

# Assessment of Urban Heat Island based on the relationship between Land Surface Temperature and Land Use/Land Cover in Greater Doha

## Abstract

Urban heat islands (UHI) are areas with elevated temperatures occurring in cities compared to surrounding rural areas. This research realizes the lack of research regarding trends of UHIs in arid cities and focuses on Doha. This study includes twelve months of two-time periods; 2000-2019. ArcGIS software was used to compute land surface temperature (LST) and Land use/land cover (LULC) maps to show how the city has evolved in 19 years. 30 field samples were used to verify the accuracy of LULC. Results showed higher temperatures were prevalent in out-skirts comprising of barren and built-up areas with high population and no vegetation. While main downtown with artificially planted vegetation and shade from skyscrapers created cooler microclimates. Overall LST of Doha has increased by 0.7°C from 2000 to 2019. Furthermore %LULC of built up, vegetation, barren land, marsh land and water body were 29%, 4.5%, 58.6%, 2.8% and 5% in 2000 and 56.5%, 8.2%, 33.2%, 0% and 2.1% in 2019 respectively. Transect profiles showed positive correlation between NDBI and LST and negative correlation between NDVI and LST.

## Objectives

- To analyse LST and its relationship with LULC, NDVI and NDBI.
- To determine the characteristics and fluctuations in LULC of greater Doha over a time series from 2000 and 2019.
- To explore the trend, location and pattern of UHIs using Geographic information systems for an arid environment represented by greater Doha city

## Literature Review

Records suggest that the mean air temperature of cities with over 1 million population can be 2.5 Kelvin warmer than surrounding rural areas (H. Akbari 2016).

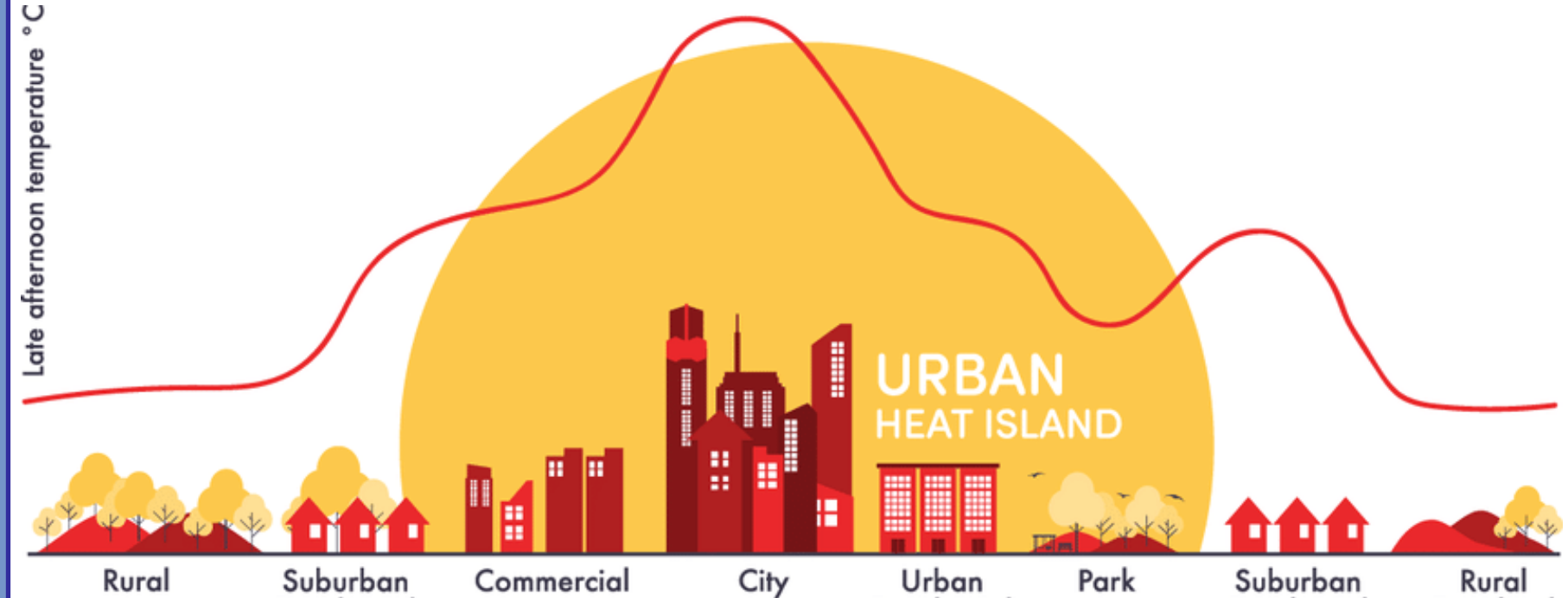


Figure 1 shows the concept of UHIs in cities and how temperature is affected by different Land covers.

Many studies conducted on relation between LST and LU/LC showed intensity of UHI is positively correlated with urban growth due to increase in impervious surfaces, traffic, population and low vegetation (Janilci, Richarde, & Celso, 2018).

Contrarily a study conducted in the city of Abu Dhabi, concluded that compared to UHI studies in non-desert cities; arid urban city had a lower temperature by 3 K compared to suburban outer skirts of the city (Larrazini et al., 2013). While other studies argue that building structures may not allow heat to escape from urban areas (Zhang, Qi, Ye, Cai, & Ma, 2013) (Taleb & Abu-Hijleh, 2013), Larrazini et al., suggests that in desert setting, tall buildings play the opposite role of shadowing the city from suns heat and providing cooler microclimates in the city. As there is a wide gap between these conclusions, more studies need to be conducted specially in desert countries such as Qatar to validate the results and allow for deeper understanding of heat islands in desert cities specially (Chunhong, 2018).

## Methodology

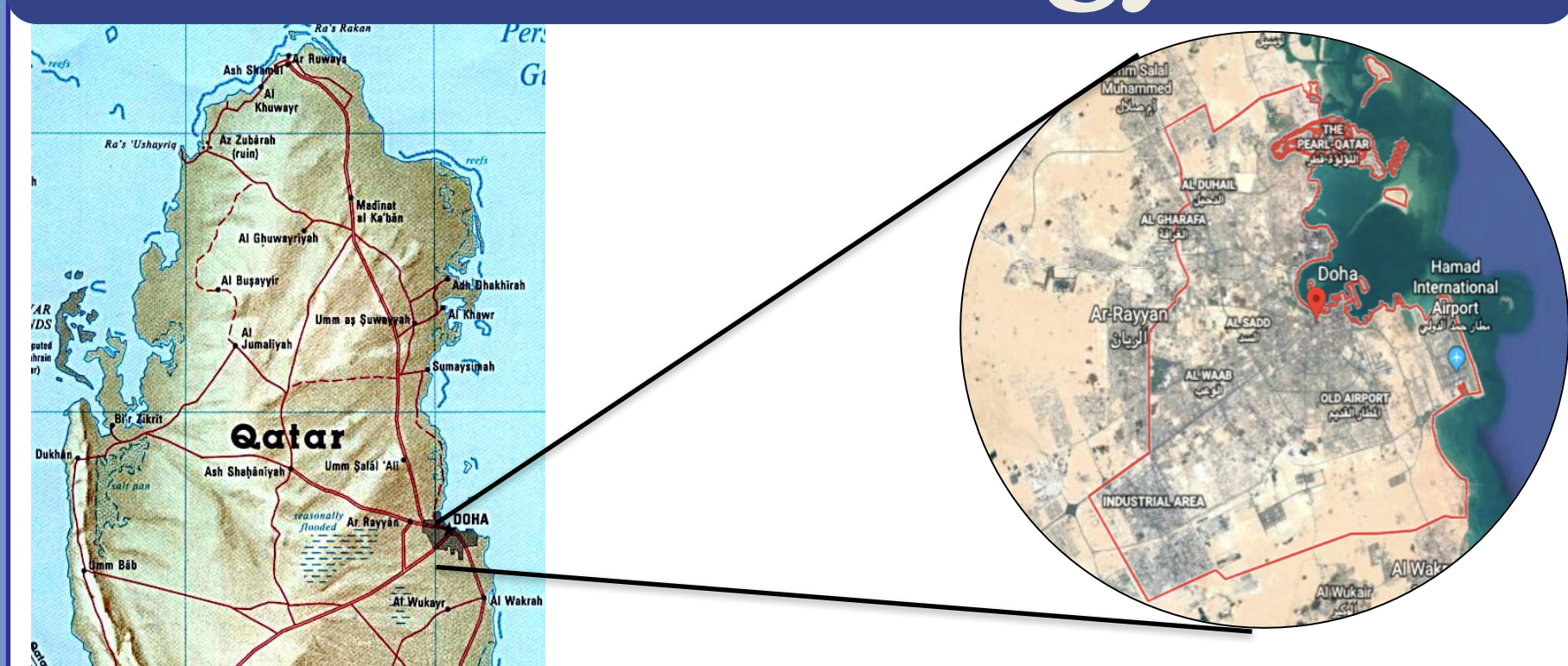
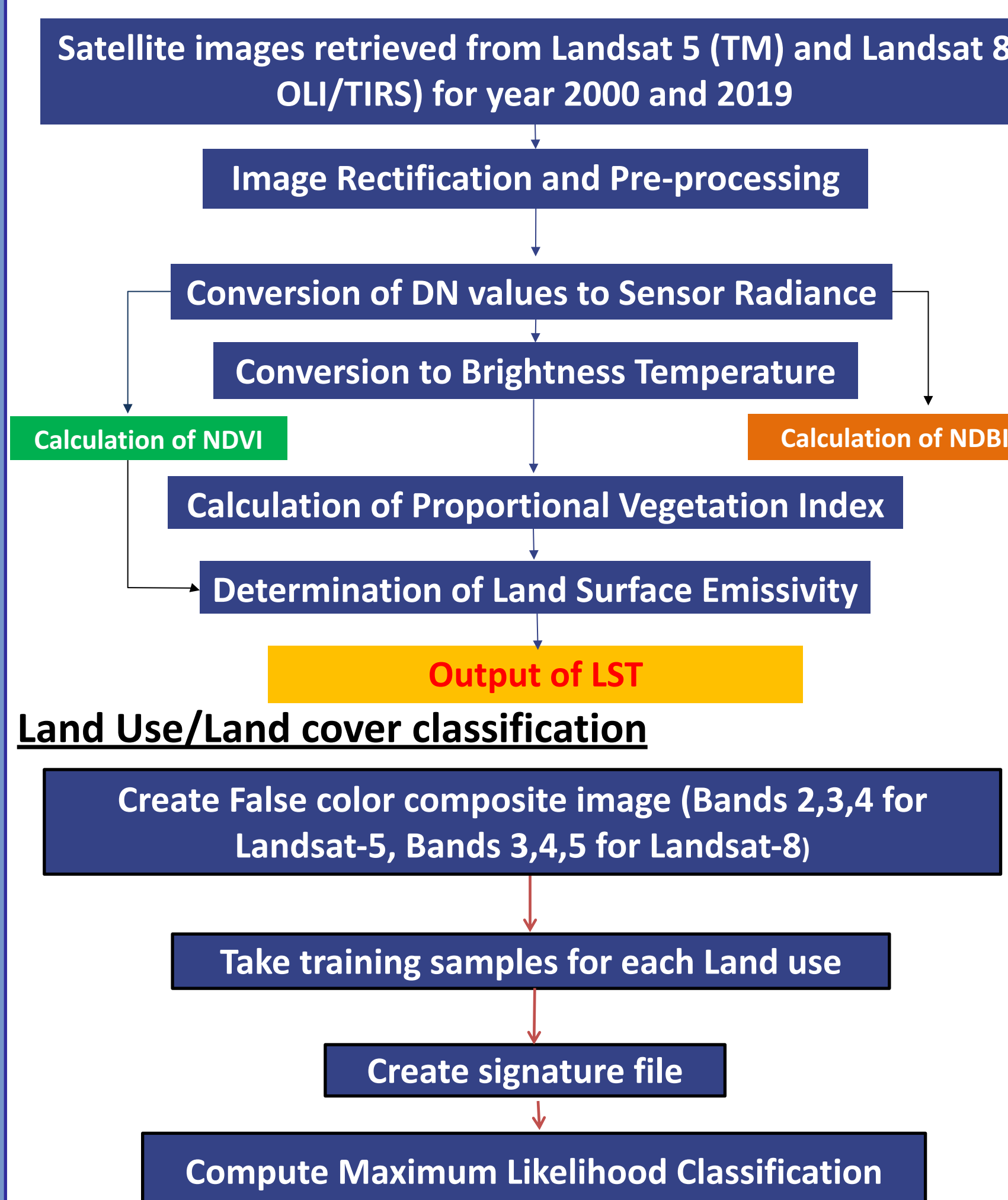


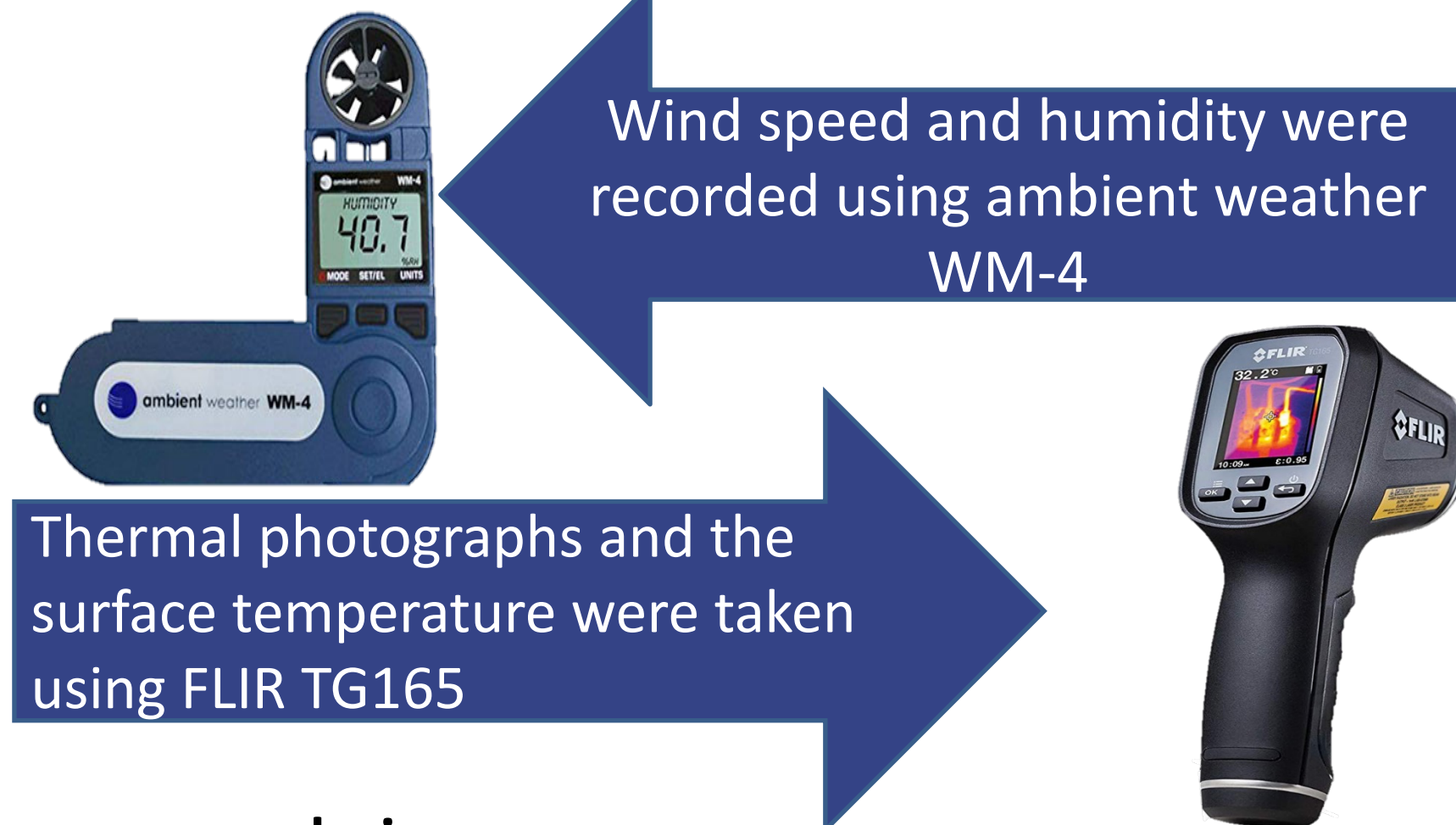
Figure 2: Doha was selected as the study area as it is one of the fastest growing cities in the gulf.

## Satellite Image processing using ArcGIS software



## Field Sampling

30 field samples were taken in 3 land cover categories: Open, Built and Green Areas. Water bodies were not classified as access was considered unsafe. Coordinates for each were recorded using using Coordinates- GPS Formatter app.



## Accuracy analysis

Accuracy for Land use/Land cover classification was verified using the field sample data.

## Comparison of LST versus NDVI and NDBI

- Profile curves to compare LST, NDVI and NDBI were created using ArcGIS

## Results & Discussion

### Land Surface Temperature pattern

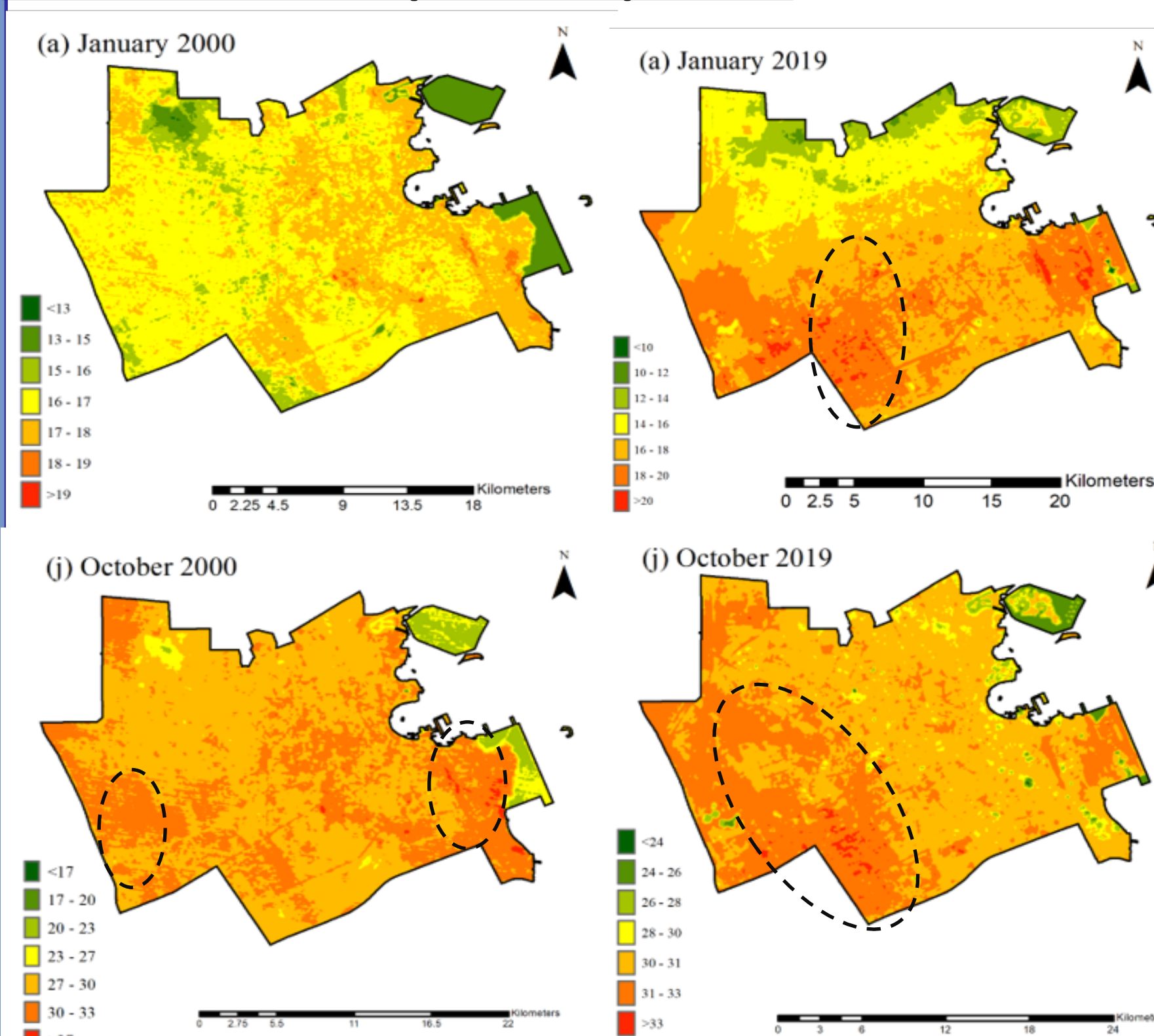


Figure 3: Spatial LST maps for Doha, a) January 2000, b) January 2019, c) October 2000, d) October 2019.

LST for January 2000 (fig.3a), shows higher temperature concentrated in eastern part of Doha, with 18°C to more than 19 °C. While in January 2019 (fig.3b), more heat can be noted on the south western part (18°C to greater than 20°C), showing a significant pattern of UHI. Pattern of UHI in October 2000 and 2019 (fig.3 c,d) can be noted as well, most of the heat accumulation occurs in south western and eastern areas in 2000 with temperature rising above 37°C. Meanwhile in October of 2019, higher temperature is noted in the western part, which consists of barren and industrial urban land.

## Land use/Land cover Classification

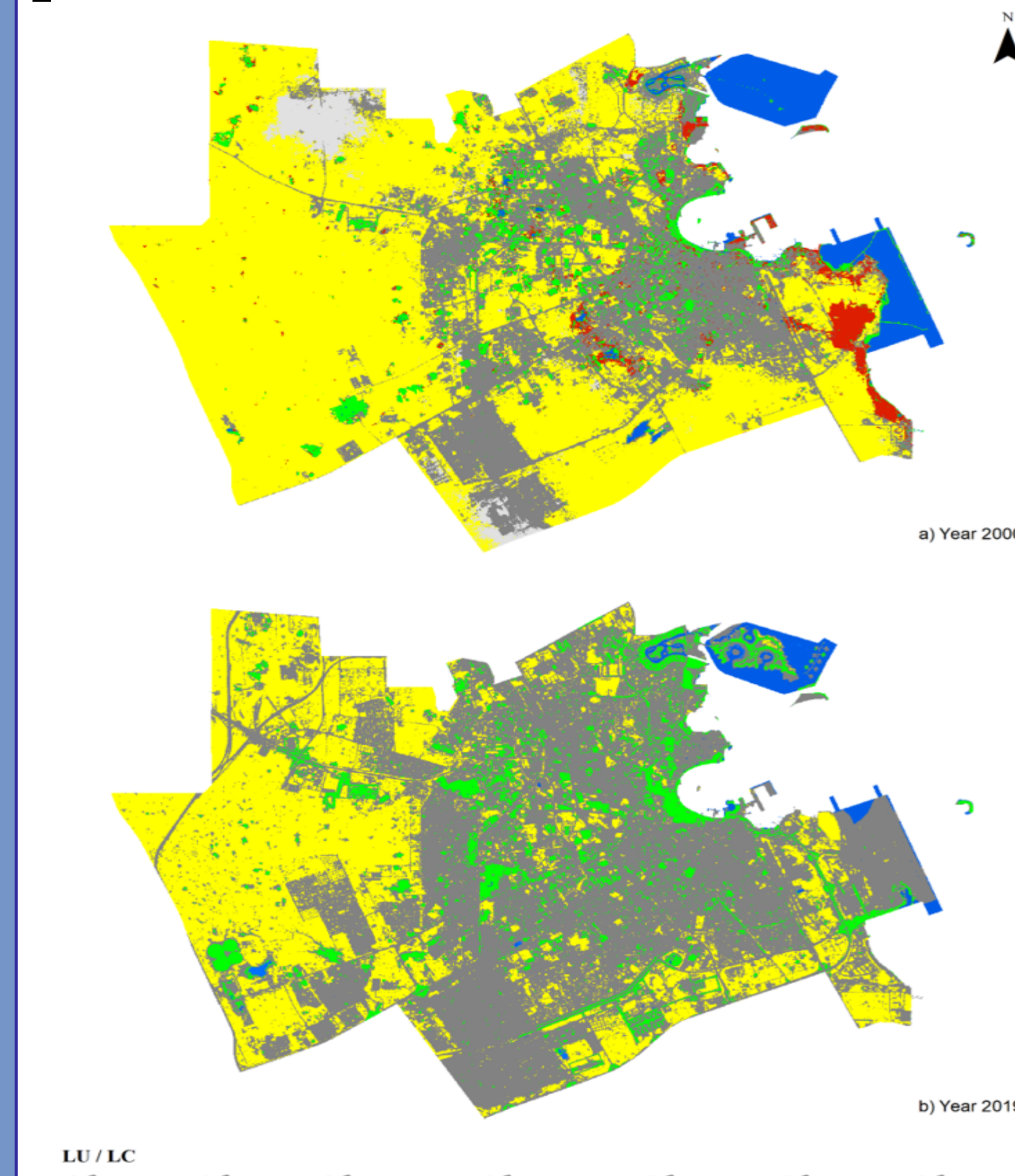


Figure 4: Spatial LU/LC for Doha, a) LU/LC map for 2000, b) LU/LC map for 2019. The map of Doha in 2000 shows more barren land which has decreased in 2019 by 25 %. While there is an increase in built-up area by 27 % and an increase in vegetation by 4 %. A decrease in water bodies is also visible in north east where Pearl was built and Southeast where the new airport was built, decreasing waterbody area by almost 3%. Marsh land areas have also been reclaimed since 2000 and have been completely eliminated in 2019.

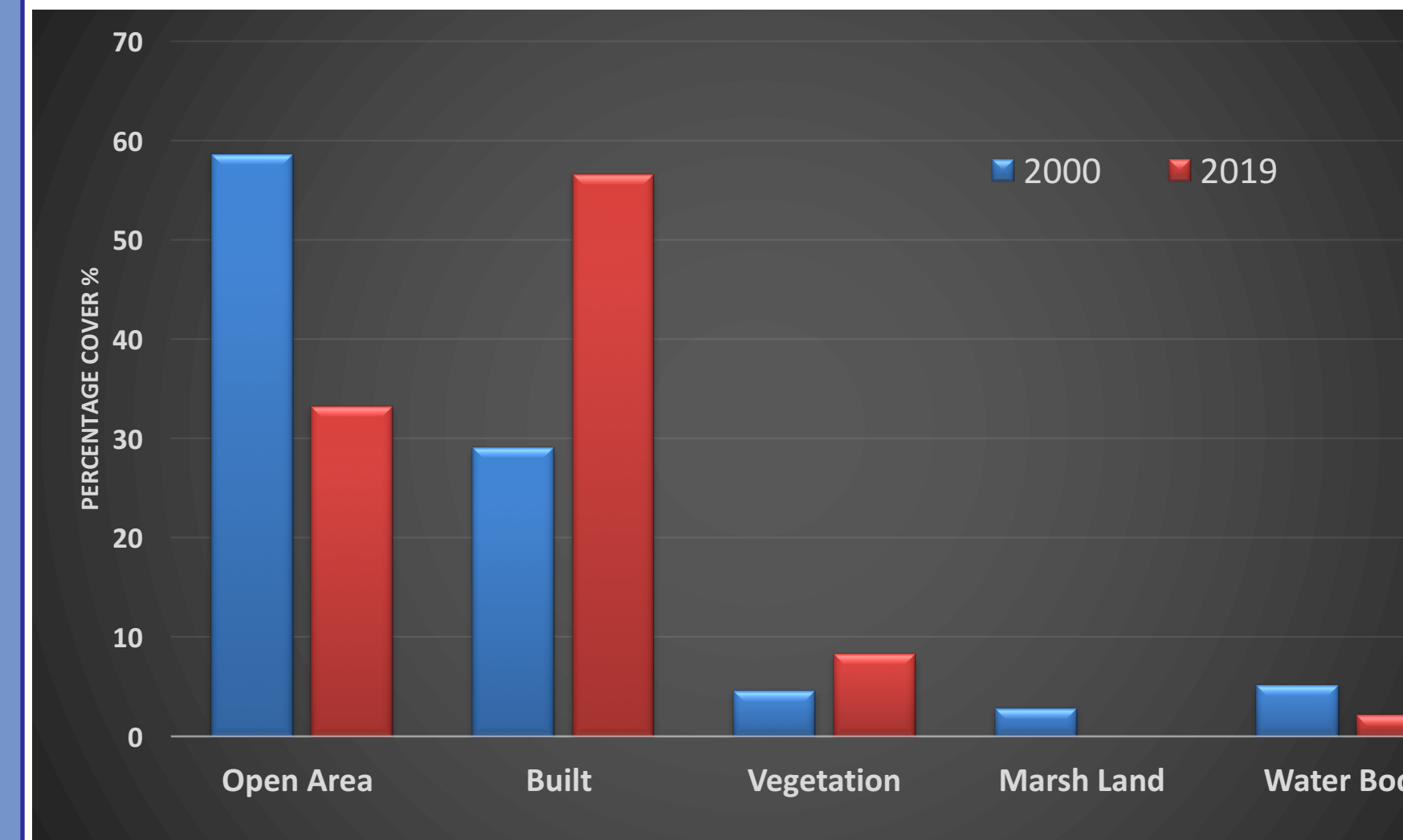
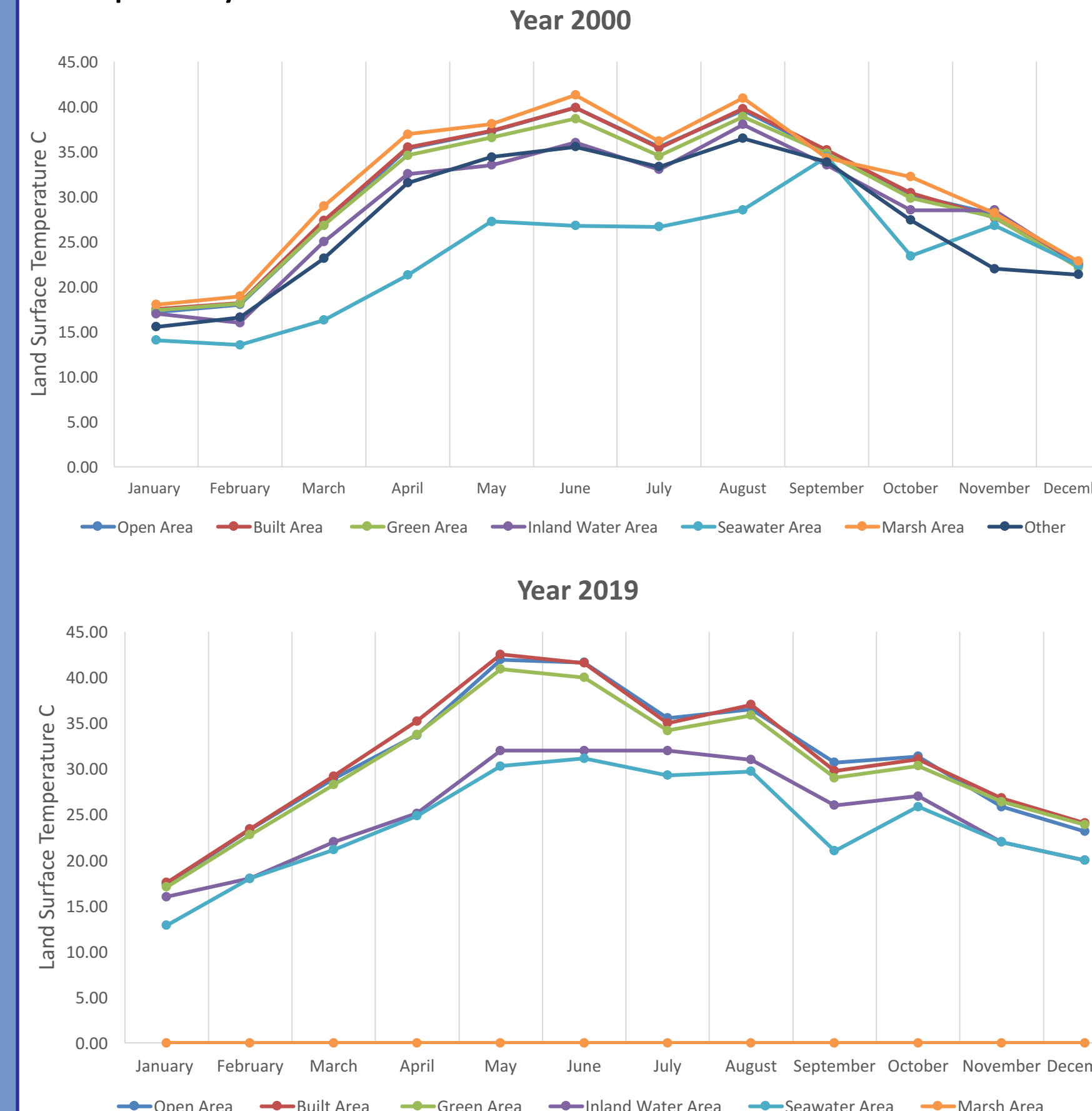


Figure 5: shows the change in land use/land cover from 2000 to 2019. There is an increase in Built up land and vegetation in 2019 and a decrease of Barren area and water body due to reclamation of land for building of areas such as the Pearl and Airport. While Marsh land has completely ceased.



Graph1: Monthly LST for each land use in a) 2000, b) 2019. Highest temperatures were found in marsh area class in 2000 and in open and built area classes in 2019. The lowest mean temperatures were recorded for seawater class in both years. In compliance with most UHI studies, this study shows elevated temperatures in Urban areas. But an unexpected finding of this study was higher temperatures in the outskirts barren land areas.



Figure 6: shows the field samples for different Land covers, a) Green area (Aspire Park), b) Barren area (Duhail), c) Built-up area (Industrial area). The overall accuracy for LU/LC classification was 90% and the kappa coefficient was calculated to be 0.85 which shows that classification was almost perfectly generated LST, NDVI and NDBI profile

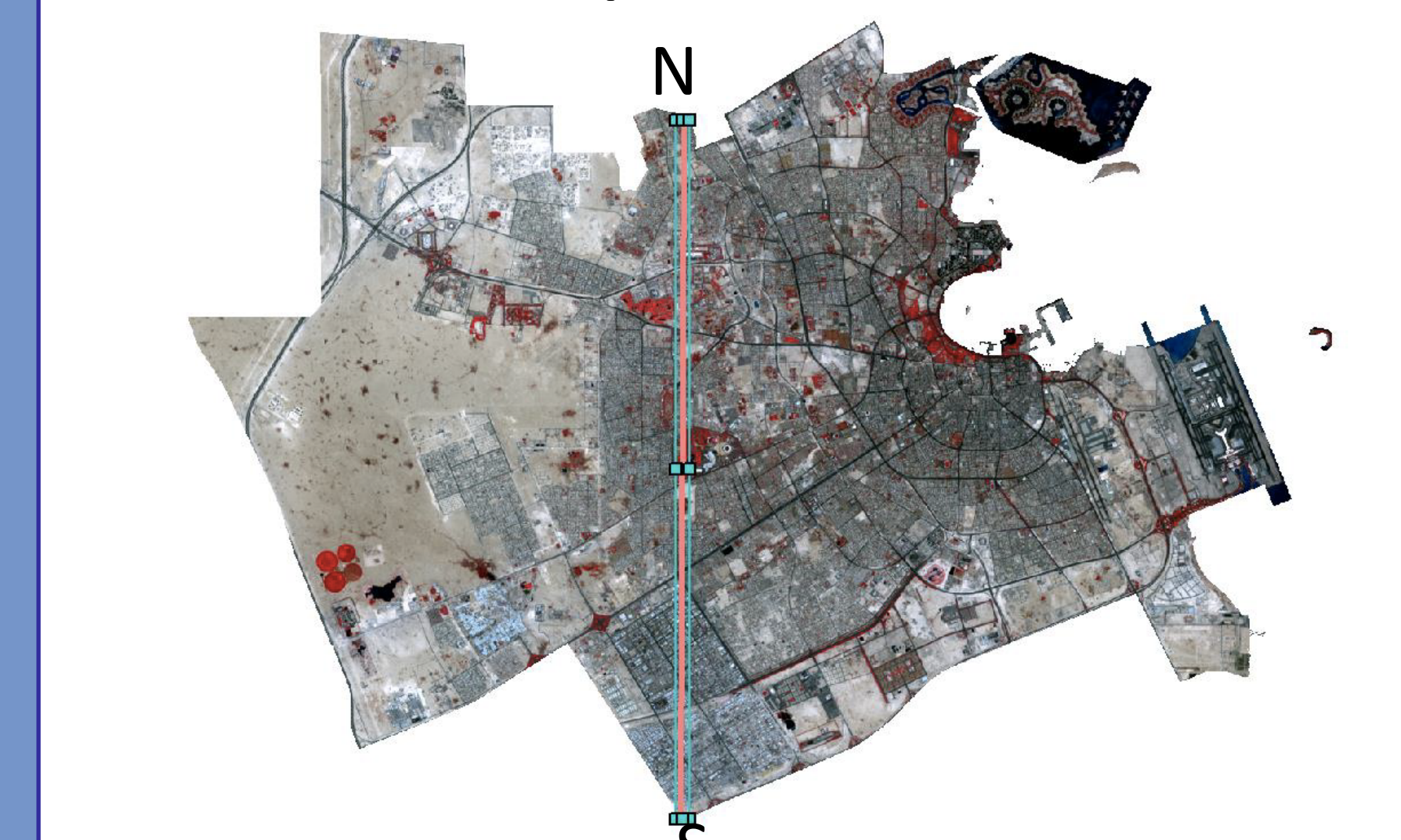


Figure 7: shows the profile curves of Doha from North to South in July, 2019, a) LST profile, b) NDVI profile, c) NDBI profile.

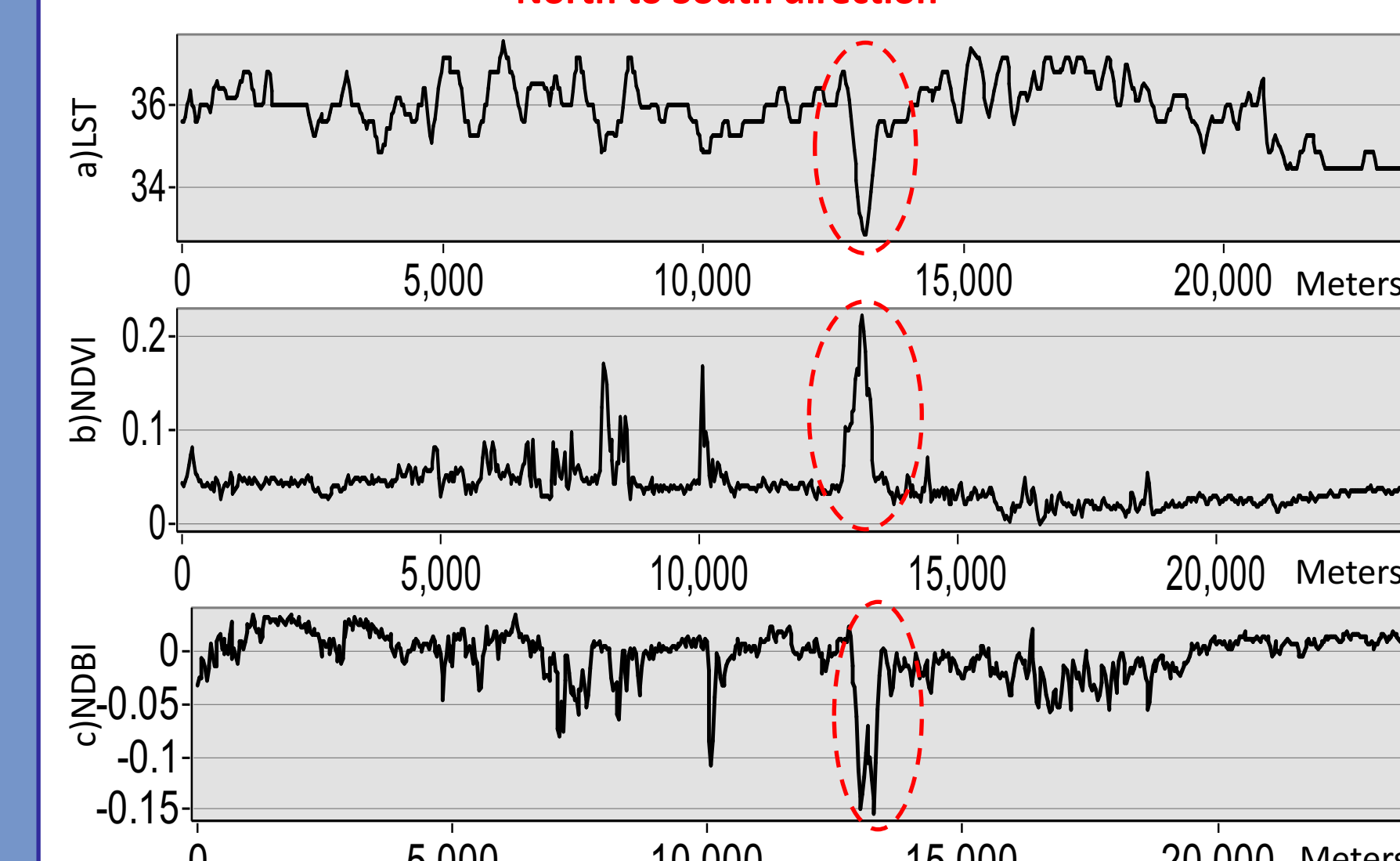


Figure 7: shows the profile curves of Doha from North to South in July, 2019, a) LST profile, b) NDVI profile, c) NDBI profile. As LST decreases there is an increase in NDVI at around 13000 m showing that NDVI is inversely proportional to LST. While for areas with high LST ranges from 36C and above the NDBI curve also shows high peaks between 0-0.1 showing that NDBI is positively correlated with LST. As impervious surfaces increase so does the heat in those areas.

## Conclusion

Overall, it can be said that the pattern of UHIs in Doha city differed from studies conducted in temperate and tropical cities. This study denies the common hypothesis of UHI existing in main urban city areas where abundance of high rising buildings exists. Desert cities such as Doha, Qatar have more vegetation in main city areas compared to the suburban and rural areas. The outer industrial and rural area having barren land absorbed more heat from direct sunlight due to lack of vegetation. Meanwhile Built up land use had tall sky scrapers creating a shadow effect and decreasing surface temperature of downtown Doha.

## References

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