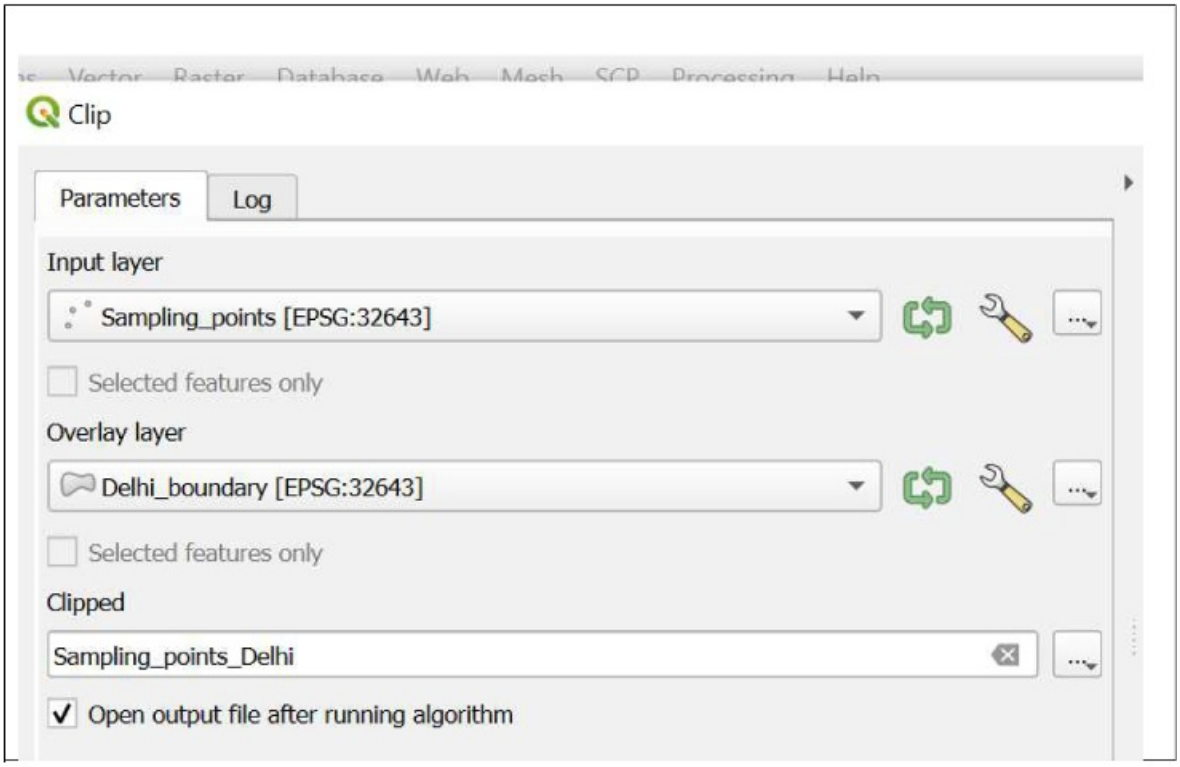
i. Vector – Geometry tools – Centroids

1. Input layer – ‘Delhi_LST_NDVI_Grid’
2. Centroids – Save as sampling points

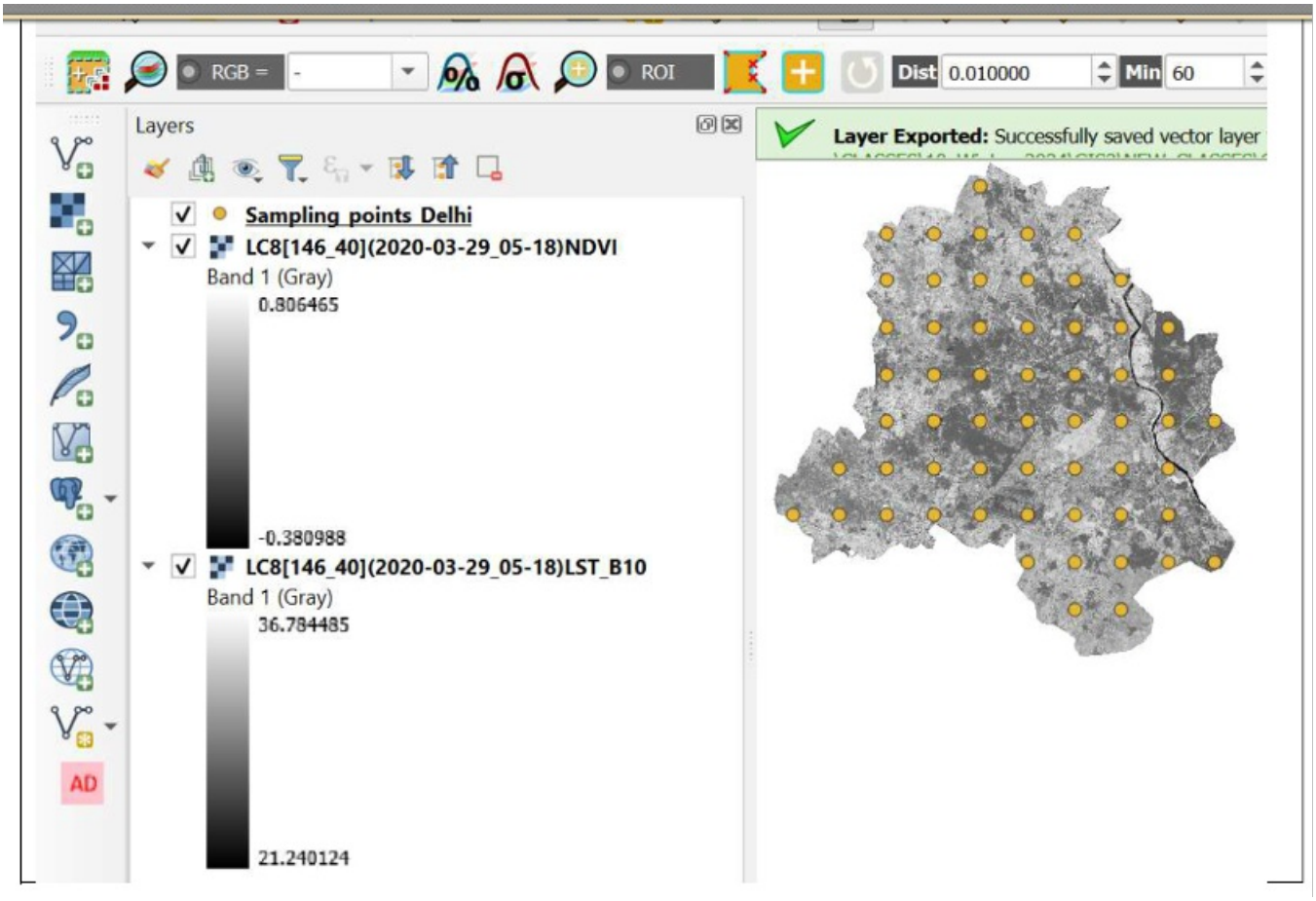


d. Points within Delhi Only and save as ‘Sampling_points_Delhi’

i. Vector – Geoprocessing tools – Clip



4. Now the sampling points are ready to extract temperature values and NDVI values



5. Add temperature and NDVI values

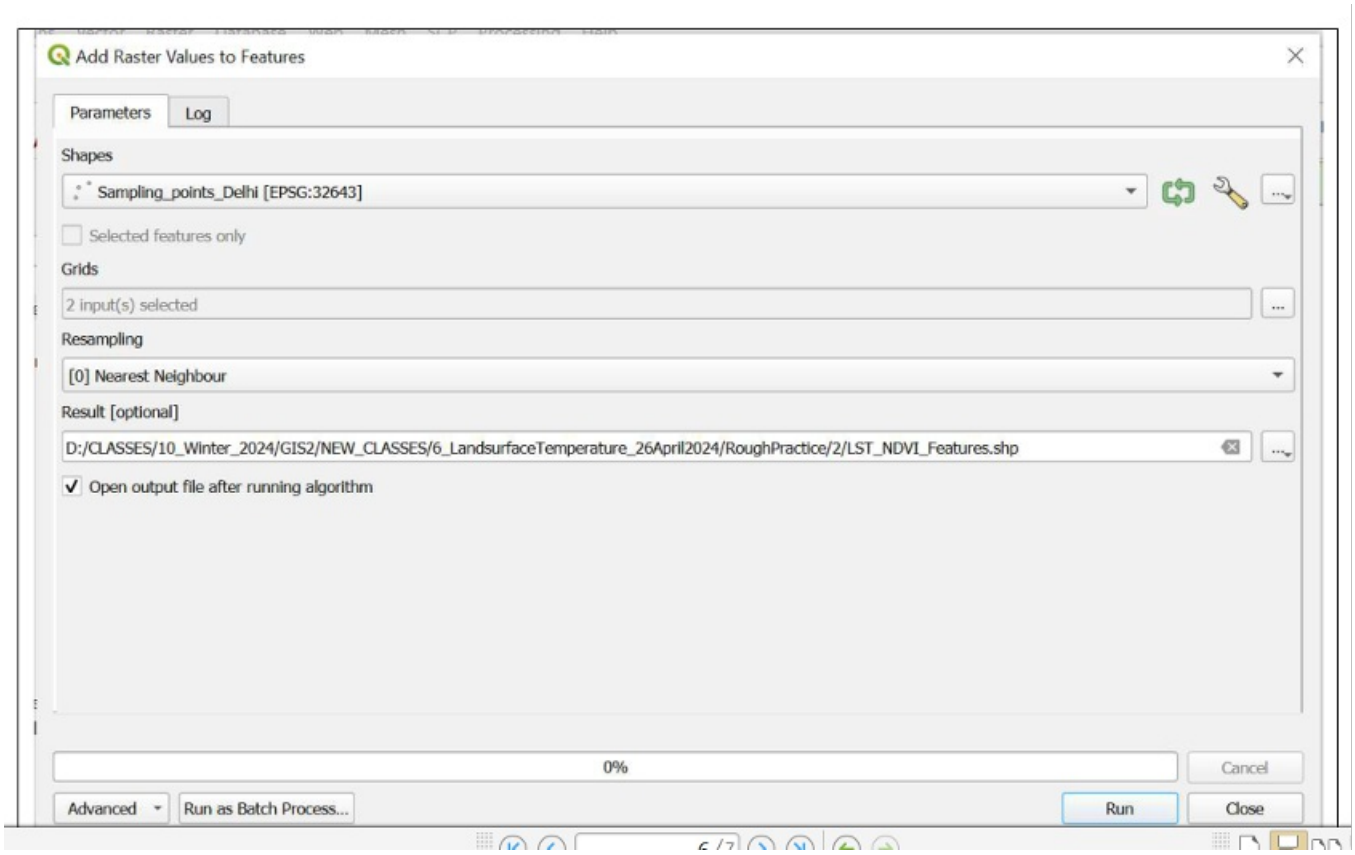
a. Processing Toolbox – Add raster value to features

i. Points – Sampling point created

ii. Grids – Select both LST and NDVI maps

iii. Interpolation – nearest neighbour

iv. Run

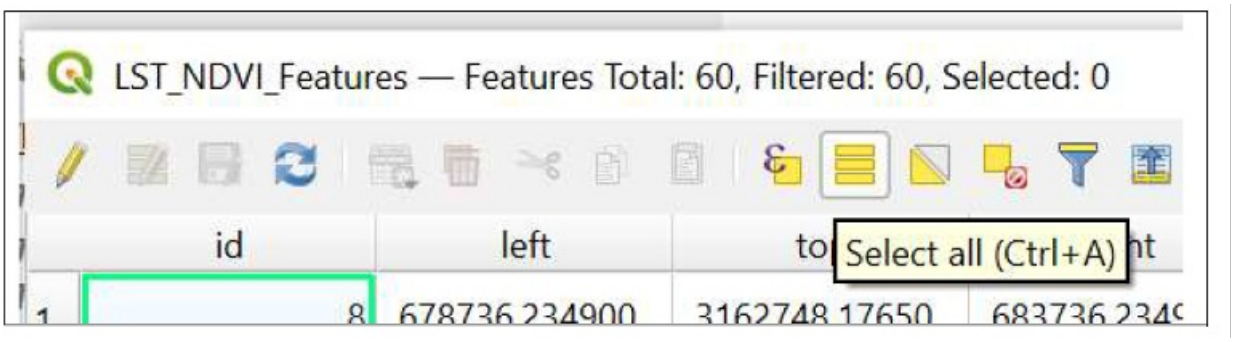


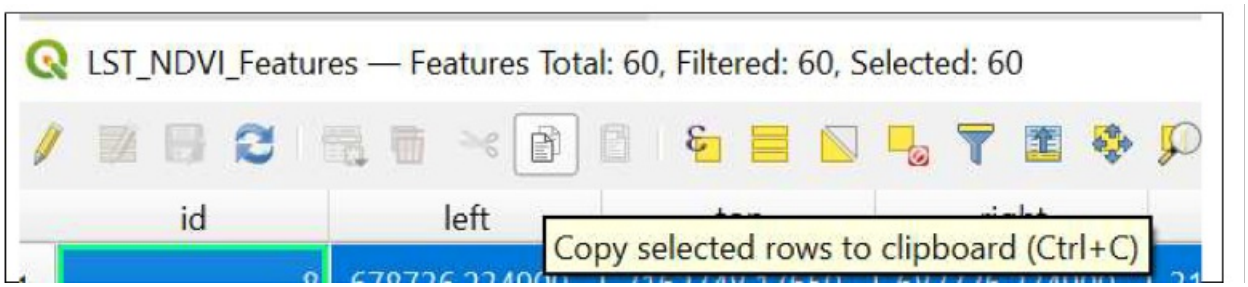
6. Scatter plot and correlation between the two variables

a. The new shape file named ‘LST_NDVI_Features’ will be added to the canvas

b. Open the attribute table ‘LST_NDVI_Features’

c. Click Select all, and ‘copy selected rows to clipboard’





d. Paste it into an Excel file
e. Delete all the columns except the last two (which are LST and NDVI values)
f. Now, using the LST and NDVI values, make a scatter plot and calculate the correlation
g. Add horizontal and vertical axes as LST and NDVI, respectively
h. Change the minimum and maximum values of LST to 22 and 32, respectively
i. Add a Chart Title
j. Observe and comment on the correlation

Results

It is observed from the figure (Fig 1) that the greenest areas (Class 4 &5) in the city during the month of March are sporadic. There is a big dark patch at the centre, some smaller patches towards the south and southwest, some contiguous smaller patches towards the northwest, north, and some linear patches along the river towards the east. Most of the central areas of the city and eastern areas are almost sparse with no or less green vegetation (yellow areas). Beyond these areas with a lack of greenness, there is another outer zone with NDVI between 0.25 and 0.5.

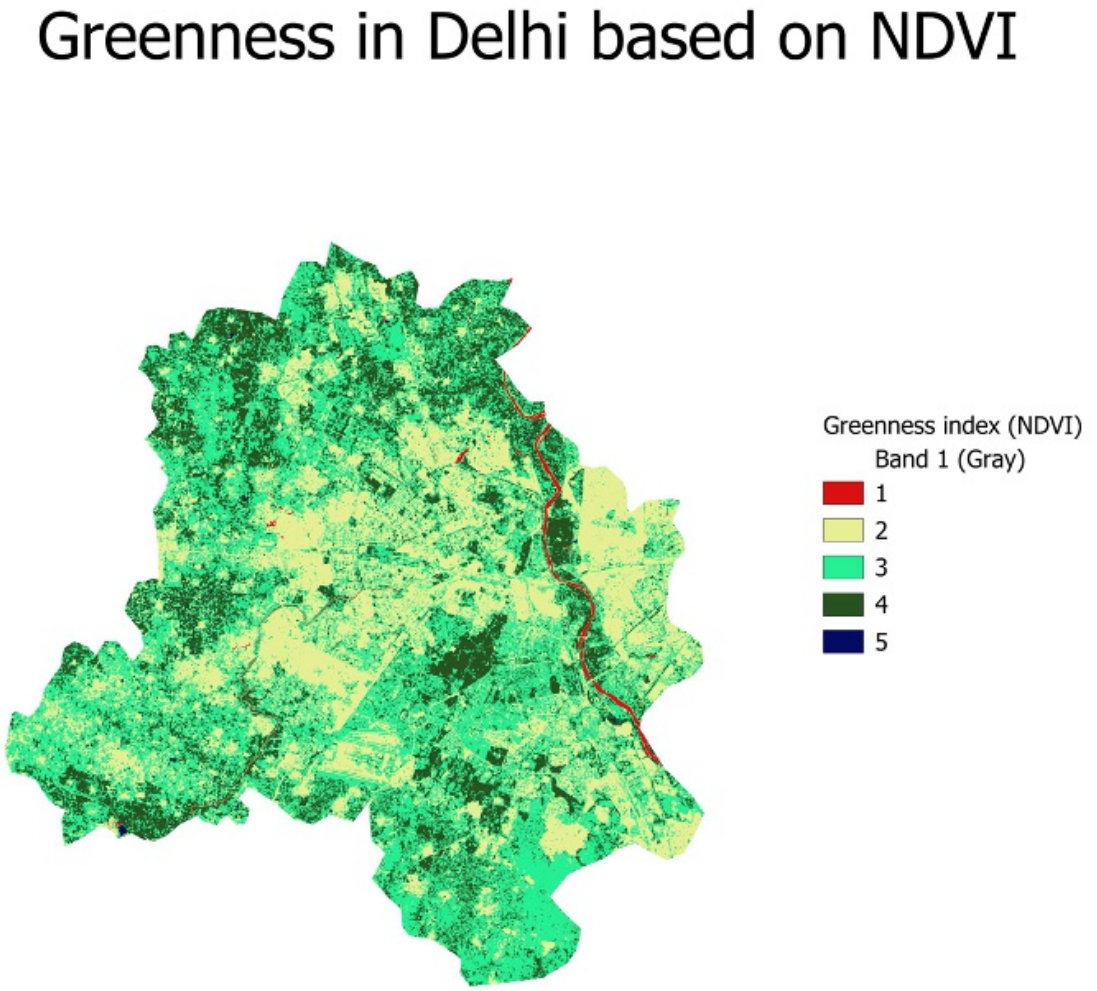


Fig.1. Greenness class in Delhi based on NDVI; Class 1(NDVI ≤ 0), Class 2 (0 < NDVI <= 0.25), Class 3 (0.25 < NDVI <= 0.5), Class 4 (2 (0.5 < NDVI <= 0.75), Class 5 (NDVI > 0.75)

It is observed from the figure below (Fig.2) that during the study period, the southern areas are comparatively hotter than the northern areas. Most of the northern part and northwestern part are comparatively cooler, with temperatures ranging between 22 degrees and 26 degrees Celsius. There is a central patch that almost overlaps with the greenest patch (in figure 1) and has a comparatively lower temperature. This patch is surrounded by areas with comparatively higher temperatures. There are some regions towards the southeast and southwest, which also happen to run along the border of the city, consisting of linear contiguous warmer patches. The narrow-elongated area along the river (towards the eastern side) is comparatively cooler. Most of the eastern region of the city has comparatively higher temperatures.

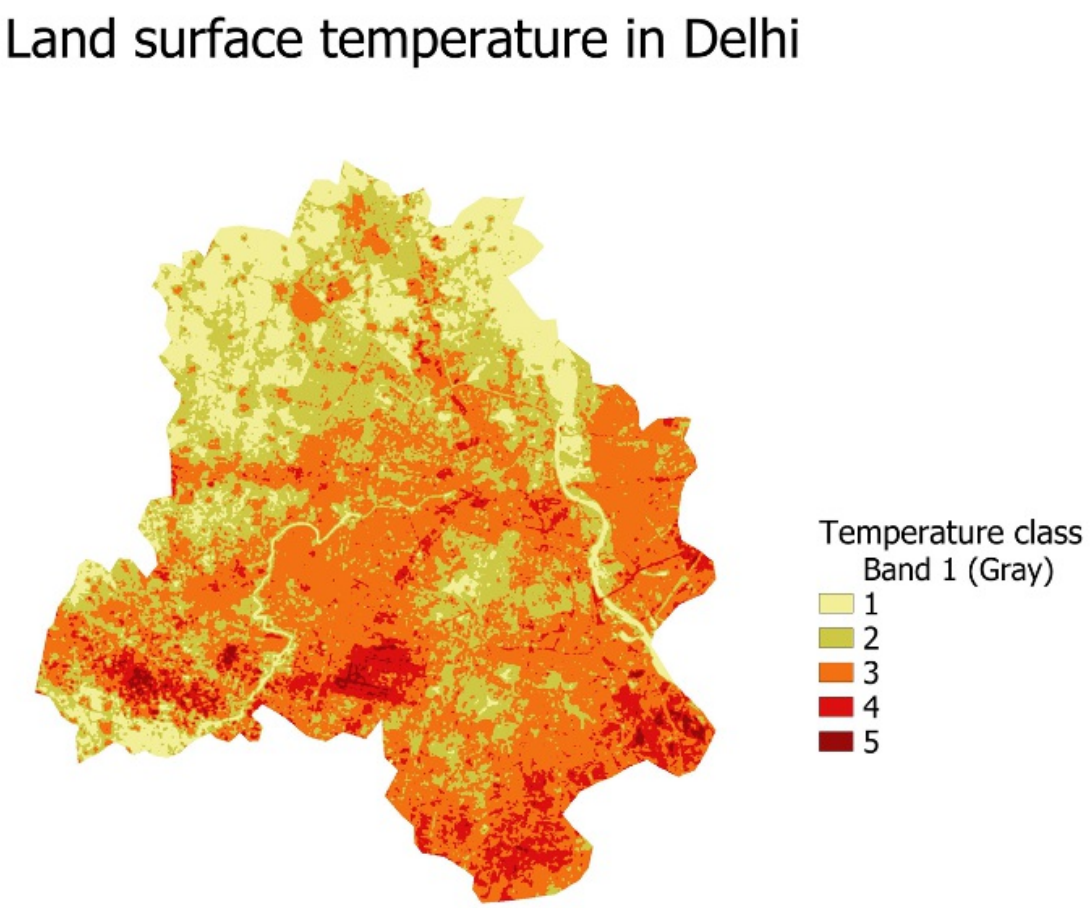


Fig.2. Land surface temperature (LST) (degrees Celsius) in Delhi; Class 1(LST ≤ 24), Class 2 (24 < LST <= 26), Class 3 (26 < LST <= 28), Class 4 (28 < LST <= 30), Class 5 (LST > 30)

It is observed from the figure (Fig.3.) that there is a general inverse relationship (y = -0.03031x + 1.1619) between NDVI measured and LST measured. The LST increases from around 22 degrees Celsius to up to 31 degrees Celsius with a change in NDVI from around 0.6 to below 0.1. Although there is a linear decreasing trend, the correlation is not significant (R2 = 0.1407)

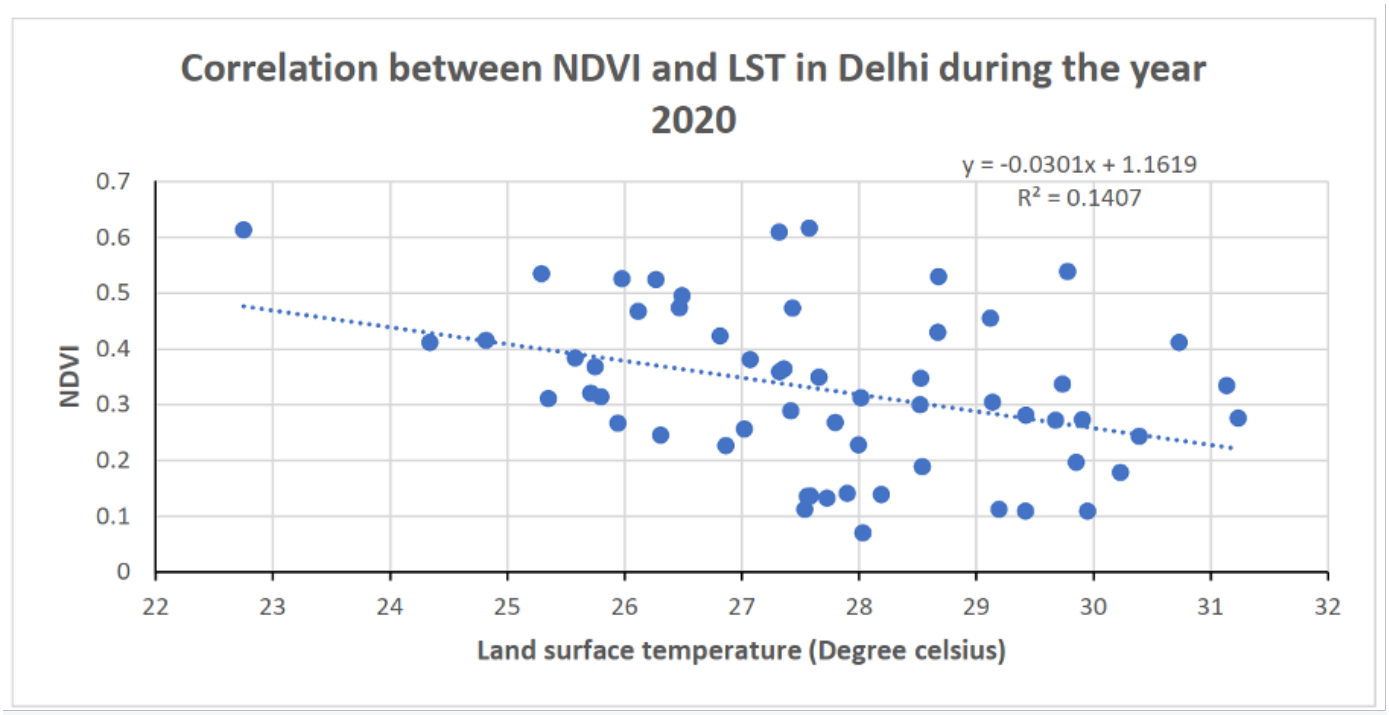


Fig.3. Correlation between NDVI and LST in Delhi

Discussion and Conclusion

Ullah et al. (2023), in a study, observed a negative correlation between LST and NDVI in Pakistan. They also observed the relationship of LST with elevation, which was also negative. Morsy and Hadi (2022), in a study in Egypt, observed that the built-up index is positively correlated with LST, and regression analysis with NDVI had a better coefficient of determination. Ferreli et al. (2018), in a study, observed that there is a significant relationship between NDVI and LST in Argentina. Cambrussi et al. (2021) observed that there is a strong interaction between LST and NDVI in southern Brazil. Jaswal and Thakur (2023), in a study in Shimla, India, observed that there is a positive relation of lower temperature with vegetation. Guha et al. (2020), in a study in Raipur, India, observed that there is a strong negative correlation between NDVI and LST. Chauhan (2023), in a study, observed that there is a negative correlation between NDVI and LST in Alwar, India. Kandel et al. (2022) observed that LST in urban areas is higher than LST in rural areas and that there is an inverse relationship between LST and NDVI. Anitha et al. (2023), in a study in Tamil Nadu, India, observed that there is an inverse relationship between NDVI and LST.

In almost all of the above cases, it is observed that the LST is negatively correlated with NDVI or vegetation. If we compare it with the present study, it can be said that although there is a declining trend of LST with NDVI, it can't be said to be statistically significant, at least in the current study. There may be various reasons behind that, among them may be the timing of the study, which may be influencing the relationship of surface temperature and the vegetation distribution. This aspect needs to be studied in more detail. There may be other reasons also, such as climate change and its impacts, etc.

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