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MONITORING AND MAPPING SPATIO-PERIODIC DYNAMICS OF VEGETATION COVER IN KARACHI USING GEOINFORMATICS

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ABSTRACT

The decline in vegetation cover of the cities is a serious issue around the globe. Karachi, as the largest city of Pakistan is experiencing the removal of vegetation at the cost of the construction of the builtup land. Karachi experiences semi-arid climate thus availability of vegetation and water is quite dynamic. Soil moisture can be predicted by density of vegetation cover. Growth of Karachi in terms of population is very high so as high consumption of food, which is grown in the nearby pockets of Malir and Gadap valley. In Karachi Hydrometeorological hazard (Drought) is common hence, monitoring and mapping of Land resources is essential.

This Study assesses the role of Geoinformatics techniques for monitoring spatio-periodic variation of surface vegetation in Karachi. Four satellite imagries of Landsat -7 TM were selected to perform various process. Through NDVI spatio-Temporal and seasonal distribution of vegetation dynamics were observed and tabulated for each Union council of Karachi using software ArcMap 10.1. Maps developed for the quick and comparative understanding. Use of remote sensing and GIS technology for the monitoring and evaluation of substantial spatio-temporal variations of land resources such as vegetation cover is ideal. Therefore, this study would be beneficial for environmentalist and planners.

Keywords: Vegetation Dynamics, NDVI, Hydrometeorological hazard, Spatio-Periodic, Landsat-7 TM/ETM, Geoinformatics.

INTRODUCTION

In Pakistan around forty percent land consists of fertile plain as drained by mighty River Indus and its tributaries. Province of Punjab and narrow strip of land along River Indus in Sindh have vast fertile plains. As far as climatic conditions are concerned these plains are included in different ecological and climatic zones thus on one hand these areas have great potential for producing variety of seasonal crops while on the other hand suffering from various climatic hazards. Spatial monitoring of natural resources such as water bodies, wet lands and forest and vegetative cover including agricultural areas is mandatory (Ghazal *et al*.2013). Similar study was made in which it has been reported that successive information of Spatio-periodic changes of land cover and land use is the key for proper management and planning of natural resources in any area (Zhu, 1997).

Vegetative cover dynamics play an important role in various mechanism of earth surface which are directly linked with hydro-meteorological phenomenon (Tyson *et al*., 2001). Monitoring the current state of green areas available at any place is somehow important for initiating any plan of plant conservation (Egbert *et al*., 2002; He *et al*., 2005).

Pakistan is at the top among the climate risk index and ranked 2nd amongst highly water stressed countries of Asia and susceptible to hydro-meteorological hazards such as drought. Based on the historic data of rainfall Pakistan is included amongst moderately drought affected countries of the world (Eric, 2009). Globally arable land and agricultural production is also declining which is a clear cut indication of drought. In Pakistan water shortage is very much associated with the production of crops; it is therefore at the verge of food crises (Eric, 2009; Ghazal *et al*., 2013).

Convectional ways of field surveys are very expensive, time consuming lacks accuracy and impractical to study spatio-periodic dynamics of vegetation cover especially at large area, hence technology of remote sensing due to its past data archives at various scales provide an ideal and economic solution for delineating vegetation cover (Longly *et al*., 2001; Nordberg and Evertson, 2005; Xie, *et al*., 2008). Use of RS and GIS is now not limited to the developed countries. Owing the significance of its application many developing countries are widely using this technology. Pakistan is also amongst the top of those developing countries where monitoring of land resources at different resolution satellite data has begun (Ghazal, 2014). Method of vegetation differencing index is being used since several years for delineating the vegetation areas on the image (Sohi, 1999).

Biomass vigor or concentration of surface vegetative matter can also be computed with the help of multi-spectral satellite images (Aronoff, 2005). For this purpose reflectance values of image are embedded with certain vegetation Indices which measures biomass concentration by mathematical computation (division, multiplication, addition or subtraction) of spectral value of images and obtain single value which clarifies or enhances pixel wise green bodies on the image.

MATERIAL AND METHODS

Thorough review of relevant literature was performed for building initial thoughts and clarification of processes for vegetation cover analysis in semi-arid environment. The study primarily focuses on exploring the potential of Landsat-7 TM satellite data thus appropriate data sources and methods were explored and applications of remote sensing and GIS techniques were keenly reviewed for image processing. Specification of Thematic Mapper and Landsat Band is shown in following [Table.1 and 2].

Table 1. Thematic Mapper Specifications.

Sensor Type	Optic-mechanical
Spatial Resolution	30 m (120m-Band 6)
Spectral Range	0.45-12.5 µm
Number of Bands	7
Temporal Resolution	16 days
Image size	185x172 Km
Areal Swath	185 Km

Table 2. Landsat -7 Band Specifications.

Band Number	Micro meter(µm)	Resolution
1	0.45-0.52	30 m
2	0.52-0.60	30 m
3	0.63-0.69	30 m
4	0.76-0.90	30 m
5	1.55-1.75	30 m
6	10.4-12.5	120 m
7	2.08-2.35	30 m

From the studies made by (Jenson, 2004; Lillesand *et al*, 2000 and Aronoff, 2005) it was deduced that various image enhancement techniques and filters are helpful for improving the quality of image so that interpretation of results become easy and more meaningful (Jenson, 2004; Aronoff, 2005). Satellite date was first geometrically rectified for the further process of enhancement (spatial, spectral and radiometric. Later on desired bands were extracted from multibands images as only Infra red and red bands are required for NDVI As our Study is aimed at assessing spatio-periodic variation of green cover so certain vegetation Indecies were worked upon and finally Normalized Difference Vegetation Index (NDVI) was applied.

Various famous vegetative indices were reviewed thoroughly then normalized Difference Vegetation Index (NDVI) was computed with the help of Multispectral satellite image Near Infra-red and Red channels are required. NDVI is commonly used to quantify plant density of earth surface in which near infrared is deducted from visible red divided by NIR and Red. Output of this formula is known as NDVI, which is mathematically expressed as following equation (Anon., 2014).

NDVI = (NIR — Red) / (NIR + Red)

Here **Red** band represents the value of Infrared radiation from a pixel, **NIR** band represents the value of near infrared radiation from a pixel. The pixels are showing the values ranging from (-1 sparse vegetation to +1 dense vegetation). In fact the NDVI calculates pixel based photosynthetic portions of green areas all over the satellite image. Portions projects maximum reflectance looks white or brighter hence, enhancing the biomass. Refer [Fig. 1] the screen shot of NDVI computation in Erdas Imagine software.

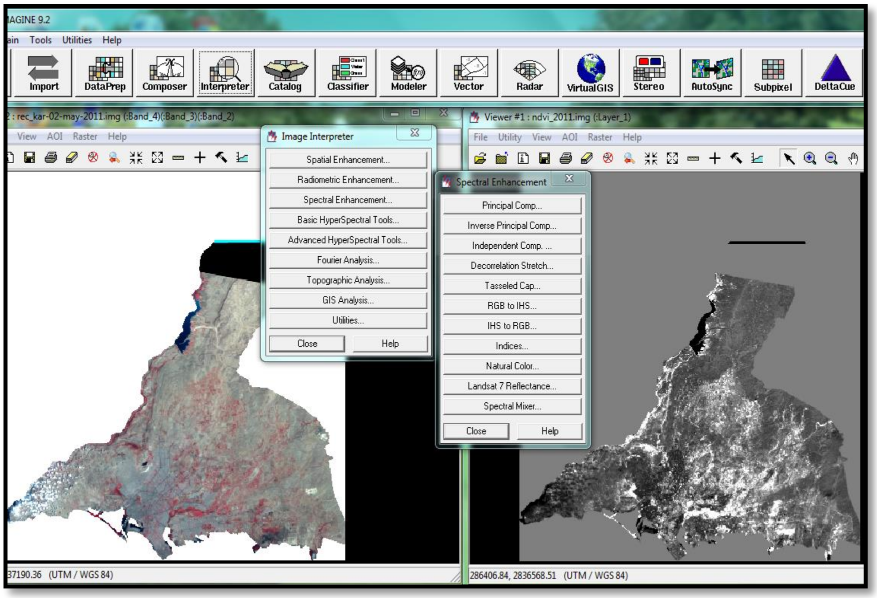

Fig. 1. Computation of NDVI in Erdas Imagine 9.2

Moreover, unsupervised classification of images were also incorporated for the validation of results. These classified images were used to extract area of green bodies of Karachi in each Union Council [UC] based on pixels. Afer area tabulation it was converted in to percentage using MSExcel. Lastly maps were deployed in Arcmap environment for all these processed images of NDVI and UC based Spatio-periodic variation of vegetation cover was observed for the interpretation. Tables and graphs are incorporated where necessary to enhance learning. Vegetation Index maps are also produced to observe and analyze the Spatio-periodic variation of greenness in the study area.

RESULT AND DISCUSSION

Gross Spatio-periodic variation of vegetation cover is being displayed in all images. The sparse vegetation cover is seen in the image of june 1992 as the value of NDVI are lowest as compared to May, 2011 [Fig. 3a and d**]** which shows more vegetatation. Although both May and June are hot and drier months in the study area but surface moisture created by by 2010 flood and winter rain of 2011 during January till March, have allowed plant growth at larger scale as shown in the image of May 2011. Large continuous patches of green bodies are mainly confined to Gadap and Malir river which are historically important agricultural areas. Similarly,Winter (rabi) crop is also at harvesting stage that is why more greenery is depicted from the image of march 2003 as compared to June and May images of 1992 and 2011respectively.

Spatio-periodic variation of vegetation cover in the study area was observed by obtaining NDVI using band-3 NIR and band -4 of all four Pre and post monsoon Satellite imageries of Landsat-7 TM. Outcome of image based NDVI are depicting seasonal changes [Fig. 2b] and [Fig. 2c] are showing that surface greenness is generally high after winter and summer rainfall. Maximum greenery is found in the [Fig. 2c] (Satellite image of Landsat 7 of September, 2007) as monsoon bring rain from July till September so more soil moisture was available for the plant growth. Similarly sporadic winter rainfall continued till March so its effects can be seen in the [Fig. 3b] which is the image of March 2003 vegetation cover along the seasonal rivers (Malir, Thaddo and Lyari and the areas surrounding of Hab reservoirs are prominent. In contrast least spatial coverage of green cover is seen in the study area in June 1992 as this is hot month with meager or no rainfall as shown in [Fig. 2a]. Variations in the range of NDVI values are depicted in graph [Fig. 3]. While monthly trend of average annual rainfall, average, maximum and minimum temperature can be referred in the climograph [Fig. 4].

Data Source: PMD, 2014

As far as area tabulation is concerned for that images were first classified then area of required class of vegetation (green pixels) was extracted for each Union Council which was further quantified into percentage. The delineation and quantification of green pixel from satellite images in is very supportive approach offered by

Geoinformatics to monitor the variations of green cover. The Resultant choropleth maps [Fig 5 a-d] and the graph of selected UCs [Fig.6] are showing spatio-periodic changes in the distribution of vegetation in different UCs. Highest Concentration of vegetation is primarily seen in UC-Gadap followed by Sognal, darsanno Channo, Ghaggar, Landhi, Murad Memon, Sharafi Goth etc. Highest percent share of vegetation in UCs is observed in the image of September 2007 while minimum is noticed in June 1992 satellite image respectively.

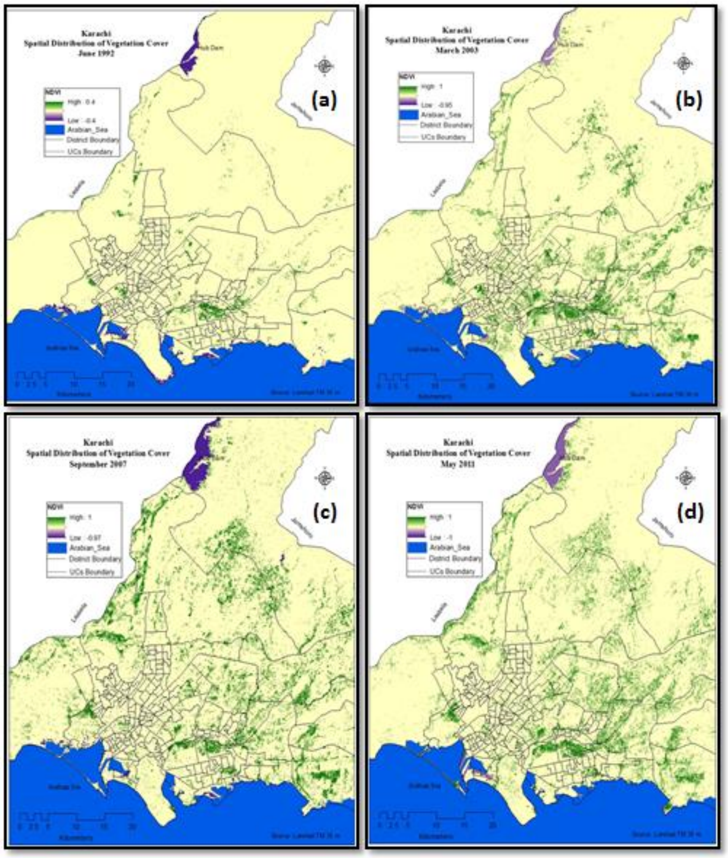

Fig. 2 Karachi: Spatio-Periodic Variation in Vegetation Cover.
a) June 1992 b) March 2003 c) September 2007 d) May 2011

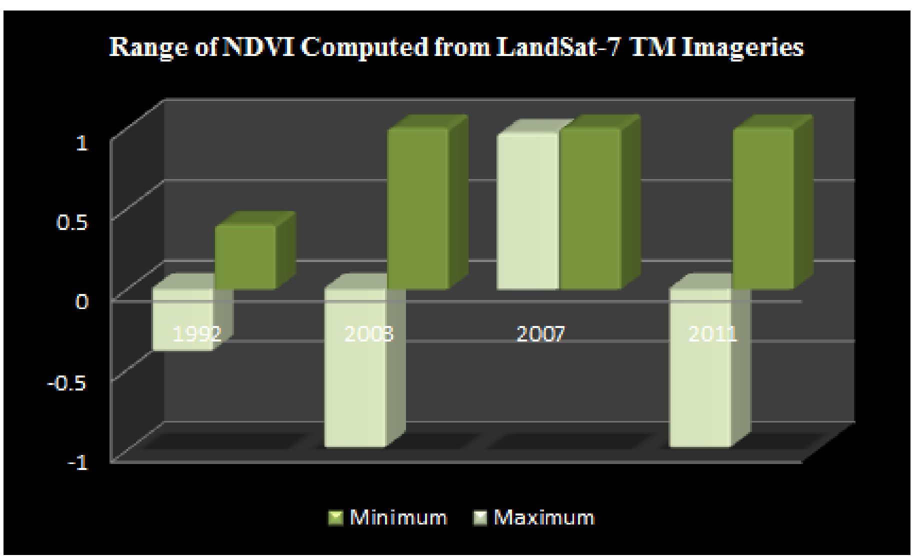

Fig. 3 Variations in the Values of NDVI.

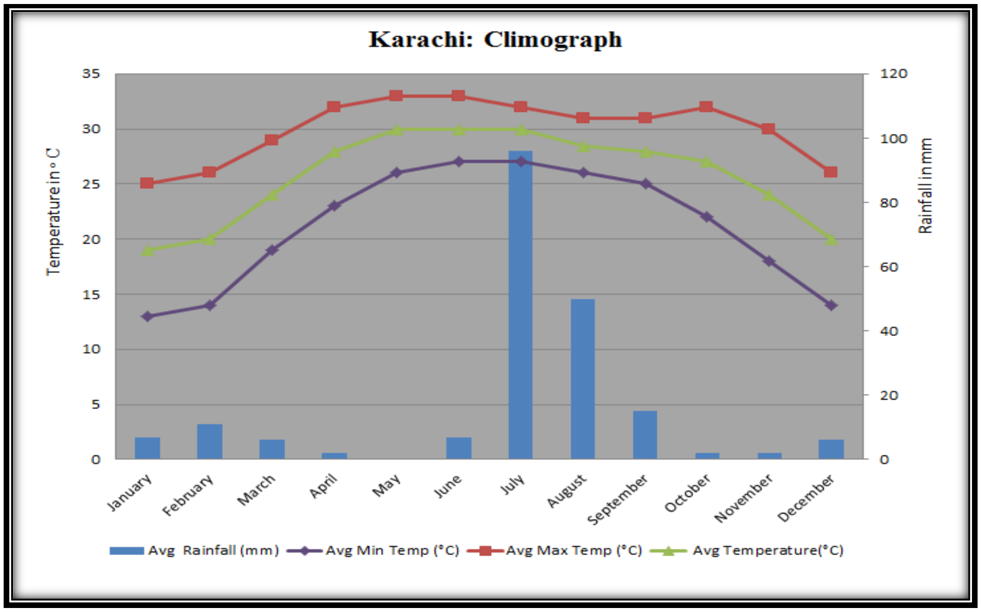

Fig. 4. Karachi: Climograph.

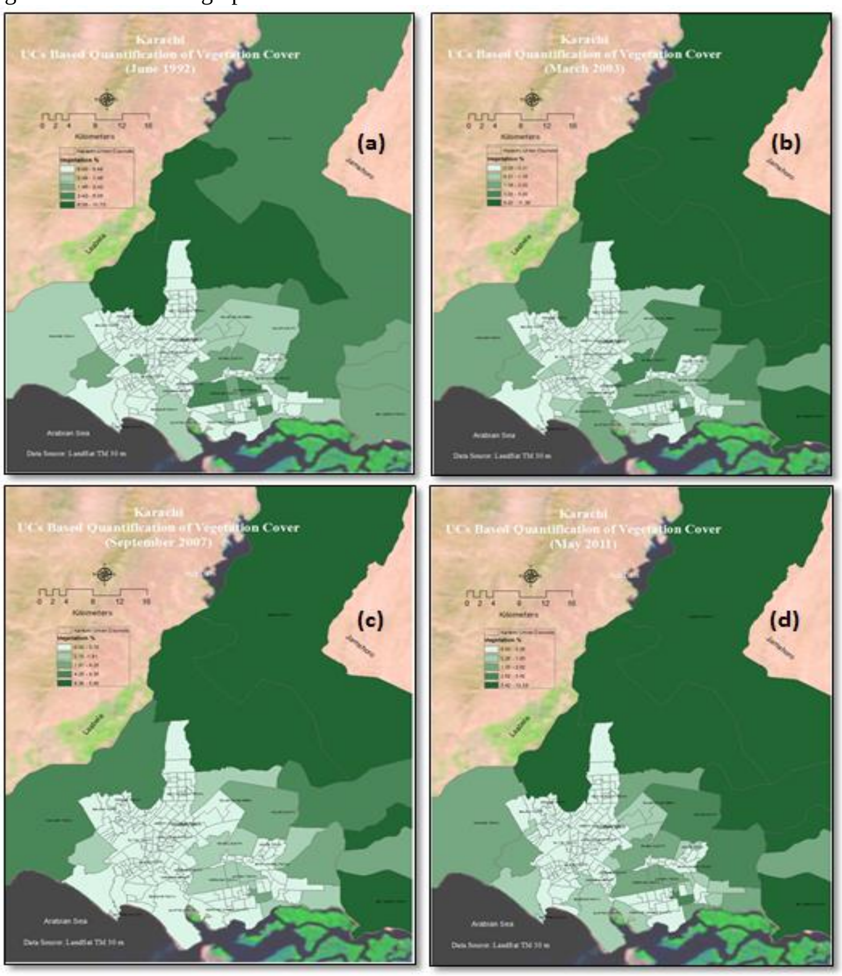

Fig. 5. Karachi: Variations of Vegetation area in Union Councils.
a) June 1992 b) March 2003 c) September 2007 d) May 2011

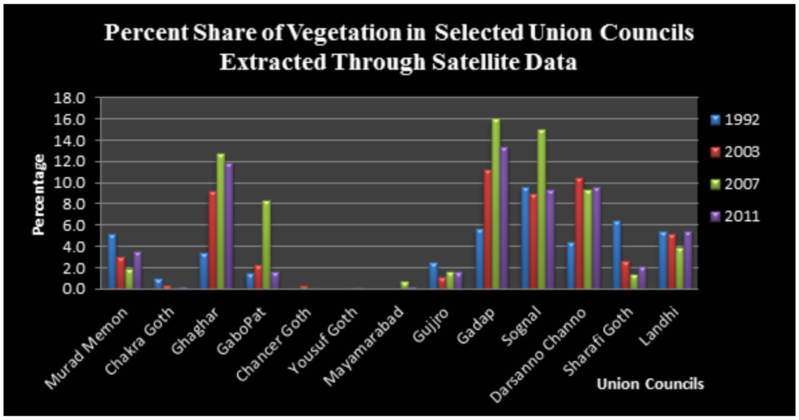

Fig. 6. Percent Share of Vegetation in Selected Union Councils.

CONCLUSION

Study was conducted to monitor the Spatio-periodic dynamics of vegetation cover in Karachi through LandSat-7 TM satellite images using NDVI and quantifying percentage of greenness in each Union Council Level. Maps were prepared to give reader easy understanding of the Spatio-seasonal variations. Spreading of Vegetation cover in any area is an important indicator for soil moisture because primary activity such as barani agriculture is directly dependent on rainwater and pervious soil.

This current Study clearly proved the potential of Remote Sensing and GIS techniques for delineating green areas in each 30 * 30 pixel of landSat-7 TM Satellite data. Reflections from the Wavelength of band 3 and 4 (Red and NIR) of LandSat -7 TM Sensor is very supportive for identification and enhancement of pixels containing biomass on satellite image. Similarly this characteristic is ideal for mapping the extent of agricultural and other green bodies. Periodic Monitoring and mapping of natural resources and cultivated land is useful for different administrative units for the sake of comparative study of past and present trend therefore, possible future outcome could have been projected.

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