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; 2000-2002. 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-skitrs 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.

Objectives

- To analyse LST and its relationship with LULC, NDVI and NDBI.
- To identify 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. Alkabi, 2016).

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, Richard, & Celso, 2018).

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 (Larrazine 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), Larrazine et al., suggests that in desert setting, tall buildings play the opposite role of shadowing the city from sun 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 desert Islands in desert cities specially (Chunhong, 2018).

Methods

Field Sampling

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

Results & Discussion

Land Surface Temperature pattern

Figure 3: Spatial LST maps for Doha, a) January 2000, b) January 2018, 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 for the city from part (18°C to greater than 20°C), showing a significant pattern of UHI. Pattern of LST in October 2000 and 2019 (fig 3c-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.

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 0.01 showing that NDBI is positively correlated with LST. As impervious surfaces increase so does the heat in those areas.

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.

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 had tall sky scrappers creating a shadow effect and decreasing surface temperature of downtown Doha.

References