CHARACTERIZATION OF ENERGY EXCHANGE PARAMETERS IN THE HIMALAYAN FOOTHILLS PAKISTAN

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INTRODUCTION

The characterization of energy exchange parameters for spring season (April-May) has been done for Margalla hills national park (MHNP) Islamabad, Pakistan. It is important because Islamabad city lies in the foothills of Himalayas and micro meteorological activity makes the climate of surrounding areas. The activity on Himalaya's foothills (i.e., Margalla hills) regulate weather and also provide fresh water to the lakes and ponds by late afternoon thunder showers. The objective of this study is to characterize the energy exchange parameters in the foothills of great Himalayas particularly on MHNP. Landsat ETM+ imageries have been used for calculating the land surface temperature (LST), normalized difference vegetation index (NDVI), and normalized difference moisture index (NDMI). SPOT 5 image has been used for land use/land cover classification over MHNP. Weather and surface conditions become more favorable for the growth of vegetation by the end of April as the spring season reaches at its peak. There is the start of growing season in the month of April whereas the vegetation becomes thick over time during the month of May over Margalla hills however, the energy exchange parameters follow the same pattern in May as in April. The relative humidity remains between 18 - 55 % and the atmospheric temperature variations are between 19 to 35 ^oC during the studied period. As the atmospheric temperature and RH fluctuate, it effects the soil moisture and land surface temperature. Even if the atmospheric temperature rise or fall, the evergreen vegetation is found throughout the year on Margalla hills maintains/regulates the land surface temperature and soil moisture.

METHODS

The LST, NDVI, and NDMI were calculated by using 30 m spatial resolution imageries of Landsat 7 Enhanced Thematic Mapper Plus (ETM+) satellite for years April 2000 and May 2002. The Landsat 7 ETM+ satellite imageries were downloaded from USGS website. The SPOT 5 multispectral dataset of 10 m spatial resolution of Islamabad was processed for supervised classification. The total area of the study region was calculated as 145 Km^2. The satellite imageries were processed in Spatial Modeler of Erdas Imagine 9.4 for the calculation of considered parameters. The 6.2 thermal band of Landsat 7 ETM+ has been used to calculate the spectral radiance by eq. 1 and was computed in the eq. 2:

$$L_{\lambda} = L_{Min} + \frac{(L_{Max} - L_{Min}) \times DN}{MaxGray} \quad \dots \ (1)$$

Where L_{λ} denotes the spectral radiance at the aperture of the sensor ($W\, m^{-2}\, sr^{-1}\, \mu m^{-1}$)

$$LST = \frac{T_B}{1 + \left(\frac{\lambda_* T_B}{\rho}\right) . ln\varepsilon} \quad \dots \ (2)$$

Where $_{\rho}$ = 5.67 x 10^{-8} Wm^{-2} $^oK^{-4}$ and is called the Stefan Boltzmann constant. The LST was calculated in ^oK and is then converted to ^oC by using T(K)-273.15. NDMI was calculated by eq.3

$$NDMI = \frac{[\text{band } 4 - \text{band}5]}{[\text{band } 4 + \text{band}5]} \quad \dots \ (3)$$

NDVI was calculated by eq. 4

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad \dots \ (4)$$

The 48 points in the study area were randomly selected to calculate the parameters in study area (i.e. MHNP). The relationship among all parameters (NDMI, NDVI, and LST) was analysed on these points and presented in the graphical form.

OBJECTIVES

This study intends to characterize the energy exchange parameters such as normalized difference moisture index (soil moisture or NDMI), land surface temperature (LST), normalized difference vegetation index (NDVI), atmospheric temperature and relative humidity over the MHNP Islamabad during peak spring season i.e., April and May.

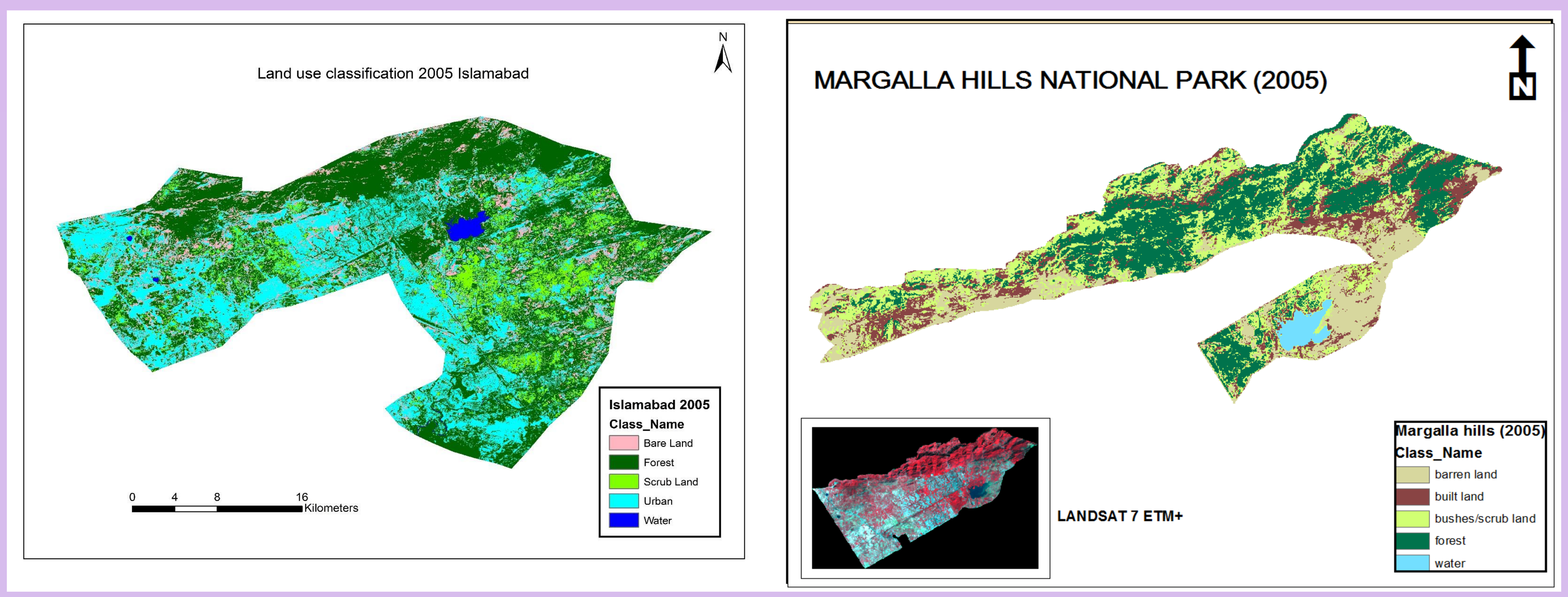
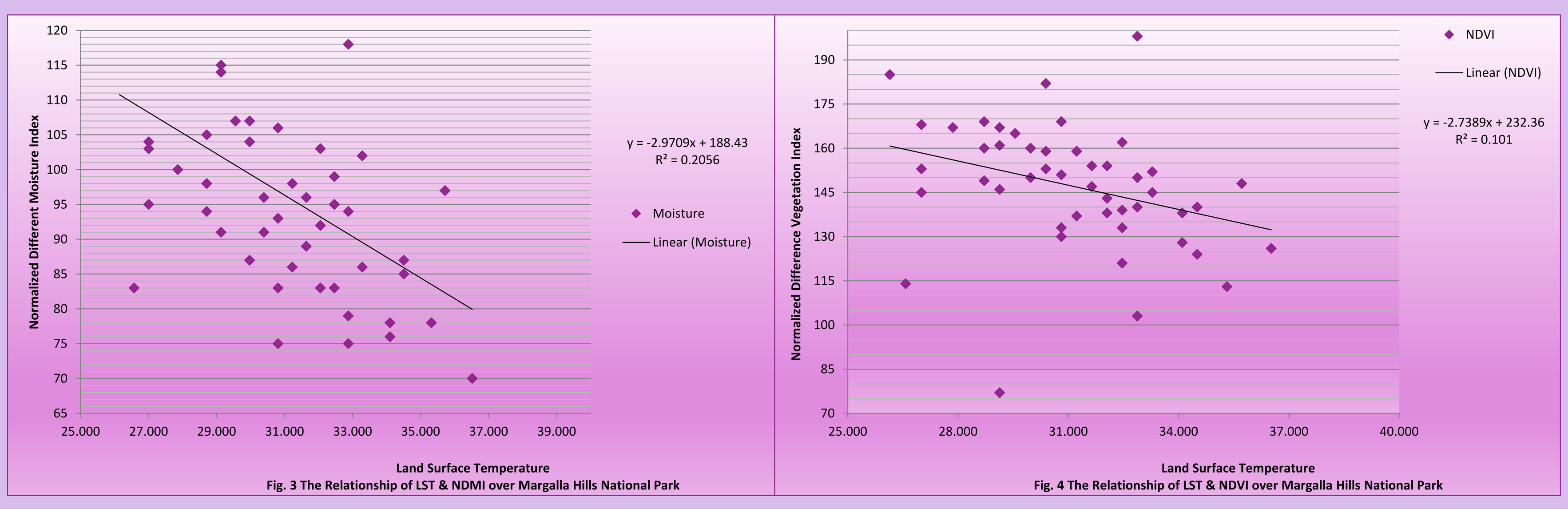
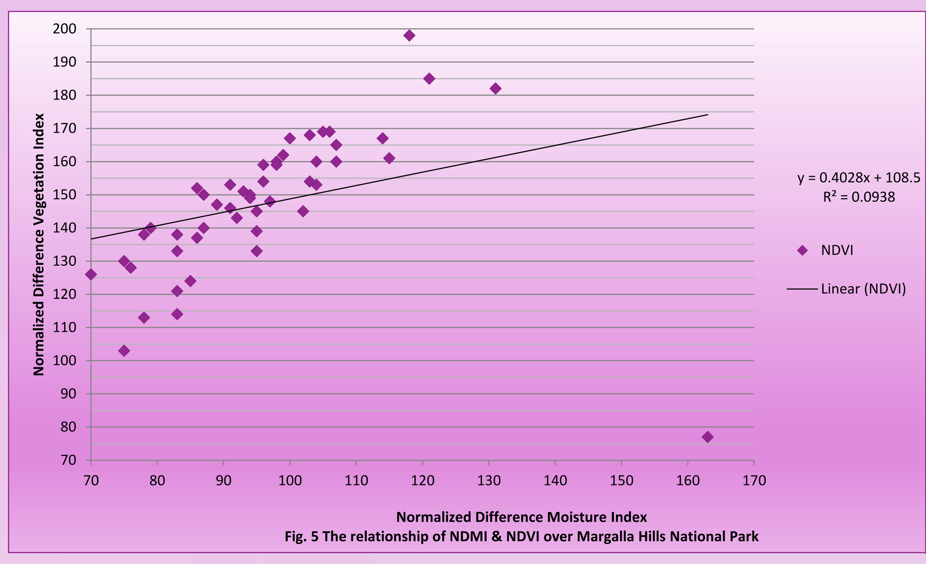
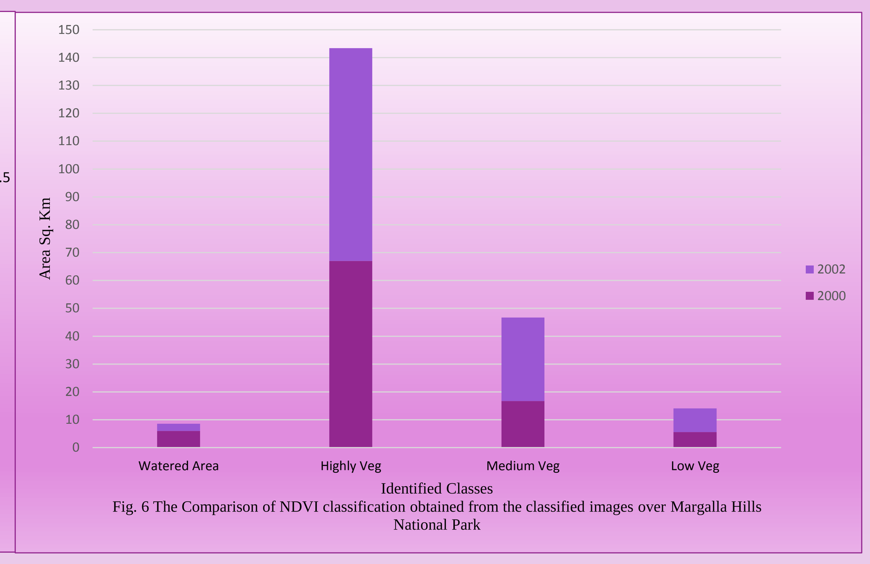
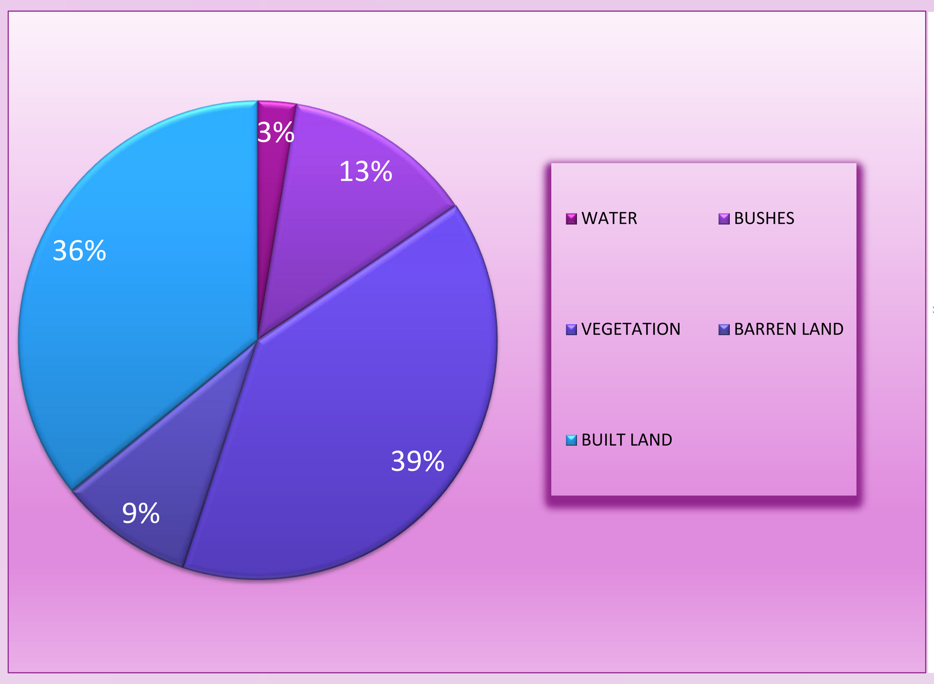


Fig. 1 Classified SPOT satellite image for the year 2005 for Islamabad city and Fig. 2 classified specifically for Margalla Hills National Park i.e. the study region.









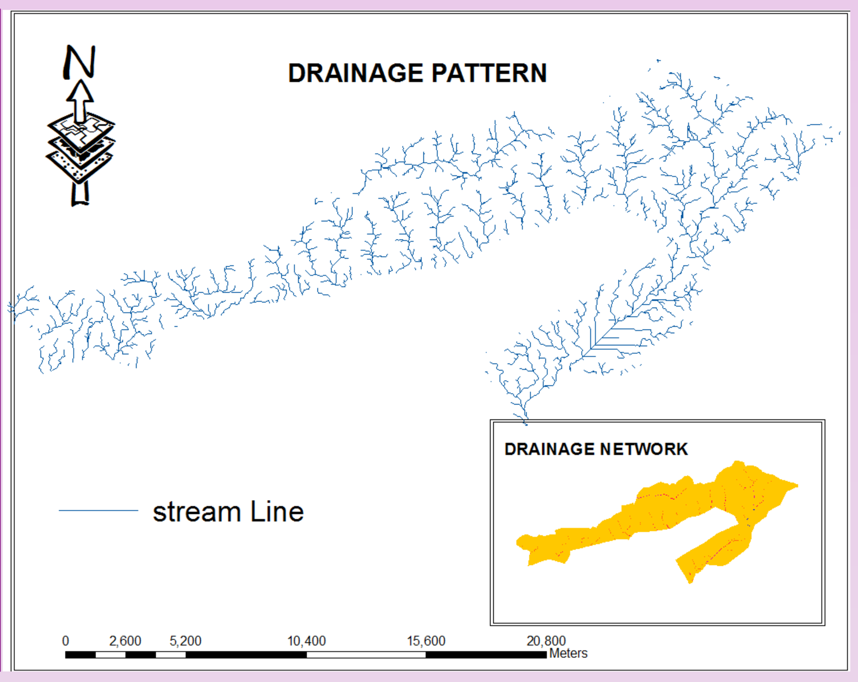


Fig. 7 Shows the land cover/land use in percentage over Margalla Hills National Park, Fig. 8 Shows the drainage pattern and network over Margalla Hills National Park

RESULTS & DISCUSSION

The Fig. 1 shows the land use classification of Islamabad city and Fig. 2 shows the classification particularly over the MHNP. The calculated LST at randomly selected points ranges from 21.30 ^oC - 40.46 ^oC and the mean LST is 30.79 ^oC. The range of NDMI values are 46 – 245 whereas the mean NDMI is 96.60. The NDVI value ranges from 31-234 and the mean NDVI is 146.85. The moisture pattern shows few extreme values. These high and low extreme values are representing the shadowy places due to vegetation and the points with very less vegetation over the Margalla hills respectively. Usually the open places with less vegetation are the muddy paths for local people to go up or down the hill whereas there is vegetation and shadows on other places which helps to maintain the soil moisture in the study area (Kauser et al., 2013). The NDVI is showing the regular variation due to similar kind of vegetation over the hill. Results show that there is a negative relationship between soil moisture and temperature (Fig. 3). Evapotranspiration phenomenon set this trend between the temperature and moisture content of the soil (Hassaballa and Matori, 2011). In addition to this, the relationship is also affected by a number of factors e.g., geology of an area, type of vegetation and soil, and environmental settings etc. During the spring time over the Margalla hills, moisture is the limiting factor for vegetation growth that shows the negative correlation between the LST and NDVI (Fig. 4), in accordance to the results of Karnieli et al., (2009). The general trend between the soil moisture and NDVI shows positive correlation. Soil moisture is the limiting factor for the growth and health of vegetation that shows its effects on the values of NDVI as well (Fig. 5). There is the start of growing season in the month of April whereas the vegetation becomes thick over time during the month of May over Margalla hills however, the energy exchanging parameters follow the same pattern in May as in April (Fig. 6).

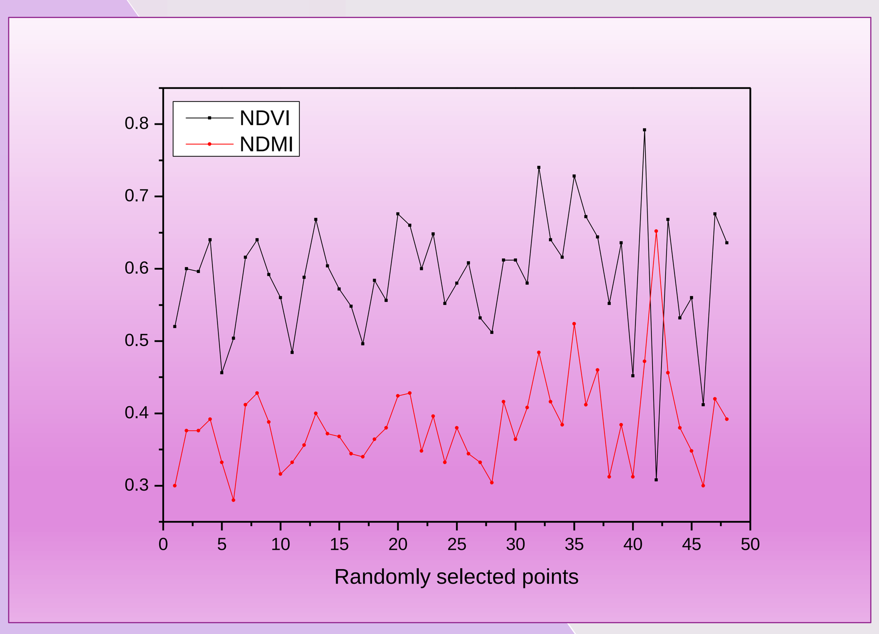


Fig. 9 The NDVI & NDMI trend is shown on random points on MHNP

CONCLUSION

- The surface temperature and soil moisture are negatively correlated with one another.
- Positive correlation exists between normalized difference vegetation index and soil moisture as moisture is limiting factor for the growth and health of plants.
- Land surface temperature and NDVI correlation is negative. The LST/NDVI analysis is also used to extract information related to soil moisture conditions.

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