Heat Island Detection on 4meters Spatial Resolution

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What is Urban Heat Islands?

Heat islands are **urbanized areas that experience higher temperatures than outlying areas**.

- buildings, roads, and other infrastructure absorb and re-emit Sun irradiance.
- It depends on the surface's Albedo and emissivity, they possess different temperatures.
- natural landscapes such as forests and water bodies are usually cooler than impervious surfaces

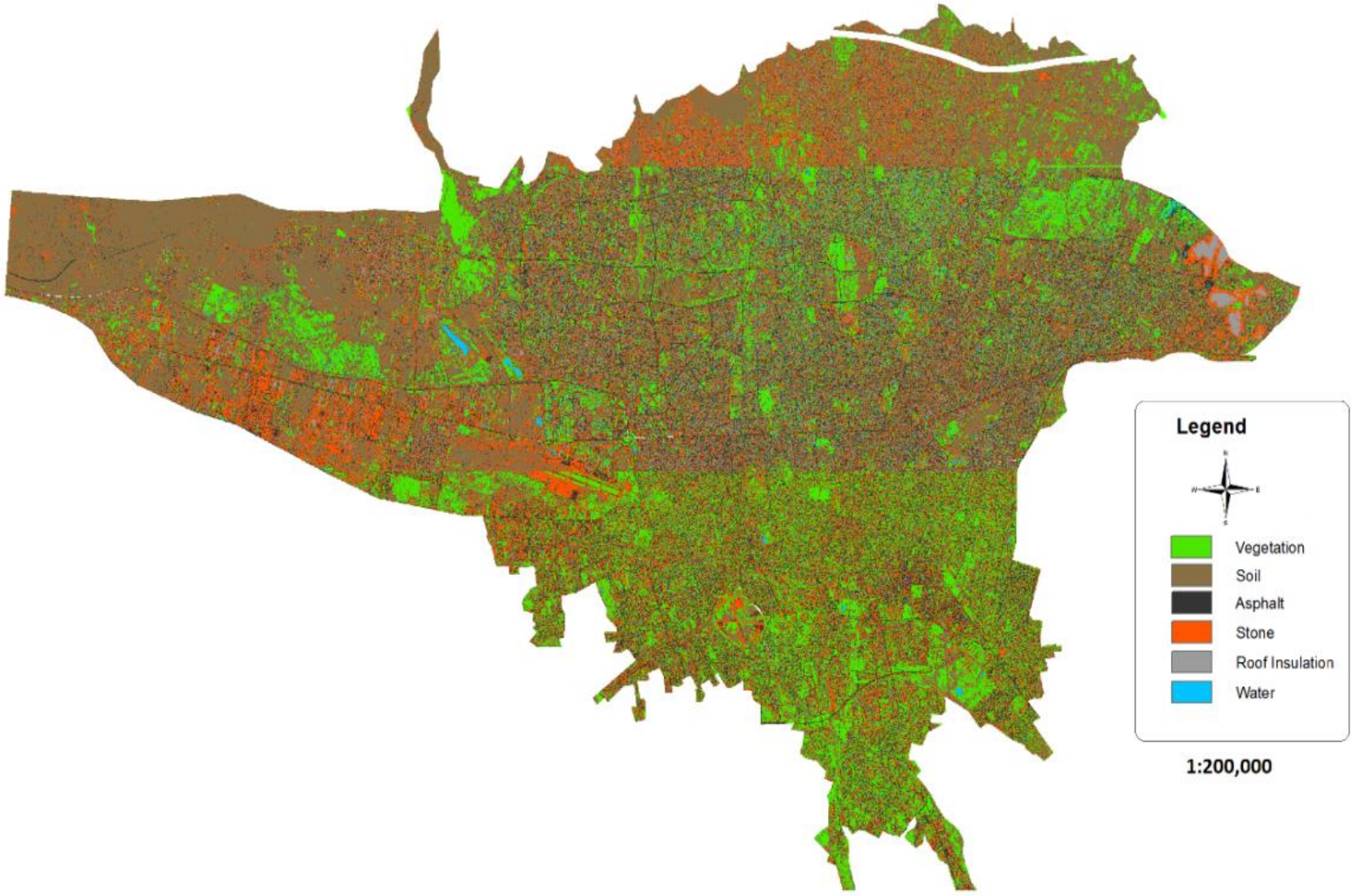
Problems, Solutions, Gadgets

- Different sensors on different platforms can detect heat islands
- Space-borne, Airborne, Weather stations and moving vehicles
- Temporal and Spatial resolution is important
- Must be cost effective too
- Daily monitoring is preferred. This makes space-borne thermal sensors bands suitable
- Geo. thermal bands are quite good in temporal but very poor in spatial
- MODIS thermal bands have 1 by 1 km resolution which are still poor
- Problem of mixed pixels when spatial resolution is poor
- Problem of emissivity

- What is needed is sensors with high spatial resolution around few meters
- But these sensors do not carry thermal bands
- Landsat is the best available but temporal is 16 days.
- GeoEye has no thermal band but perfect spatial resolution of 1.64m
- Is it possible to fuse GeoEye into MODIS?. This is what we did.

Methodology

- Georeferencing GeoEye using 1/2000 **Tehran Metropolitan** map
- Resampling GeoEye to 4m
- GeoEye classification for soil, vegetation, roof insulation, Asphalt, Stone pavement (two impervious surfaces) and water bodies.
- Validation using google map and field observation



GeoEye1 classified image (Tehran Metropolitan).

Methodology

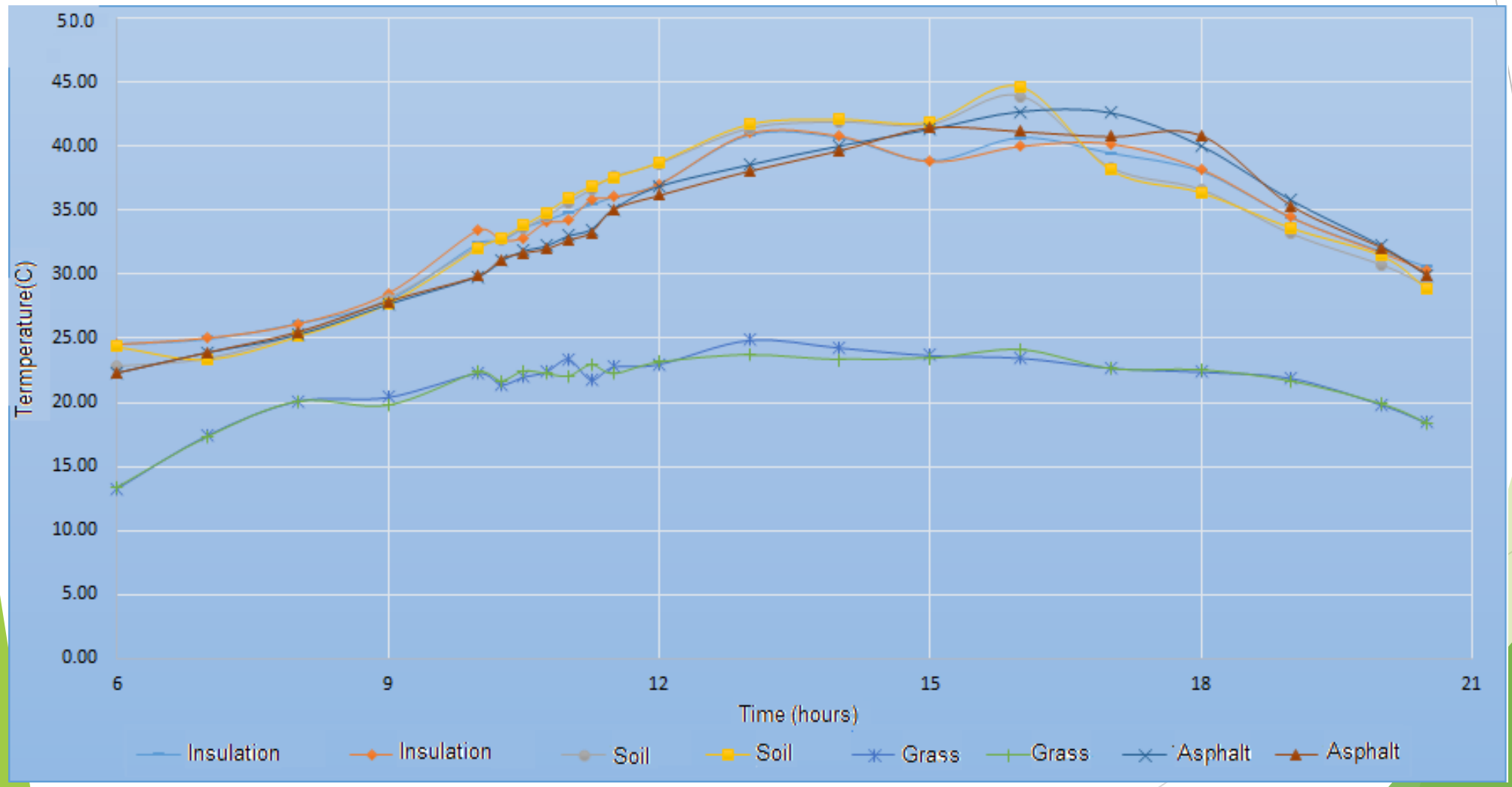
- Selecting cloud-free MODIS land surface temperature and emissivity products
- Overlaying GeoEye classified image on the MODIS surface temperature (LST)
- Calculating the fraction of each surface covers in each MODIS pixel (f_i)

Methodology

Inter-relationship between different class temperatures

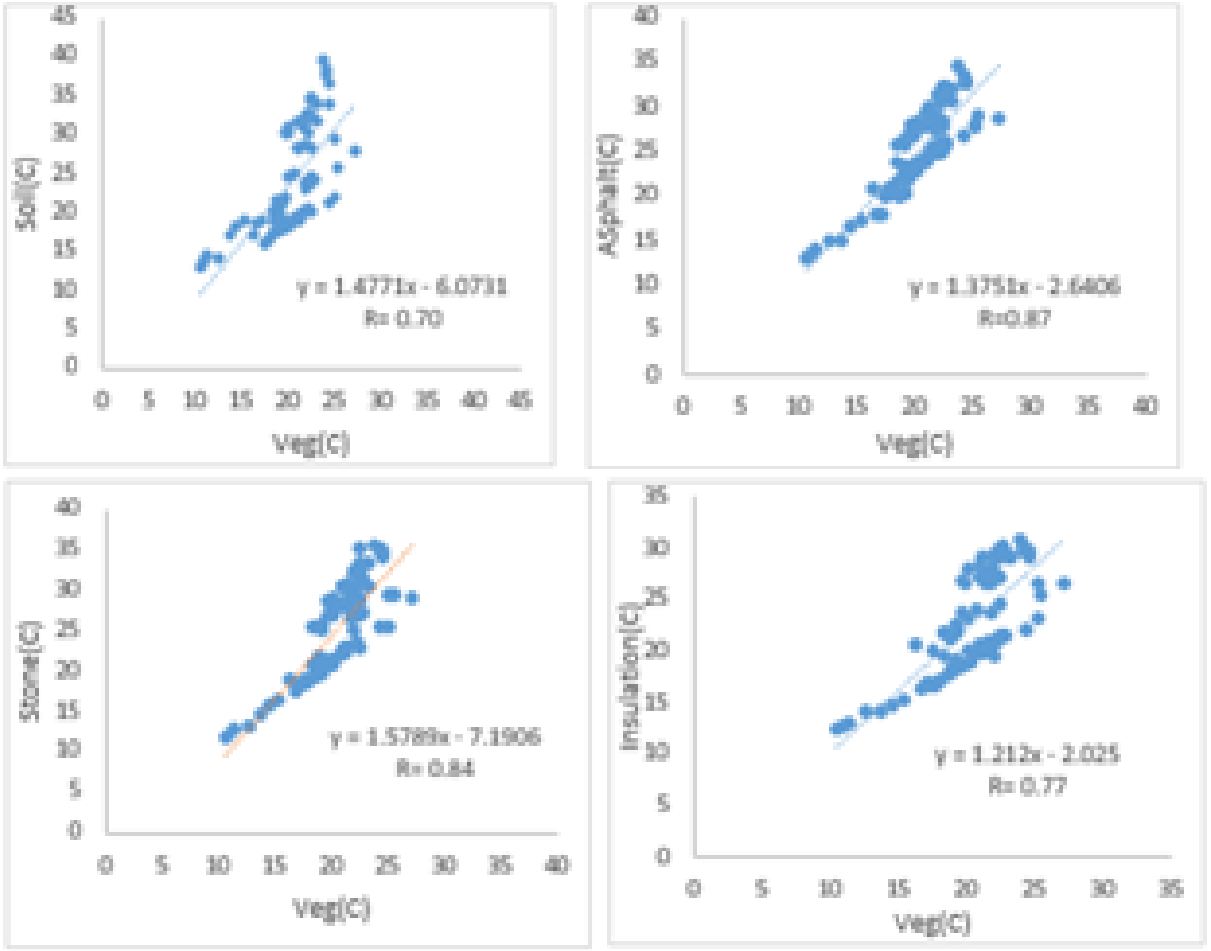
- ***Two weeks field campaign for insitu temperature measurements.***
- ***Thermometers were inter-calibrated to better than 0.01C***
- **There are no perfect correlations seen between temperatures of diff. classes during the whole day**

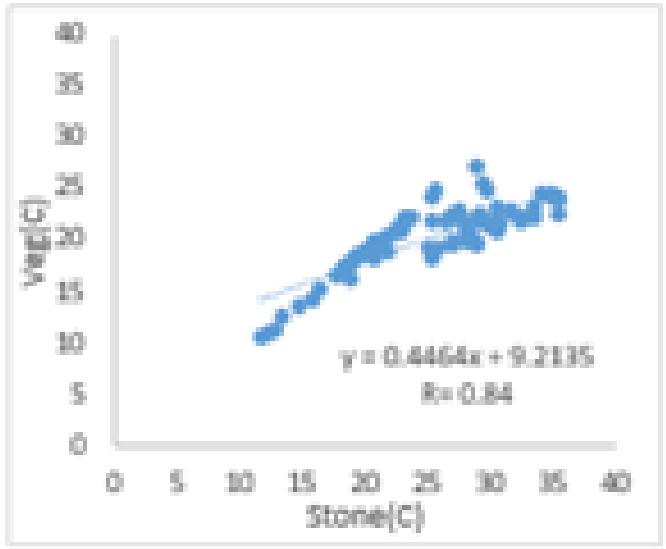
There were no perfect correlations seen between temperatures of diff. classes during the whole day due to different special heat capacities.

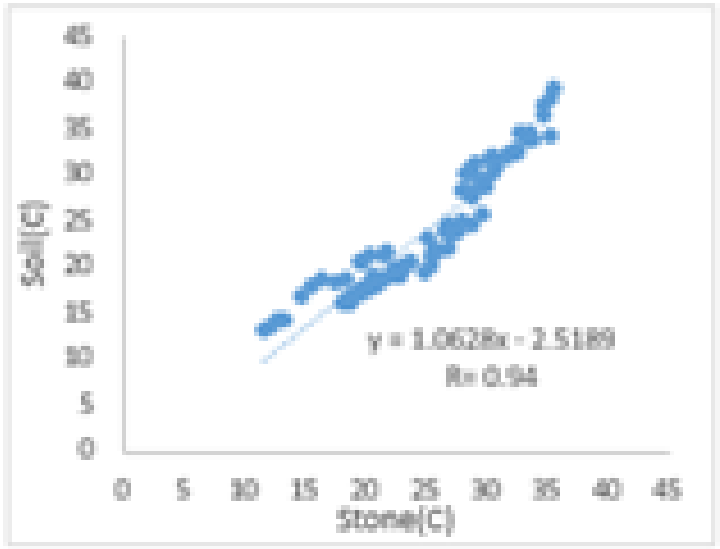


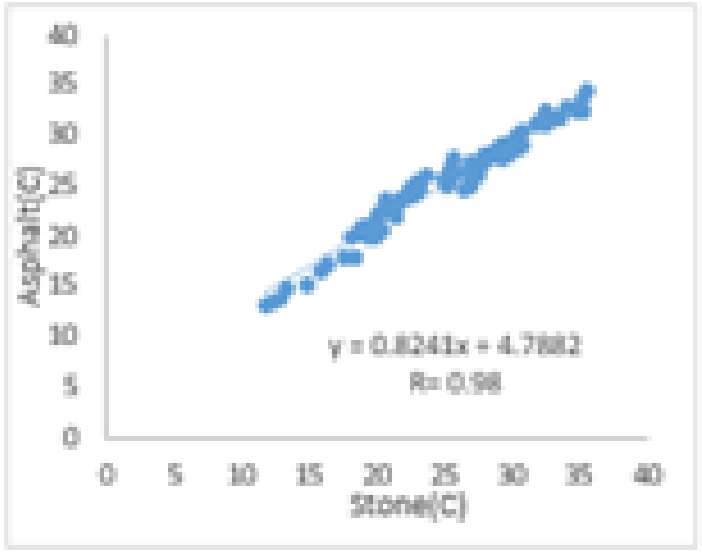
Methodology

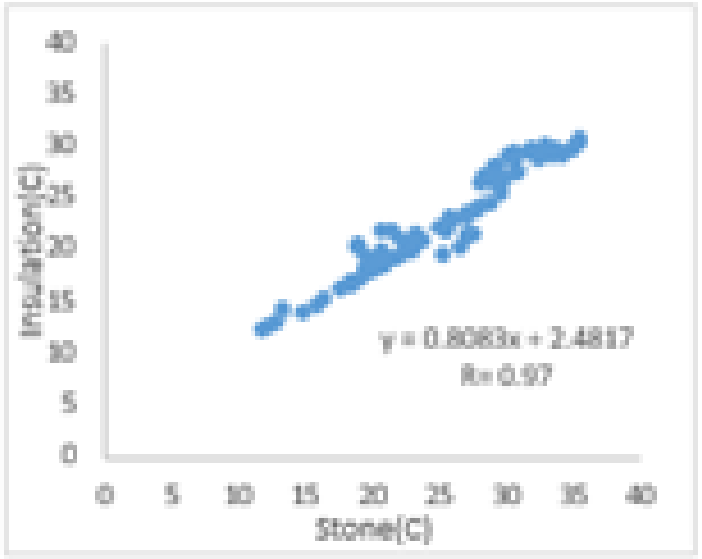
If we confine ourselves to satellite passage time, then acceptable linear correlations may exist.

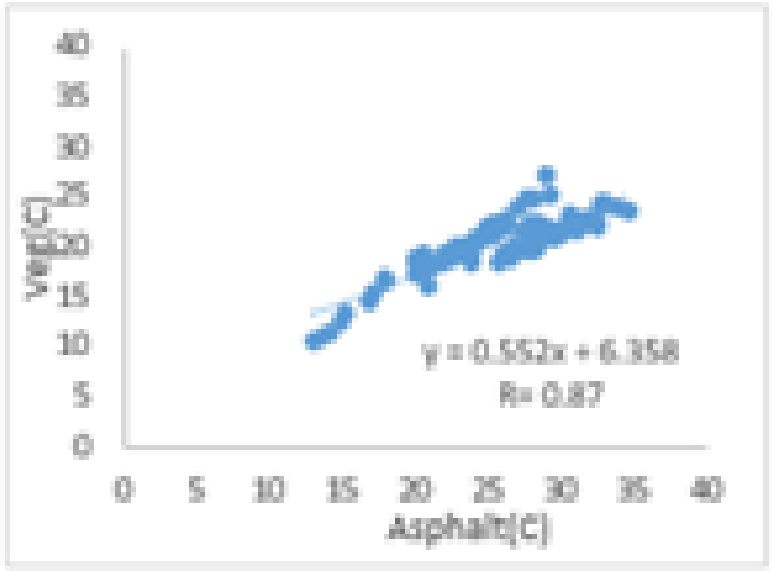


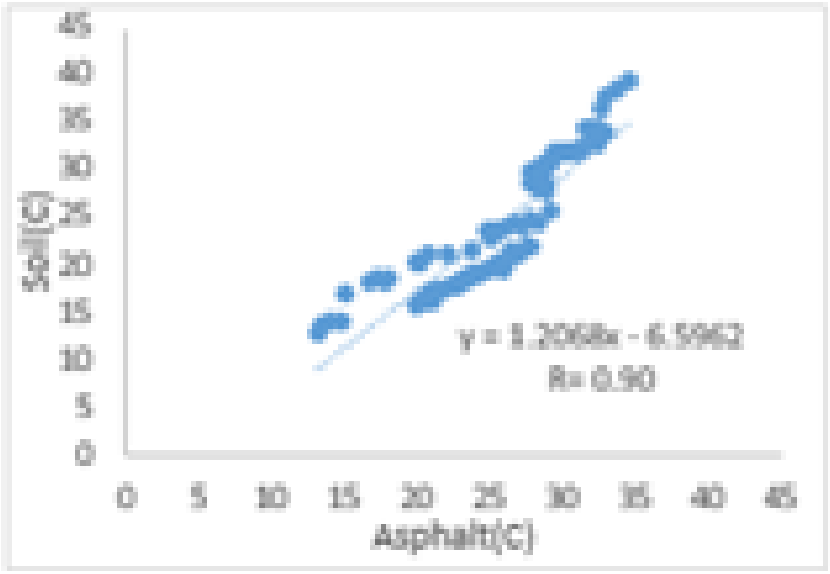

Veg(C)
Stone(C)
y = 0.4464x + 9.2135
R= 0.84

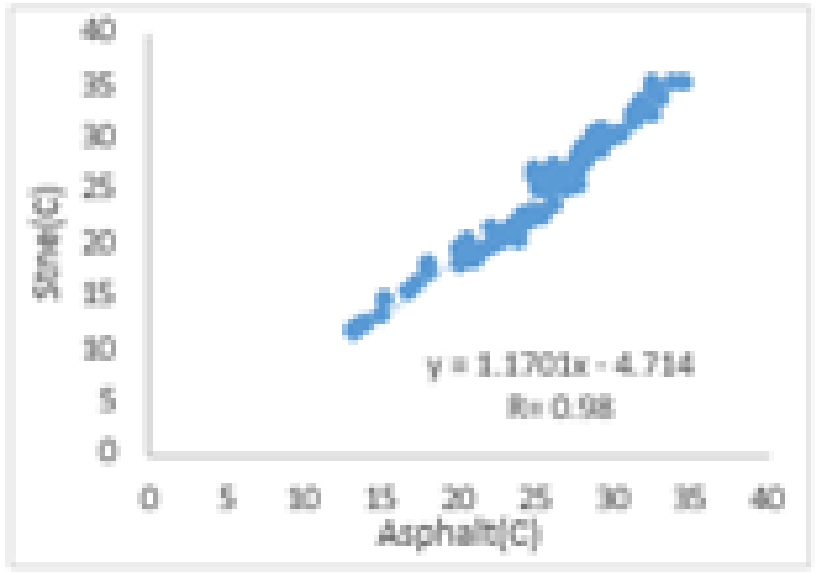

Soil(C)
Stone(C)
y = 1.0628x - 2.5189
R= 0.94

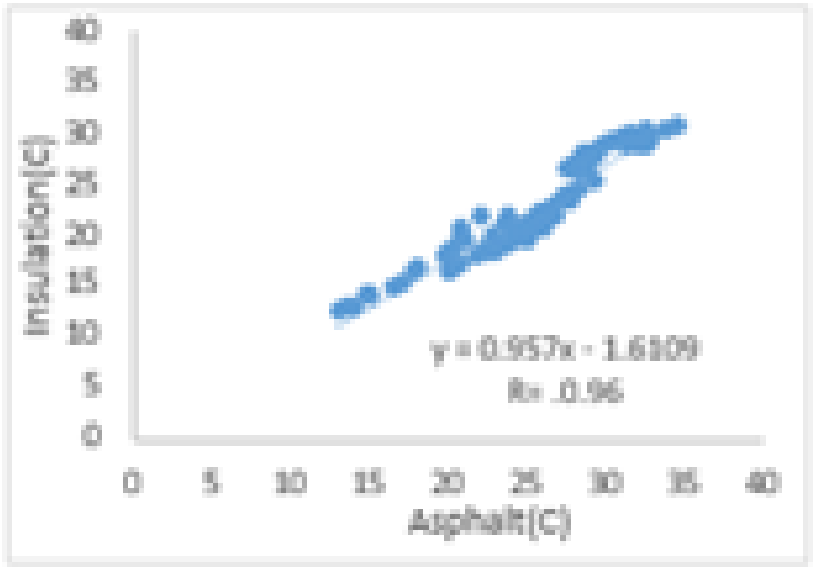

Asphalt(C)
Stone(C)
y = 0.8241x + 4.7882
R= 0.98

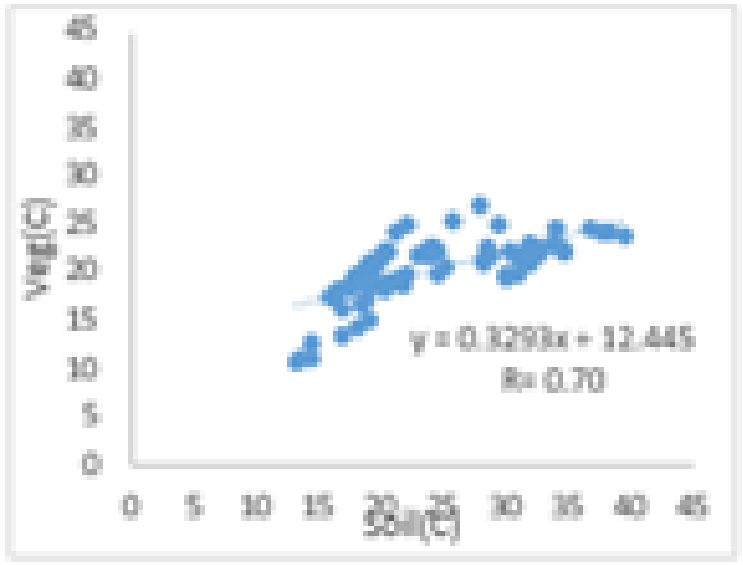

Insulation(C)
Stone(C)
y = 0.8083x + 2.4817
R= 0.97

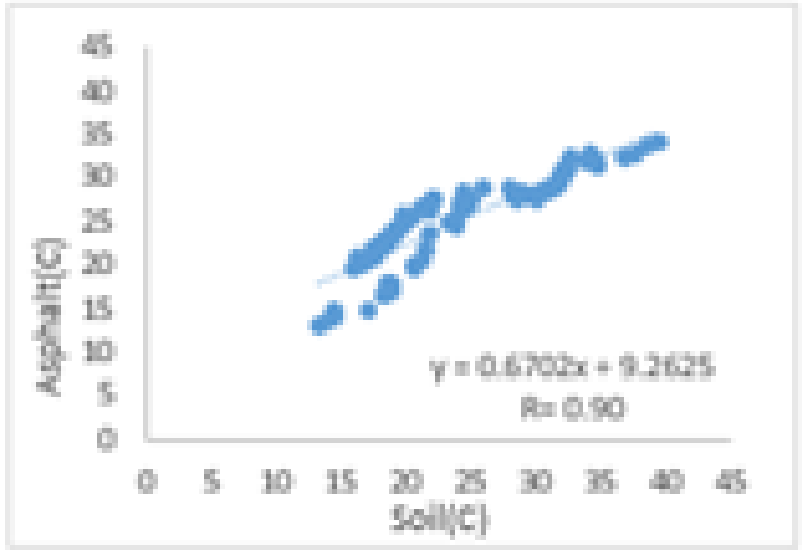

Veg(C)
Asphalt(C)
y = 0.552x + 6.358
R= 0.87

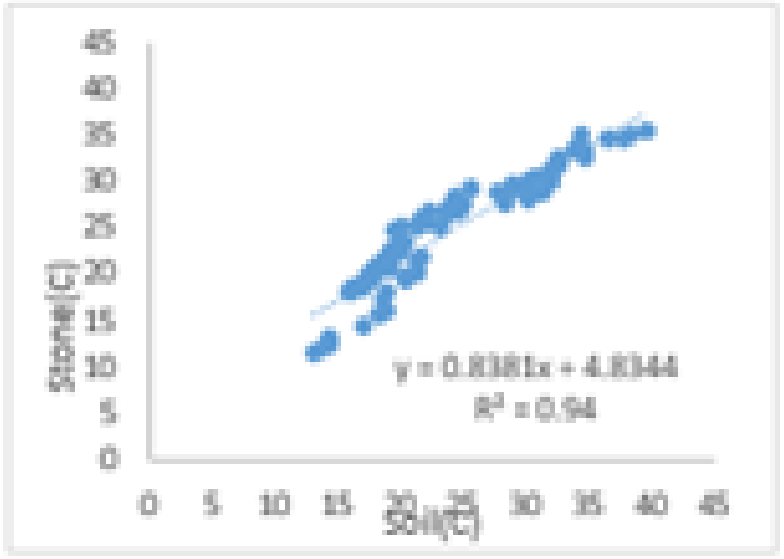

Soil(C)
Asphalt(C)
y = 1.2068x - 6.5962
R= 0.90

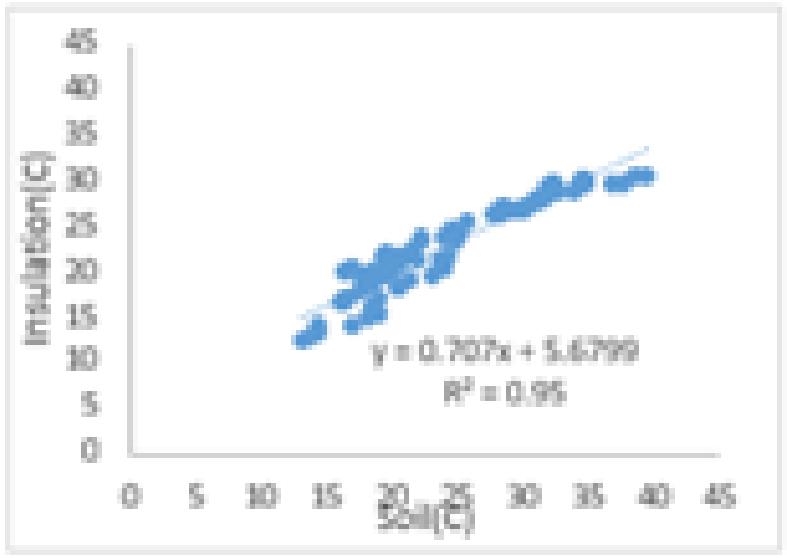

Stone(C)
Asphalt(C)
y = 1.1701x - 4.714
R= 0.98

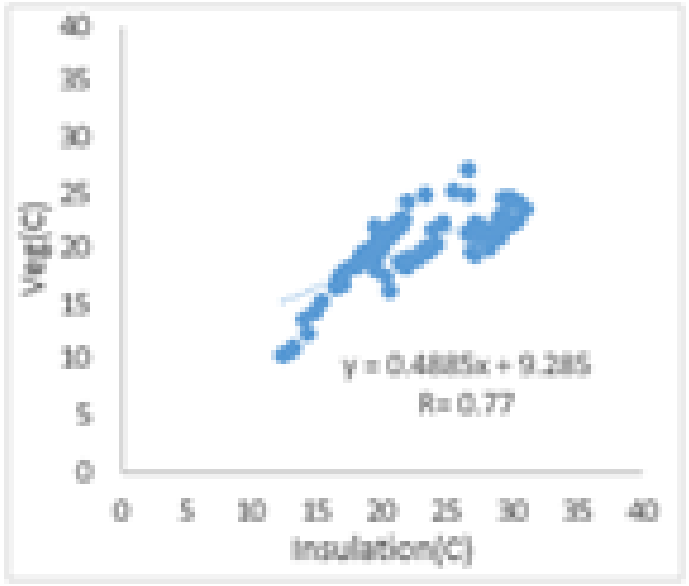

Insulation(C)
Asphalt(C)
y = 0.957x - 1.6109
R= .0.96

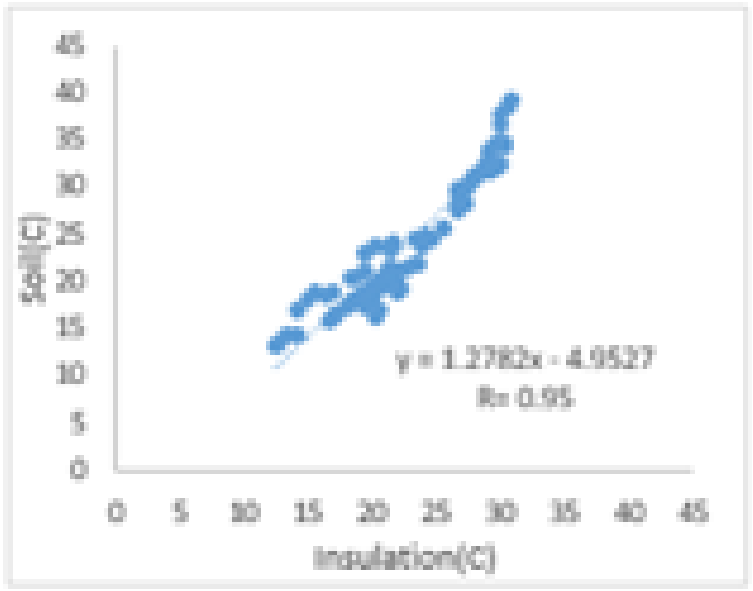

Vegt(C)
y = 0.3293x + 12.445
R= 0.70
Soil(C)

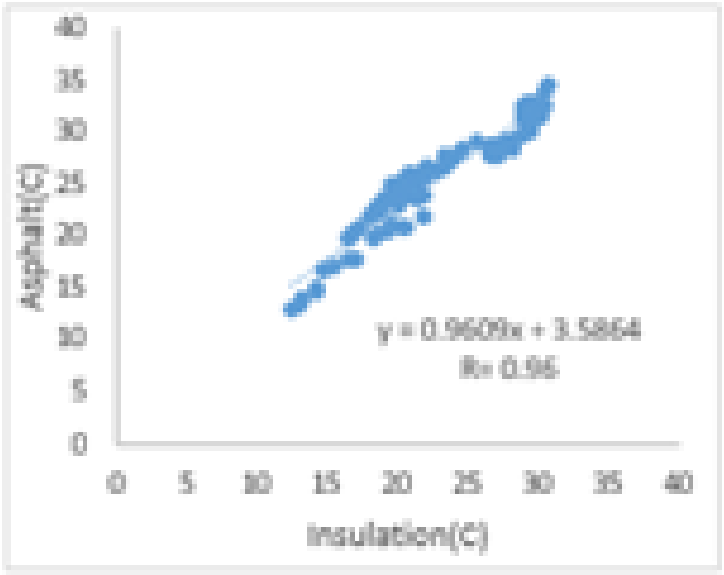

Asphalt(C)
y = 0.6702x + 9.2625
R= 0.90
Soil(C)

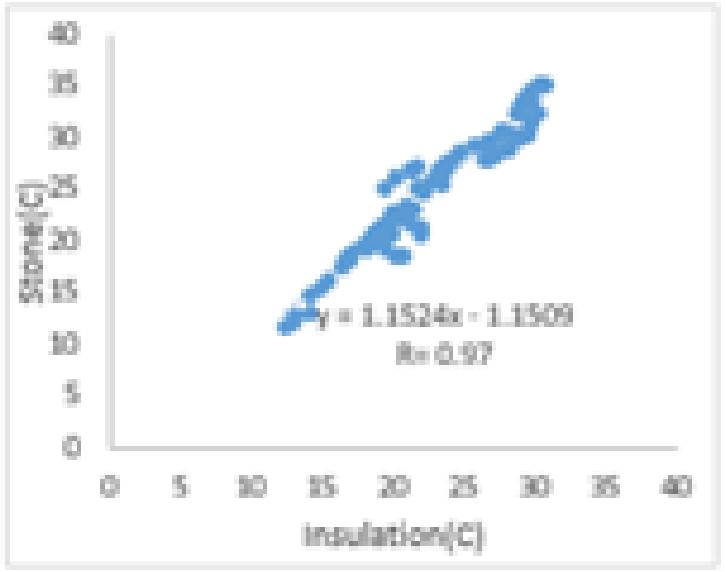

Stone(C)
y = 0.8381x + 4.8344
R² = 0.94
Soil(C)


Insulation(C)
y = 0.707x + 5.6799
R² = 0.95
Soil(C)


Vegi(C)
y = 0.4885x + 9.285
R= 0.77
Insulation(C)


Soil(C)
y = 1.2782x - 4.9527
R= 0.95
Insulation(C)


Asphalt(C)
y = 0.9609x + 3.5864
R= 0.96
Insulation(C)


Stone(C)
y = 1.1524x - 1.1509
R= 0.97
Insulation(C)

Methodology

$$L_{sen} = \sum_{i=1}^{5} f_i L_i$$

$$L = \alpha T$$

$$T_{sen} = \sum_{i=1}^{5} f_i T_i = f_{veg} T_{veg} + f_{soi} T_{soi} + f_{asp} T_{asp} + f_{ins} T_{ins} + f_{sto} T_{sto}$$

Methodology

$$T_{soi} = a_{soi} \cdot T_{veg} + b_{soi}$$

$$T_{asp} = a_{asp} \cdot T_{veg} + b_{asp}$$

$$T_{ins} = a_{ins} \cdot T_{veg} + b_{ins}$$

$$T_{sto} = a_{sto} \cdot T_{veg} + b_{sto}$$

Methodology

$$T_s = A \,.\, T_{veg} + B$$

where;

$$A = f_{veg} + f_{soi} a_{soi} + f_{asp} a_{asp} + f_{ins}\, a_{ins} + f_{sto} a_{sto}$$

and

$$B = f_{soi} b_{soi} + f_{asp} b_{asp} + f_{ins} b_{ins} + f_{sto} b_{sto}$$

Methodology

$$T_{soi} = a_{soi} \cdot T_{veg} + b_{soi}$$

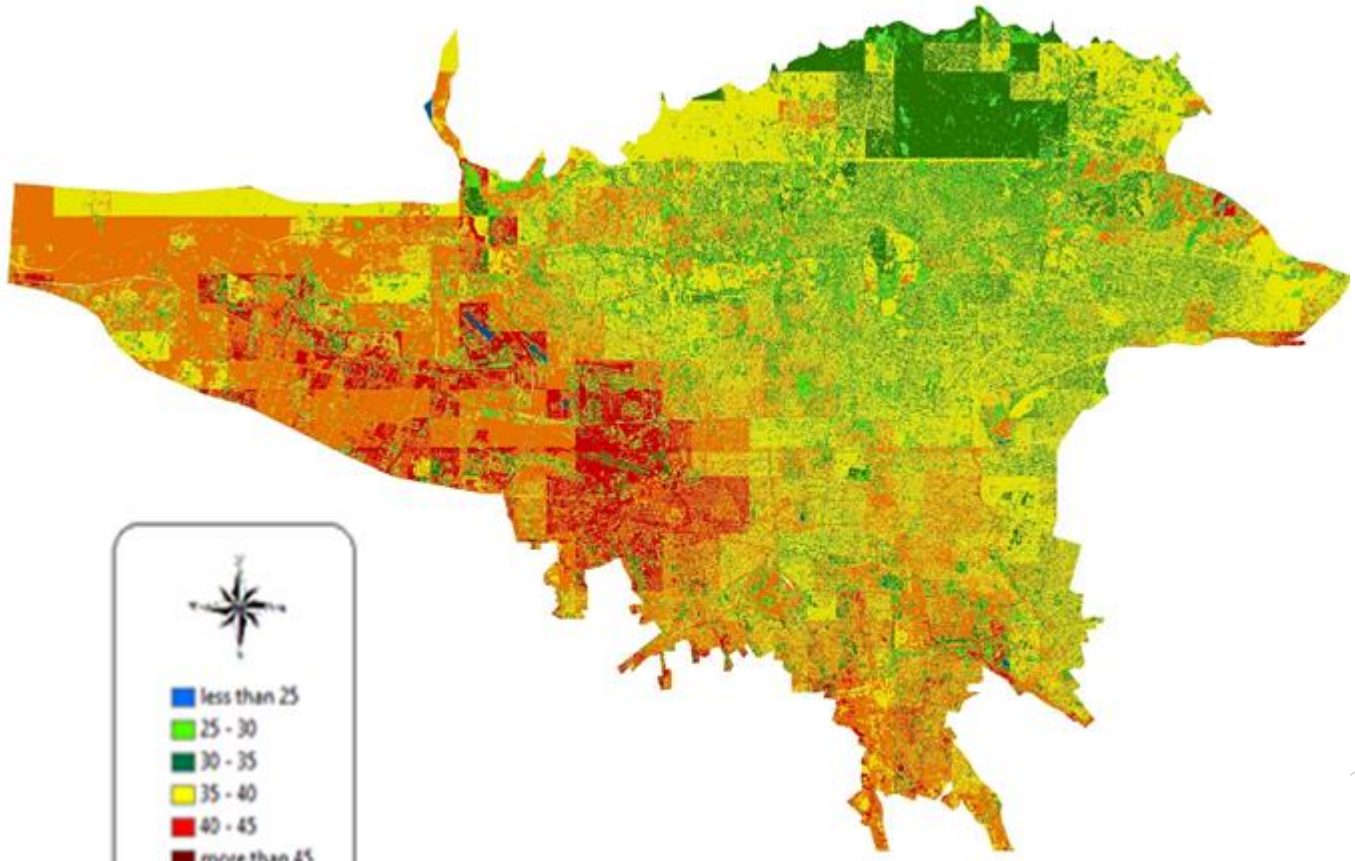
$$T_{asp} = a_{asp} \cdot T_{veg} + b_{asp}$$

$$T_{ins} = a_{ins} \cdot T_{veg} + b_{ins}$$

$$T_{sto} = a_{sto} \cdot T_{veg} + b_{sto}$$

Methodology

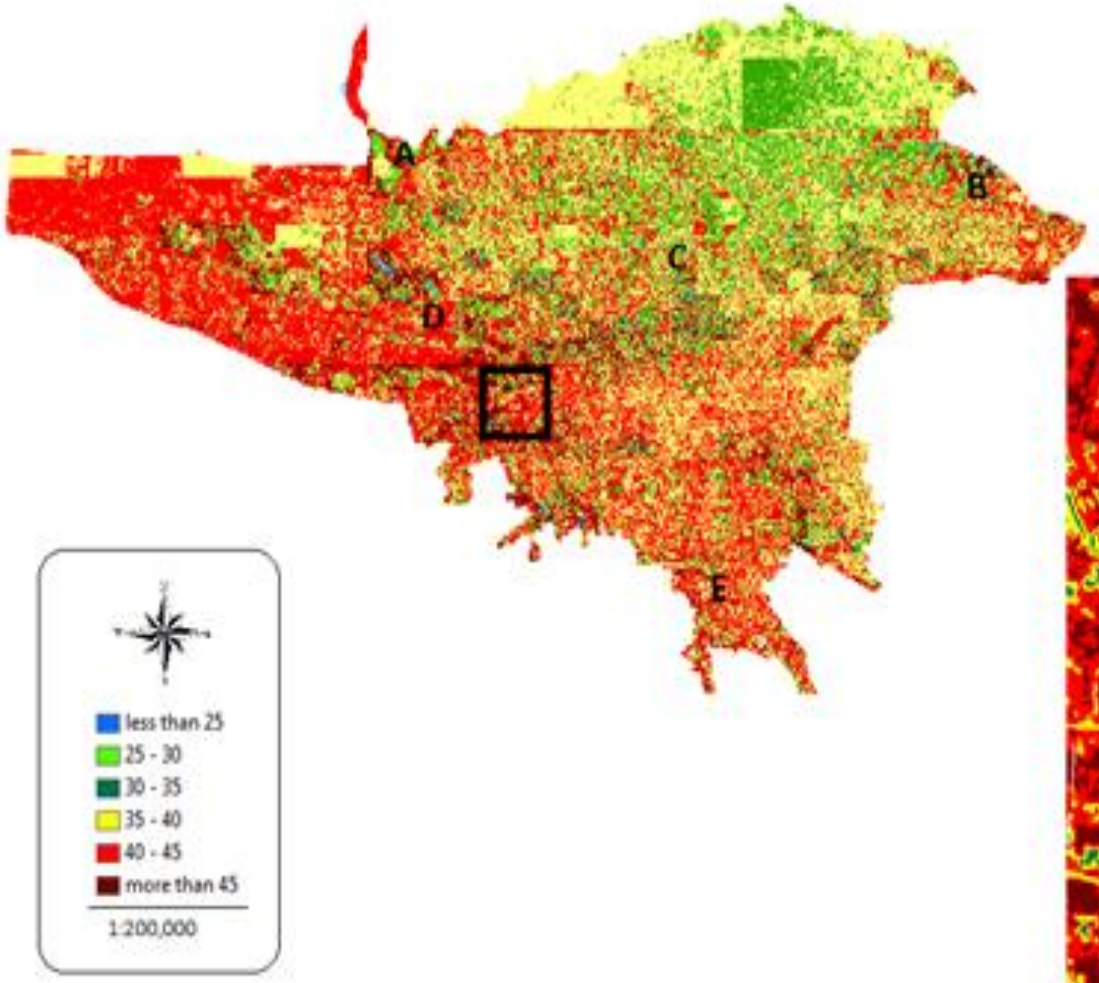
Assigning these temperatures to the relevant class in GeoEye image, you will come up with an LST image with 4m resolution.

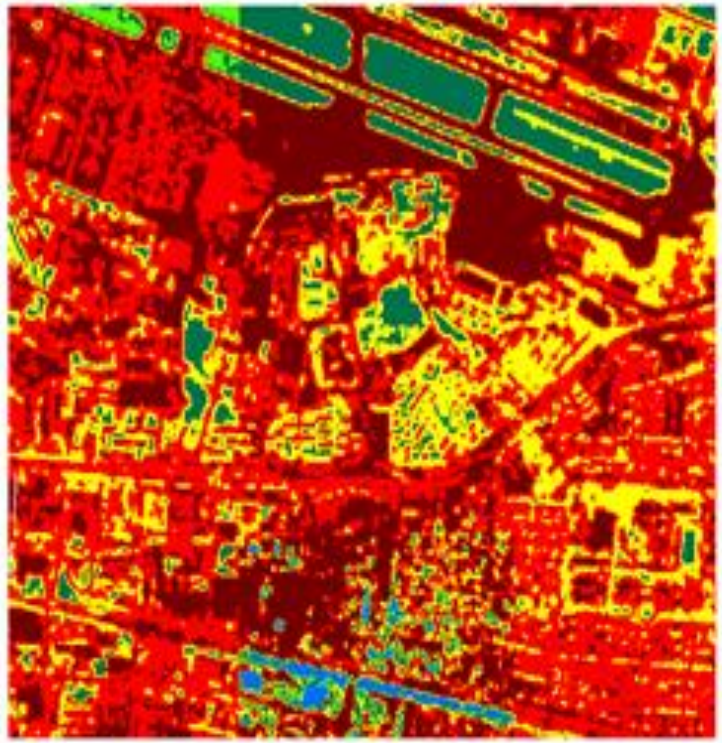


Results and Analysis

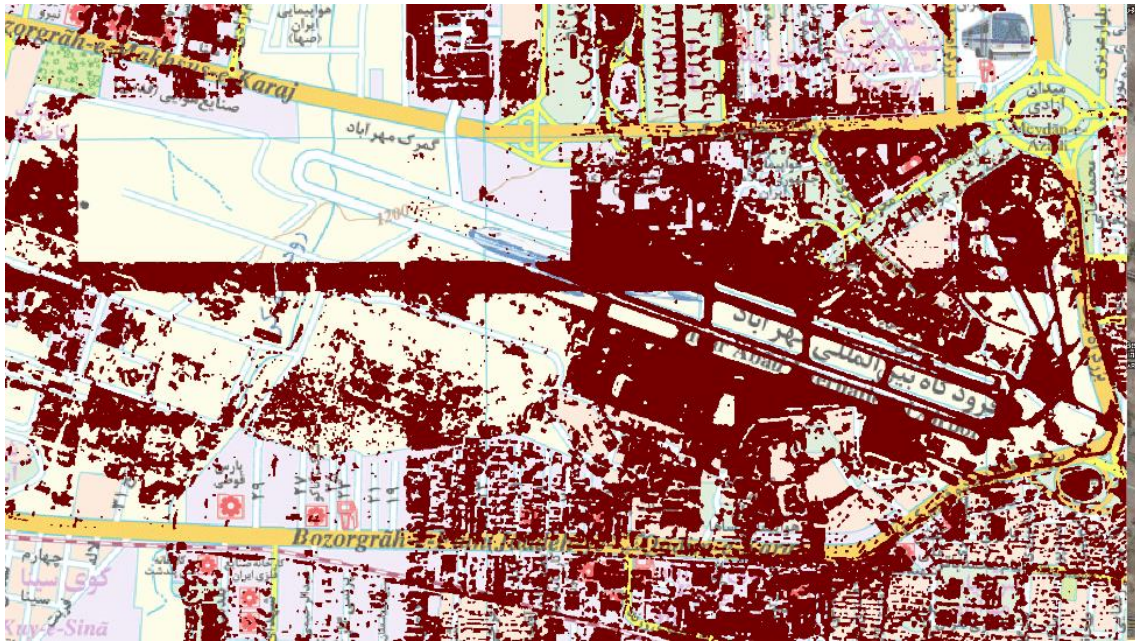
- The objective of this work was determination of heat islands through out the city (**CRITICAL REGIONS**).
- Certainly there exists some uncertainties in class temperatures calculated this way.
- But, since the goal is to locate the **CRITICAL REGIONS**, **then accumulation of two weeks classified image may mitigate the uncertainties.**
  - **This is what we have done here**

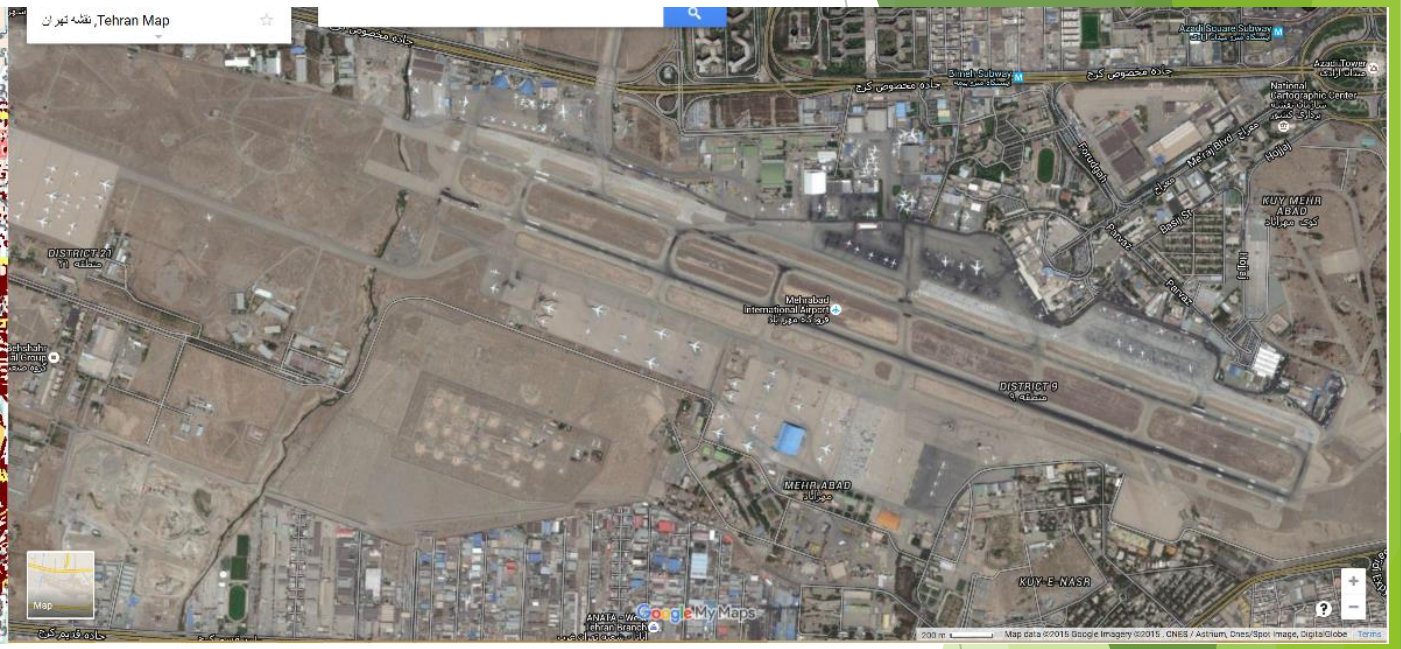
13 days averaged GeoEye LST in Aug.

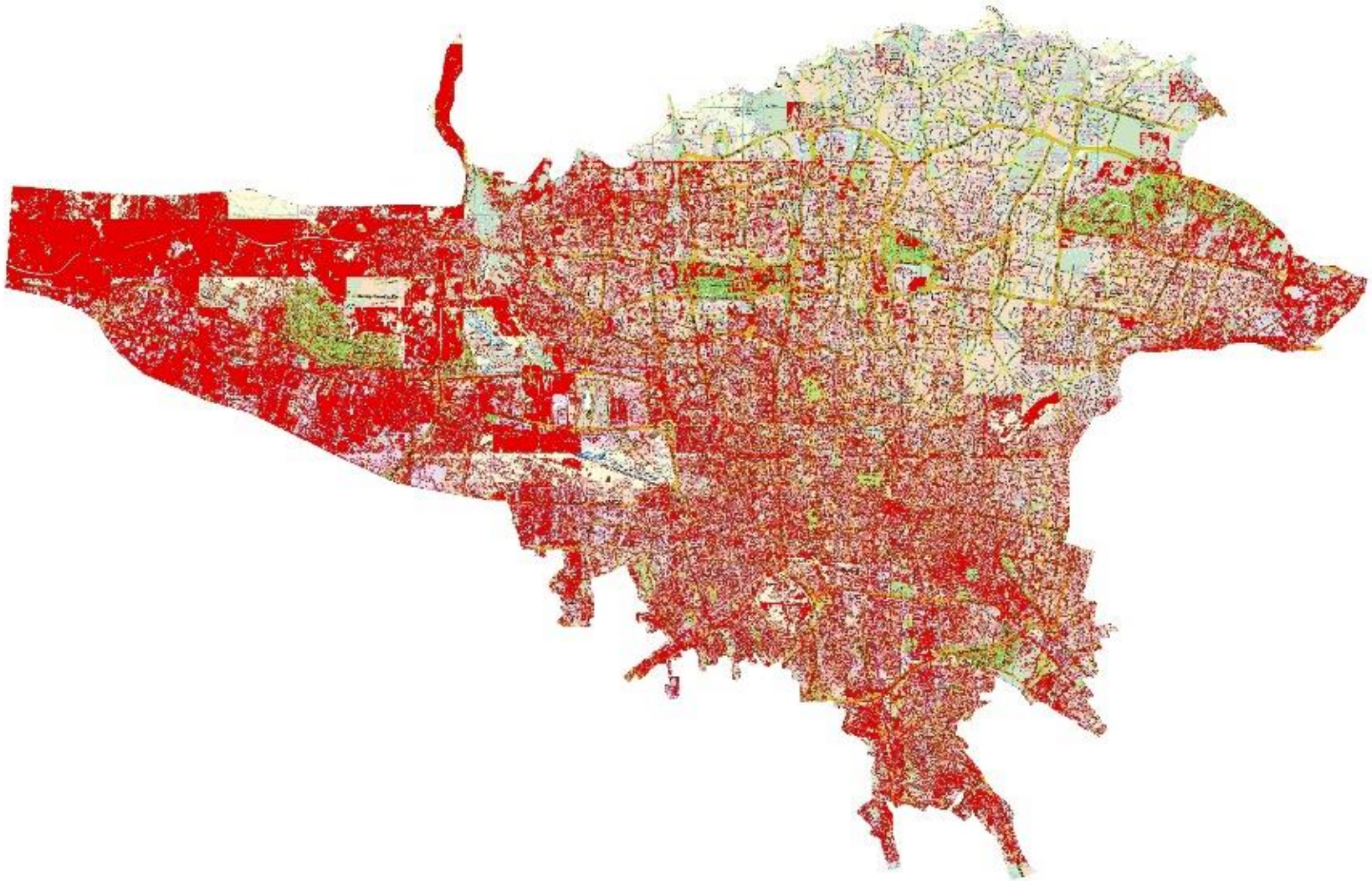




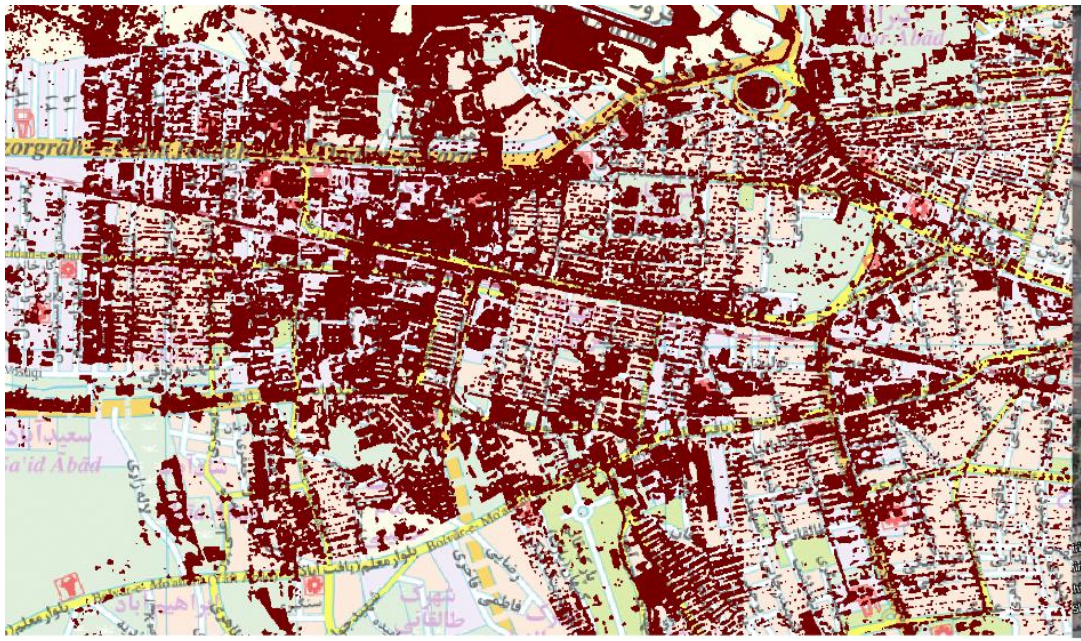
The most CRITICAL POINTS

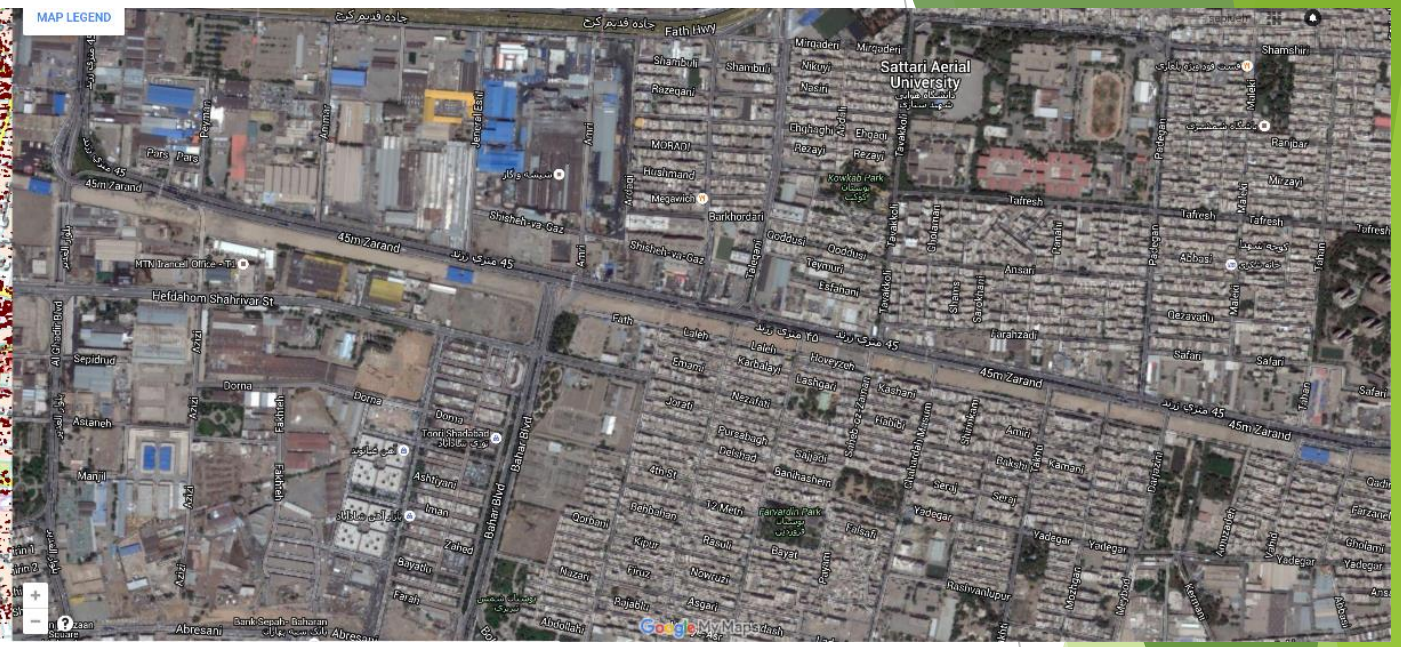

Karaj
گمرک مهرآباد
Bozorgrāh-e-Tehran-Karaj
Kuy-e-Sinā

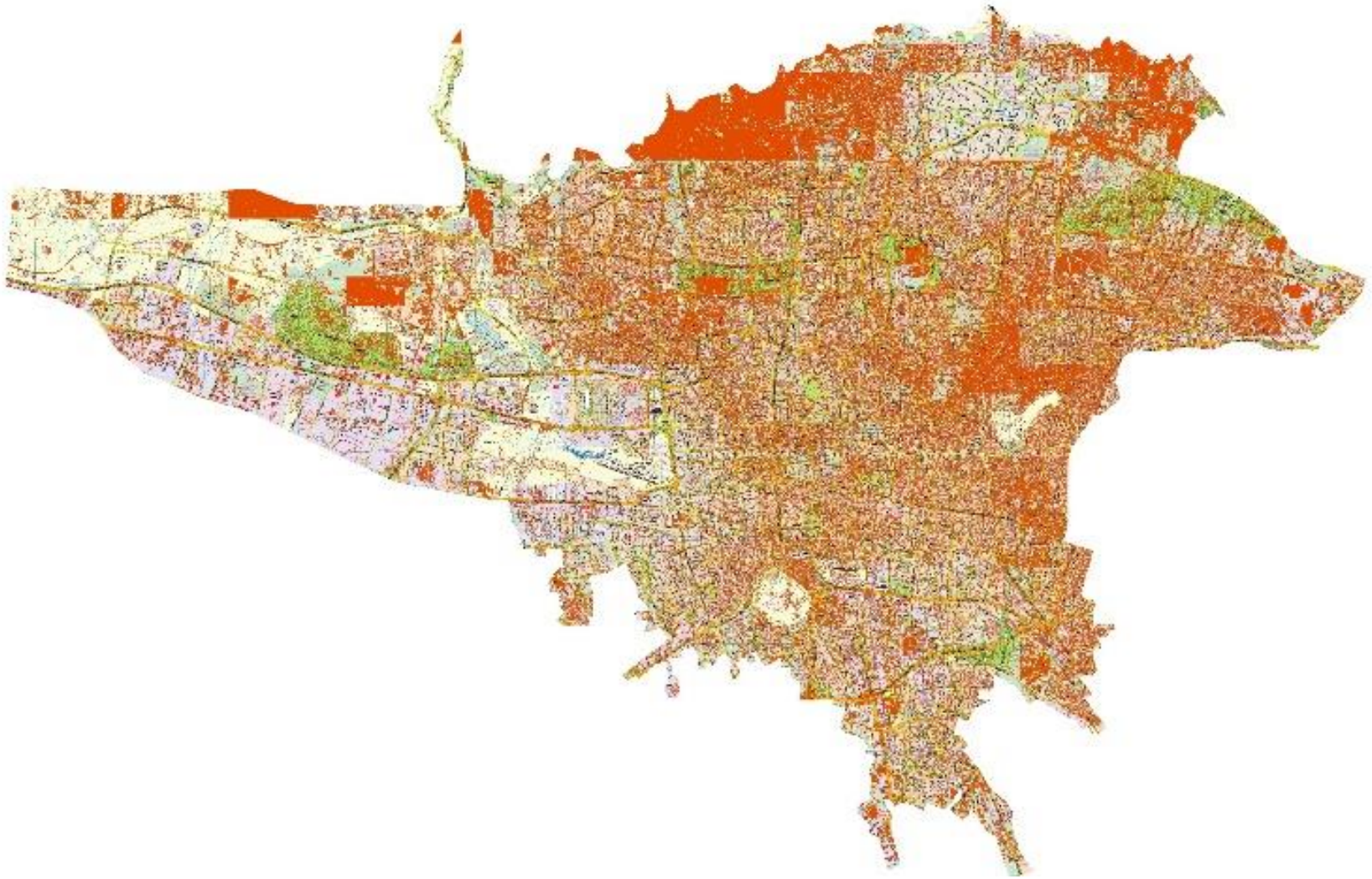

Tehran Map, نقشه تهران
DISTRICT 20
DISTRICT 9
MEHR ABAD
KUY-E NASR
KUY MEHR ABAD
Mehrabad International Airport
Azadi Square Subway
Google My Maps



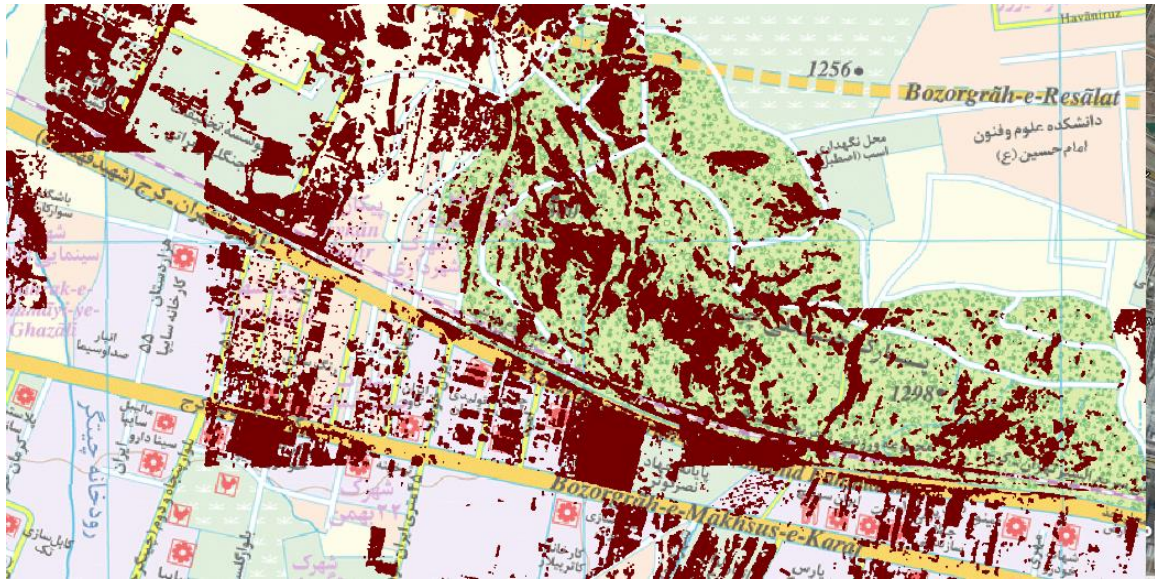
The second most CRITICAL POINTS

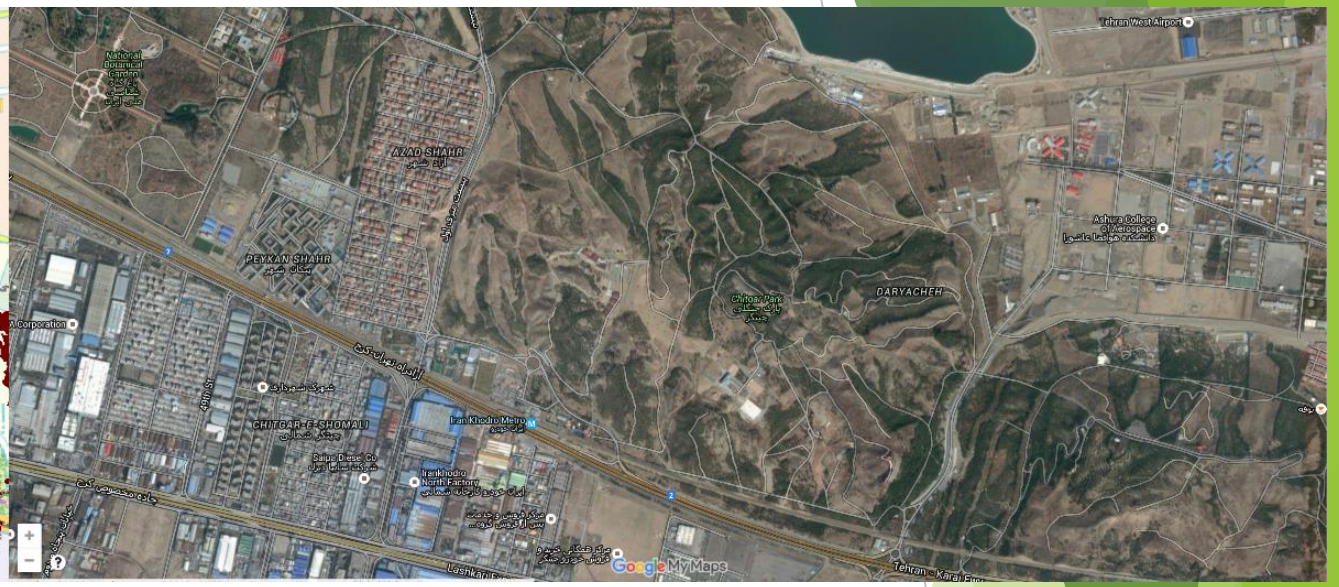



MAP LEGEND
Sattari Aerial University
45m Zarand
Hefdahom Shahrivar St
Bahar Blvd
Abresani



The third most CRITICAL POINTS


1256
Bozorgrāh-e-Resālat
1298
Bozorgrāh-e-Makhsus-e-Karaj


AZAD SHAHR
PEYKAN SHAHR
GHITGAR-E-SHOMALI
DARYACHEH
Tehran West Airport
Google My Maps

The next most CRITICAL POINTS

The least temperature class

Concluding remarks:

Applying this method to all industrial and big cities may:

1-help to locate city heat islands

2-help to change surface cover and increase albedos

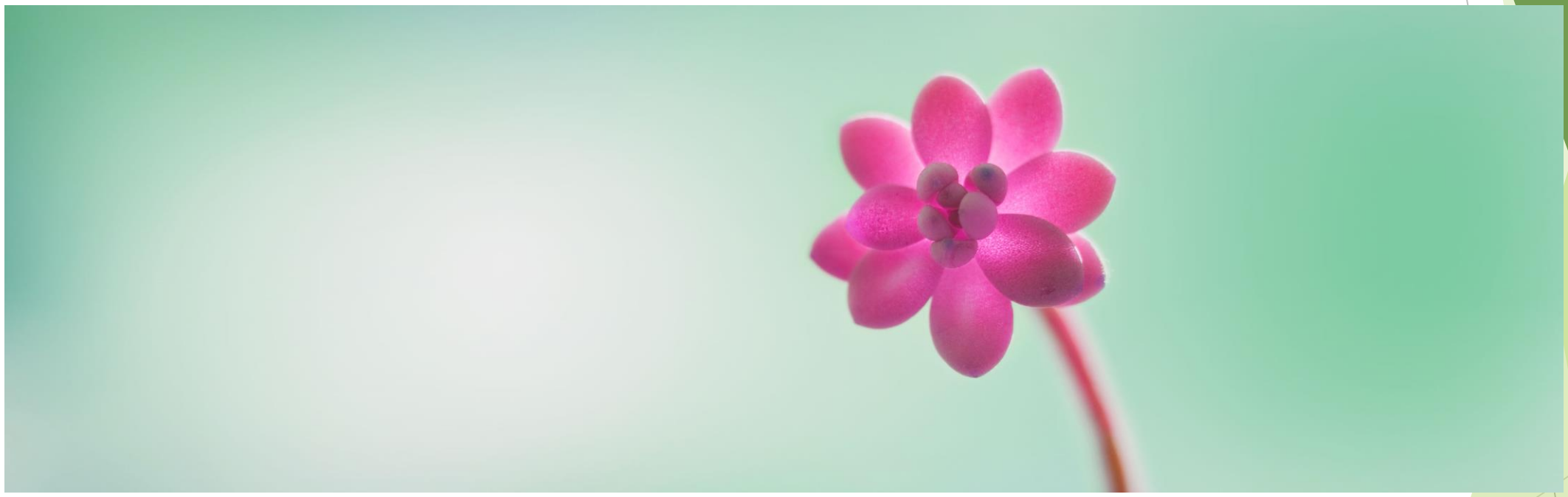
3-reduce electricity consumption, fossil fuel consumption

4- reduce green-house gases and pollutions

5-less water consumption

6- help to mitigate the effects of drought

Thanks for your patience and forbearance



Needed more detail, please Skype me on this number:
+989121226630, Mobasheri