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Effects of Urban Sprawl on Temperature – A Case Study of Karachi

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***Abstract*— Right from independence of Pakistan till date, Karachi's population has increased exponentially thanks to growing rates of migration in middle class families. While this increment calls for applause, in actual it is affecting city's environment adversely. Increase in ambient temperature and pollution can attest to that. Consequently, demands for food and water have drastically increased leaving behind a huge gap to ponder. This study, therefore, aims to thrive for land cover change pattern of Karachi city. The pattern would reflect the amount of land consumed by urban sprawl that was originally assigned to agricultural activities. Further interpretation would be in context of heat intensity and migration rates of Karachi.**

***Keywords*—Urban Heat Island (UHI), Land Surface Temperature (LST), Land Use Land Cover (LULC), Urban Sprawl, Karachi.**

I. Introduction

Urbanization along with technology has brought drastic change in land use and lands cover both at global and regional scale. Pakistan is a strong candidate of urbanization for its major cities are expanding exponentially and haphazardly. Karachi, one of many cosmopolitan cities, is major victim of urbanization bearing 24 million people only 4 million back from New York City *(Fikree, 1996).* Asian Development Bank report states that Karachi's population would increase 50%, in next 15 years, that would make it seventh most populous city of the world *(Tribune, Pakistan).* Report depicts an alarming situation begging urgency for strategies and management of resource allocation. These resources primarily include land and water. Unfortunately Karachi is scarce in both resources. Karachi Water & Sewerage Board (KWSB) states that per capita demand at rate of 54 GPCD is 1080 MGD while present supply is hardly 650 MGD having a gap of 430 MGD. If current rate of demographical expansion continued then the gap would probably increase. Situation with land is not impressive. This study would enlighten the land use change pattern of Karachi since 16 years and change in water demand. It is mainly concerned in delineating a pattern of expansion be it present past or future.

According to an NGO report, number of houses in 2005 was about 2.1 million and by 2020 predicted to be 3.9 million. This precisely narrates 1.77 million households at an average size of seven people per household. Land is already scarce and profuse migration from rural areas is exacerbating condition altogether putting heavy pressure on the physical, infrastructural, financial and institutional systems of city not to mention food nexus. Karachi is undergoing vertical as well as horizontal growth which is eating agricultural land that resides in hinterland. This urban sprawl is main culprit in increasing ambient temperature.

II. Objectives

This study aims to delineate past, present and future land use trend; analyse migration rate; examine expansion pattern: one-dimensional or multidimensional; and finally provide cognitive recommendation to policy maker relating urbanization.

III. Methodology

A. Data acquisition

Data is acquired in two ways: Primary and Secondary

Primary data is prioritized. It includes satellite data-main content of study. Secondary source boils down to publish materials.

1) *Satellite Data:* For baseline study, Landsat 7 enhanced thematic mapper+ data is acquired from official earth explorer USGS website (*earthexplorer.usgs.gov*).
2) *Published data:* The published research work from different relevant articles is used to get the guidance for this study.

B. Processing

Software: After data acquisition, GIS software is used for processing. Precisely, the software is ArcGIS 10.1. An image analysis would be done in order to extract required data from remote sensing image.

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C. Classification

This phase was carried out in two ways:

1. A supervised classification was done that successfully detected area of water, urban sprawl and barren land. However, it failed to delineate area of vegetation correctly. When searched for reason, it was found that few small patches of vegetation, significantly less than 30 metre-pixel size of Landsat-were present in the area. This results in to carrying out research in two phases.
2. Classification with aid of NDVI was meticulously carried out in order to acquire area for vegetation.

D. Thermal Analysis:

This analysis included Band 6 of Landsat image.

The analysis is done in ArcMap 10.1. With aid of raster calculator, one of spatial analyst tools, temperature was calculated. Calculator performed manipulations on the basis of formulas mentioned below:

$$L\lambda = ((LMAX\lambda - LMIN\lambda)/ (QCALMAX-QCALMIN)) * (QCAL-QCALMIN) + LMIN\lambda$$

$$T= (K2/\ln (K1/ L\lambda+1))-273.16$$

Where,
T= surface temperature in celcius.

For Band #6 following values can be acquired from metadata

$LMAX\lambda=17.04$
$LMIN\lambda=0$
$QCALMAX=255$
$QCALMIN=1$

It is worth to note that formulas vary with the type of Landsat. In this study Landsat 7 has been utilized.

E. Analysis:

Processed data was analyzed in EXCEL to delineate a trend of land cover changes as well as temperature analysis.

IV. Material Of Study

This study would engage Landsat images obtained Landsat 7. Image correction will be done by using ERDAS Imagine: powerful tool for imagery processing and analysis. Remote sensing images utilized would be for year 2000, 2001, 2003, 2007, 2011, 2015 in order to visualize the land covers and temperatures of Karachi. These images would later assess the effect of land cover changes on temperature rise and ultimate impact on water cycle in the locality.

Landsat 7 ETM+ images consist of 8 spectral bands with a spatial resolution of 30 meters for band 1 to 7. The panchromatic band 8 has a resolution of 15 meters. All bands can collect one of two gain settings (high or low) for increased radiometric sensitivity and dynamic range, while Band 6 collects both high and low gain for all scenes. Approximate scene size is 170 km north-south by 183 km east-west (106 miles by 114 miles).

Landsat 7 Enhanced Thematic Mapper Plus (ETM+) Scan Line Corrector Off (SLC-Off) has following salient features

1. Images acquired after July 2003 are displayed as RGB composites, bands 5, 4, and 3. Landsat 7 ETM+ scenes acquired from 5/31/03 - 7/14/03 and 9/3/03 - 9/17/03 are not available.
2. Images are resampled to a pixel size of 180 meters from the original 30-meter data.
3. The "Show Browse" option displays an overlay that illustrates the approximate extent of the SLC-off image gaps.
4. Each Landsat 7 scene is color-stretched based on individual scene content. This may result in an apparent mismatch of colors between scenes.
5. In the 240-meter display mode, browse images are JPEG compressed files with an average file size of ~130K. In the 1000-meter display mode, the browse images are GIFs with an average file size of ~35K.
6. The browse previews that are used to create the "Show Browse" display are uncorrected images in satellite orientation, and they can be viewed in a separate window.

Increase in urbanization would adversely affect climate. Temperature would be raised; cropping pattern completely changed; variation in crops; reduction of water availability; alteration in monsoon pattern and transformations of monsoon duration are few of many symptoms illuminating climate change. To visualize all these effects this study will carefully analyse satellite images to find out relation of land cover changes on all these entities.

V. Results

Less than 2% of worlds land surface is occupied by urbanization as in the form of buildup and paved surfaces *(Meyer, 1994).*With the results found it can be depicted that on average 8.97% urban developemnt per year has been carried for karachi in 15 years also suggesting surcafe area occupation will increase significantly as rapid urban growth is taking place *(Xu, 2007).*As urbanization is increasing barren land is being convered into builtup areas and paved surfaces contracing the barren land and expanding urban

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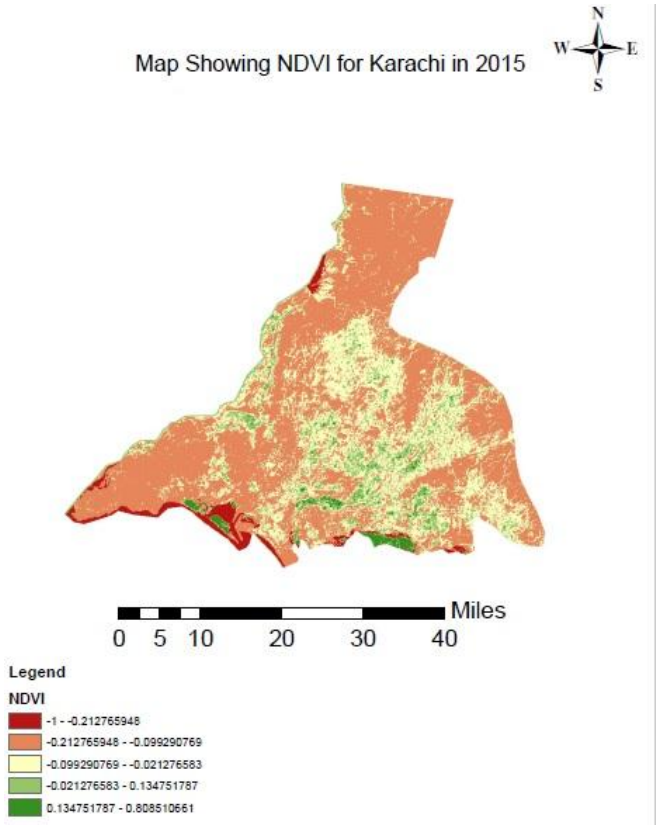
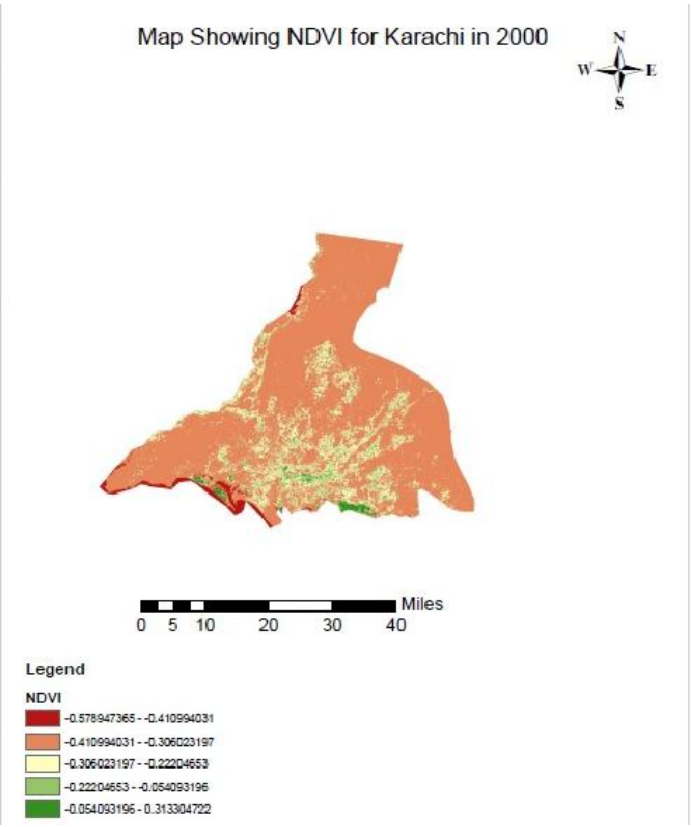
sprawl.In terms of vegetation karachi has no ample resources of water to produce mass level agriculture, proposing vegetaition mostly observed in mangrooves.

So the increase and decrease in vegetation is the affect of moonsoon rainfalls and behavior of sea towards mangroves.





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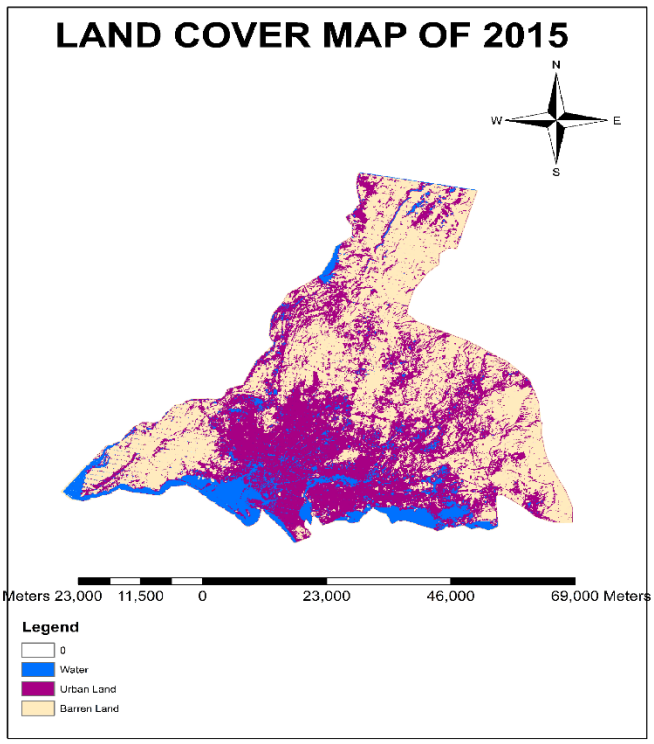
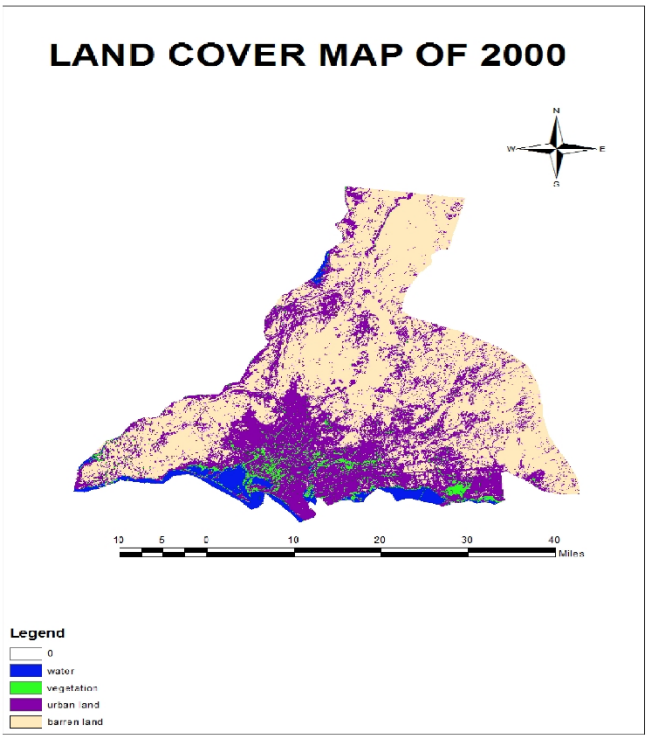
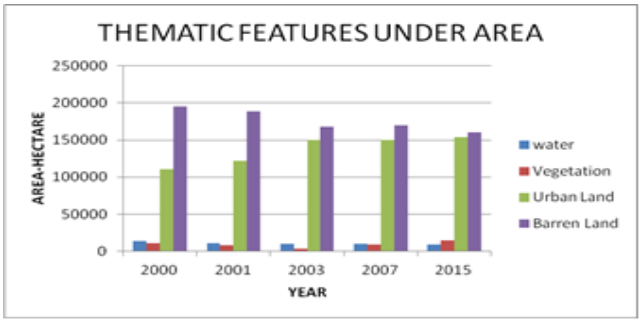
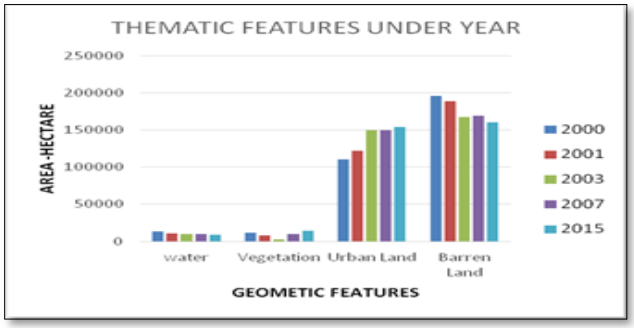




CLASS	2000	2001	2003	2007	2015
water	13733.66663	10675.75473	10100.73211	10013.94102	9057.569939
Vegetation	11365.73271	8324.026969	3124.132526	9400.590056	14316.69168
Urban Land	110476.0504	121723.2094	149583.2562	149765.4643	153810.2059
Barren Land	195572.3763	188772.8232	167513.6992	169404.8812	160591.2953





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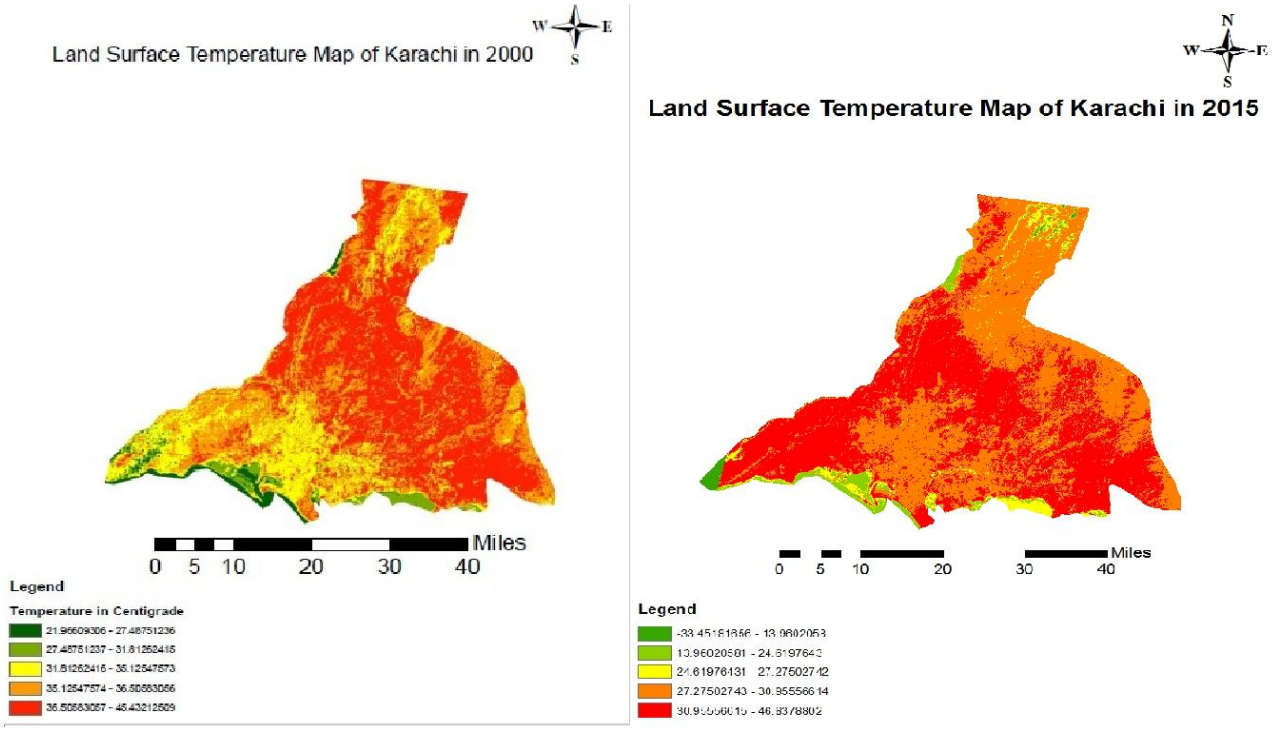

Figure 1 caption

VI. Discussion

The above analysis depicts very likely pattern of urban sprawl and vegetation. Right from 2000 to 2015, little amount of depletion in water has occurred. It's because of the fact that Karachi is mainly bestowed with two water resources Hub Dam & Sea Water. Conversely, there is steady increase in urban sprawl. Similar is the case with vegetation, 2003 being an exceptional case. Consequently, urbanization has made prominent decrease in barren land.

Furthermore, there has been aggregate radial expansion in existing urban sprawl in the north east of Karachi i.e. Gadap. Expansion has been visible in north of Surjani Town. Depletion of urbanization has been detected in south west of Karachi. While as unidirectional expansion has been detected in north east side of super highway.

Karachi portrays unique thermal effect. In general, urban areas are warmer than their surroundings. The case of Karachi is an entirely opposite tale for it has positive effect of urbanization on heat. Mean surface temperature in the rural area is greater than the urban area, but lower than that of high density urban area (*Xian, An analysis of urban thermal characteristics and associated land cover in Tampa Bay and Las Vegas using Landsat satellite data, 2006*).

This bizarre effect is only observed in areas with desert blankets, where amount of vegetation is minimum. Initial analysis of Karachi confirms such unique temperature behaviour. With spread of urban sprawl temperature has been decreased. The reason can be proximity of arid & humid area that altogether discourages vegetation and increase temperature. From thermal land surface temperature it can be seen that presence of vegetation significantly elevated temperature.

References

[1] Landsat, N. (n.d.). Science Data Users Handbook.

[2] Landsberg, H. E. (1981). The urban climate. Academic press.

[3] Meyer, W. B. (1994). Changes in land use and land cover: a global perspective. Cambridge University Press..

[4] Xian, G. a. (2006). An analysis of urban thermal characteristics and associated land cover in Tampa Bay and Las Vegas using Landsat satellite data. Remote Sensing of environment, 104, 147--156.

[5] Xian, G. a. (2006). An analysis of urban thermal characteristics and associated land cover in Tampa Bay and Las Vegas using Landsat satellite data. Remote Sensing of environment, 147--156.

[6] Xu, C. a. (2007). The spatiotemporal dynamics of rapid urban growth in the Nanjing metropolitan region of China. Landscape ecology, 22(Springer), 925--937.