AN ANALYSIS OF THE NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI) AND IT'S RELATIONSHIP WITH THE POPULATION DISTRIBUTION OF FAISALABAD-PAKISTAN

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ABSTRACT*:* The monitoring of global vegetation with the help of SRS (satellite remote sensing) data is convenient to improve upon our knowledge concerning spatial distribution and characteristics of vegetation. The continuous surge of anthropogenic activities on the face of the earth and resultant change in land use of an urban center has increased concern of researchers to undertake studies to investigate and establish a relationship between population distribution &density and vegetation. The main focus of most remote sensing digital data is to illustrate the type, size and condition of vegetation in any region. The present study is aimed to find the Normalized Difference Vegetation Index (NDVI) and to relate it to population density in Faisalabad Saddar. Since in urban ecology, assessment of the Spatio-temporal state of any vegetation is significant field of study as it is a potent parameter of all the global surfaces. Therefore, in the present study the temporal analysis of vegetation cover has been carried out through NDVI using two Landsat images (1998 and 2010) and a time span for the last 12 years. The NDVI change and population density at town level has also been correlated. The research reveals the applicability of Landsat digital and demographic data for the evaluation and analysis of NDVI change over time. By visualizing the temporal land cover it is clear that the greenness has been reduced since 1998 due to change in population distribution and density. The study highlighted the NDVI for better results regarding accuracy to assess the vegetation cover.

Key words: Indices; NDVI, Vegetation, Population Density, Landsat

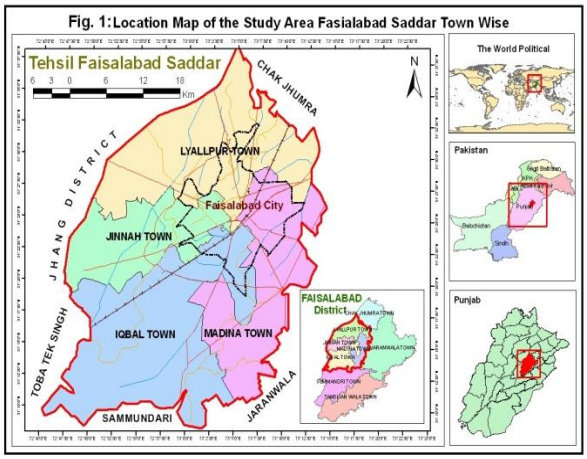
INTRODUCTION

Nowadays, Spatio-temporal analysis of vegetation cover can be performed efficiently and precisely by using remote sensing satellite imageries (Hashemi, 2011). The access to satellite remote sensing (SRS) data widely supported in LULC mapping, managing earth resources and analyzing Spatio-temporal LULC changes. It has benefited a lot and is globally used (Waqar, 2012). When Land cover changes owing to anthropogenic activities our natural ecosystems are immensely disturbed. Rapid increased in urban population and trend to get urbanized are possibly the most alarming land cover change agents because of its divergence to native habitats and its permanence (Vitousek, 1994; Marzluff and Ewing, 2001). The global urban population is estimated to increase from 50% in 2008 to 60% by 2030 (United Nation, 2010). Urban expansion and development will lead to a huge destruction of forested and agricultural lands (Morawitz *et al*., 2005).

The vegetation of a region has significant impact on ecological environment and climate change (Chen and Tian, 2007). Currently the classification of regional and global vegetation patterns has been analyzed with remote sensing satellite imageries. Numerous researches have extensively employed to the normalized difference vegetation index (NDVI) to analyze the various factors regarding vegetation and Climate change and population change response to vegetation cover disparity (Brian *et al*., 2007). In present researchers used various vegetation classification methods such as NDVI in the different parts of the World. The conventional approaches of the Supervised and unsupervised classification based on the spectrum of remotely sensed data without taking into account the phrenology of vegetation. Modern methods of vegetation cover classification are the Fuzzy Classification, Distance Tree technology (Tapia *et al.*, 2005; Filippi and Jensen, 2006), Object based classification (Mallinis *et al*., 2008).

The most Prominent method to recognize the vegetation cover land and its condition is NDVI (Yang *et al*., 2008). This index is saturated in dense biomass and most sensitive to disturbing factors such as clouds, soil and atmospheric effects (Karaburun, 2010). For this reason in the scientific researches numerous

alternatives and derivatives have been applied to NDVI in order to tackle these shortcomings (Yang *et al.,* 2003). The NDVI indices have been used globally in SRS studies since its evolution (Jensen, 2005). The NDVI indices values range from -1.0 to 1.0, where higher values are for green vegetation and tiny values for other widespread surface resources. Bare soil is symbolized with NDVI values which are contiguous to 0 and water bodies are characterize with negative NDVI values (Lillesand *et al.,* 2004) the NDVI make available constructive information for distinguishing and interpreting vegetation ground cover it has been broadly used in remote sensing studies (Sesnie *et al.,* 2008). The Current research aiming to investigate the change of NDVI and its correlation with change in population density at town level by using land sat Satellite images and Geoinformatic techniques. The primary objectives of this research were to quantify and describe the amount and type of change in vegetation as measured by NDVI change increase, decrease, or no change and the relationships between change and anthropogenic indices; population density.



Source: GOP, 2000

Study area description: Faisalabad is the third largest city of Pakistan. It is an important industrial center, situated in the province of the Punjab, about 100 kilometers west of Lahore. Faisalabad is located in a fairly flat plain area, with ample undeveloped land to meet any future urban expansion. It was founded upon its agricultural market based agro industries, particularly cotton and textile industries. (CGDF, 2010) The total population of Faisalabad District has been growing rapidly in recent years. At present it is approximately 6.7 million of whom about 40% or 2.7 million live in Faisalabad city. Faisalabad received the status of district govt. in 2001 and the status of City district govt. in 2005. Faisalabad is a big district that has been divided into eight towns for administrative purposes (Fig. 1), four of which are predominantly urban. Each town is further divided into various Union Councils. There are total 289 Union Councils (128 urban and 161 rural) in the District with average population of slightly under 25,000 each (CDGF, 2010) Faisalabad City and Saddar Tehsils have been replaced by four Towns (Fig. 1), namely Lyallpur Town, Jinnah town, Iqbal and Madina Towns and the present study is carried out in above said four towns.

MATERIALS AND METHODS

For studying the chronological changes in LULC and interpreting green spaces pattern of Faisalabad Saddar (4 Town) area , used two Landsat imageries ETM (1998 & 2010) bands 3 (0.63-0.69 µm) & 4 (0.75-0.90 µm) with 30m resolution were acquired for analysis purpose & also used to execute the vegetation indices; (NDVI) the normalized difference vegetation index (Gao, 1996). ERDAS IMAGINE 9.1 is used to produce the FCC (false colour composite) images by combining the near-infrared (NIR), red and green bands (4, 3, 2, respectively) for two Landsat images 1998 & 2010. Atmospheric corrections, band stretching, band combination manipulation and contrast adjustment image enhancement tools were employed on Landsat imageries using ERDAS IMAGINE 9.1 and Arc GIS 9.3 (Bhaskar, 2012).The radiometric and geometric correction was also carried out while importing these Landsat ETM images in ERDAS IMAGINE 9.1.

Vegetation indices NDVI were applied upon 1998 and 2010 ETM images and also developed the NDVI maps of the study region Faisalabad above said four towns (Ahmad, 2012). The normalized difference vegetation index (NDVI) provides constructive information about green spaces and for interpreting and detecting vegetation land cover and it has been globally used in (SRS) satellite remote sensing studies (Dennison and Roberts, 2003; Sesnie *et al.,* 2008; Karaburun, 2010)**.** NDVI (normalized difference vegetation index) is a good indicator of the ability for vegetation to absorb photo, synthetically active radiation and researchers use it to estimate green biomass all over the world (Wang *et al.,* 2003; Lillesand & Kiefer, 2004). Kriegler *et al*., (1969) was the pioneer to propose normalized difference vegetation index (NDVI) (Gibson and Power, 2000) and calculated NDVI from two bands of multispectral satellite remote sensing digital data. NDVI index was first used in 1973 by Rouse *et al.* from the Remote Sensing Centre of Texas A&M University. A ratio image is used for detecting and calculated vegetation cover by using the following formula (Rouse *et al*., 1973)

- **NDVI= (NIR-Red)/ (NIR+ Red) ……(1)**

An NDVI index in Eq. (1) is normally used to articulate the density of vegetation (Purevdorj *et al.*, 1998). For the present research band 3 and 4 for year 1998 and 2010 were preferred and analyzed via equation 1, consequence obtained through single band dataset with values ranging from between -1.0 and 1.0 (fig 3), The ordinary range for green vegetation is 0.2 to 0.8, where lower values corresponds to built-upland structures, barren areas of rock and sand. Modest and higher values characterize thin and dense vegetation land cover (ESRI, 2008).

- **Density of Population= Population of an area/Area (sq.kms)…… (2)**

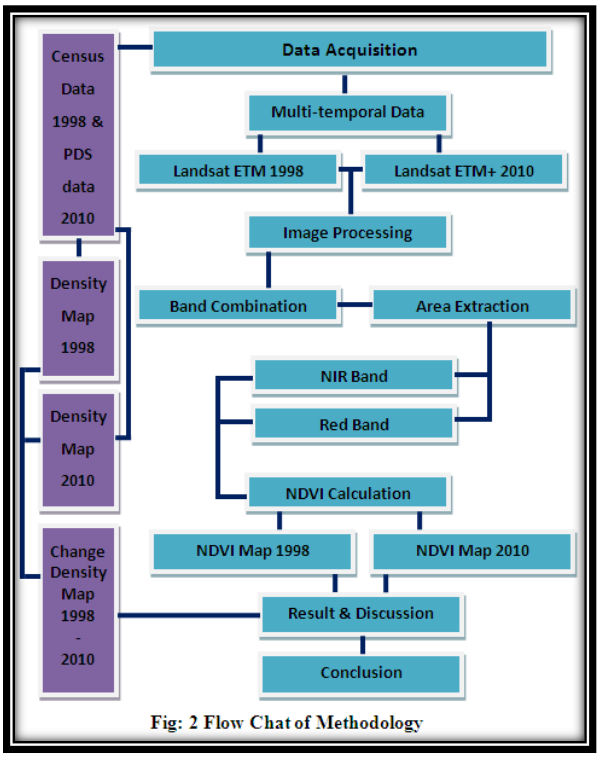


Fig: 2 Flow Chat of Methodology

After calculating NDVI for all four towns of City District Government Faisalabad it was correlated this index with the population density of the same town. . The density of population is commonly used index of population concentration in an area. It deals with number of persons to the area they have occupied. The term was invented and first used by Henry Drury in 1837 (Clarke, 1972). It is in fact man land ratio and can be distinct as number of persons living in per unit area. The unit of area can be square meters, kilometers.

The last census in Pakistan was carried out in 1998 and its data was released after two or more years. In order to calculate density of population of all the four towns of Faisalabad we have divided population of each town with its geographical area for both points on time i.e.; 1998 and 2010 (Table1). After calculating the density it was also calculated the change from 1998 to 2010 and then represent it on maps (Fig. 2 & 3). Finally superimposed index of density and its change (demographic data) over the NDVI status of respective towns to reach at some conclusion therefore hypothesized that that more the population density and its change less is the greenness in that town (Shirazi, 2012).Census data hand books are the authentic source of population data which are published by the Government of Pakistan. For the present study, the census data of 1998 and Punjab Development Statics 2010 are used. The 1998 population data was attached with the vectorized shape file and applied to 1998 image of Landsat ETM. The 2010 census data were attached to 2010 image. Population density was computed using the eq. 2: (Dhorde *et al*., 2012).

Population distribution and density: The demographic data laid the foundation of a comprehensive study like the present one. The demographics of a region are the apex of a pivot, from which all intervention of human venture such as weather conditions, natural or anthropogenic and development activities (Shirazi, 2012). The geography has been gifted with a strong relation with the population numbers and regional natural resources. The population distribution and its diversity will ultimately influence on the vegetation patterns and urban growth of a region. Population patterns in various towns of the study area tabulated from 1998-2010. Currently the City District Government of Faisalabad is consisted of four towns viz; Iqbal town, Jinnah Town, Lyallpur town, Madina town and Faisalabad Saddar (Table 1). In 1998 Iqbal town had a population of 764000 souls and in 2010 population 1044000 with change in density 518. Jinnah town population was 767000 in 1998, with increase 1016000 in 2010 along with 1073 density change. Lyallpur town population increase from 758000 to 955000 during 1998 to 2010, Madina town observed change 836 in population density and increase in population from 774000 to 1046000 during 1998 to 2010 and Faisalabad Saddar observed the maximum change in population density 2867 among all towns with population change from 3063000 to 4061000 since 1998 to 2010 (Table 1) (GOP, 2000; GOP, 2010).

Table 1. Population and Density of Faisalabad Sadder area by Towns, 1998-2010*

Tehsil /Town	Area***	Population	Density**	Population	Density **	Change in Density

	Sq. Km	1998	1998	2010	2010	1998-2010
Iqbal Town	540	764000	1415	1044000	1933	+518
Jinnah Town	232	767000	3306	1016000	4379	+1073
Lyallpur Town	447	758000	1696	955000	2136	+440
Medina Town	325	774000	2382	1046000	3218	+836
Faisalabad Saddar	1544	3063000	8799	4061000	11666	+2867

*estimated population; **Persons/sq.kms; *** Area calculated through shape file of CDGF 2010

Source: GOP, 2000; GOP, 2010

RESULT AND DISCUSSION

Normalized Difference Vegetation Index (NDVI) measures the amount of green vegetation in an area. The NDVI algorithm subtracts the red reflectance values from the near-infrared and divides it by the sum of near-infrared and red bands. Figure 5 explain spatial variations in NDVI values during the period from 1998-2010. The figure 5 portrays the NDVI calculated for Saddar, Faisalabad. As Faisalabad Saddar is divided administratively into 4 towns so, the findings reveal that NDVI spatial patterns in all 4 towns are mainly related to temporal population increase of these towns and consequent patterns of urban land use & land cover. The increasing rate of urbanization in Faisalabad has influenced the vegetative areas and green crop agricultural fields consequently, temporal deviation of NDVI and its spatial pattern has largely been described by visual interpretation, LULC and population density changes during 12 years of research span.

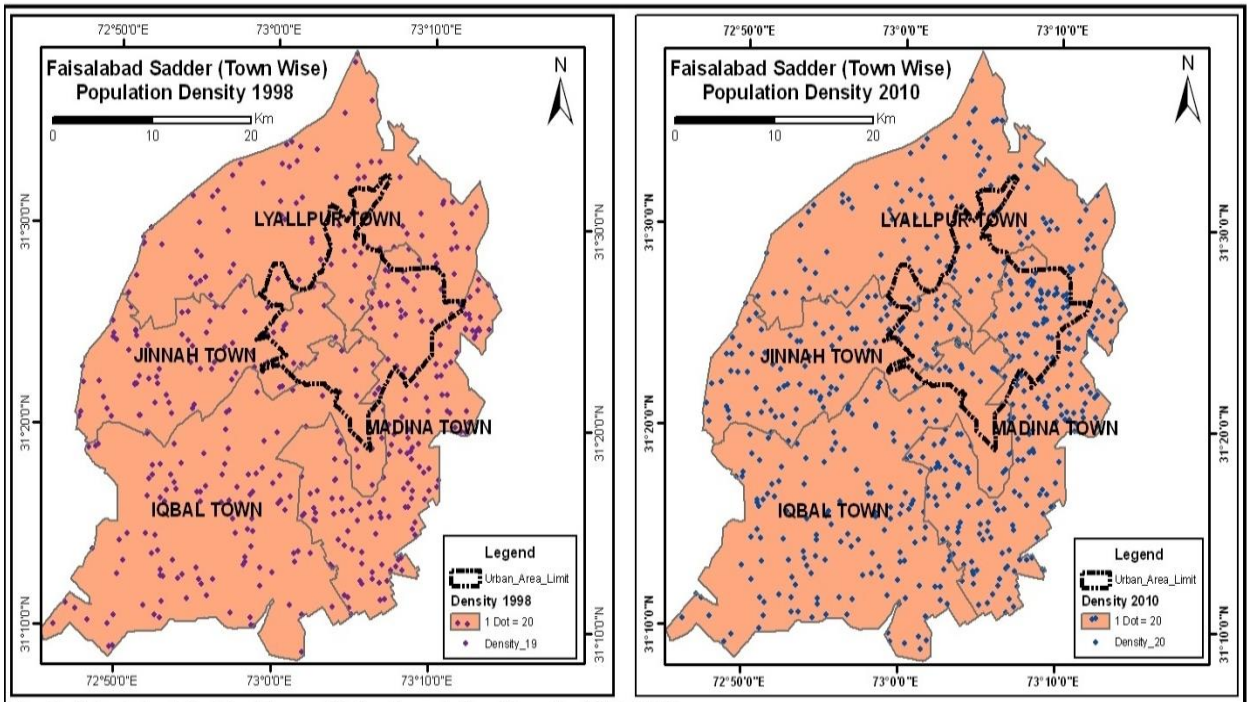


Fig. 3: Faisalabad Saddar Towns Weise Population Density 1998-2010

A fleeting look at the figs. 3, 4 and 5 disclose town vise population density of Faisalabad for the years 1998, 2010 and change during 1998-2010 as well as spatial distribution of NDVI of the four towns identified from two Landsat images i.e., 1998 and 2010. It is crystal clear from maps that, there is a great reduction in greenery in the four towns of Faisalabad in 2010 as compared to 1998 image.

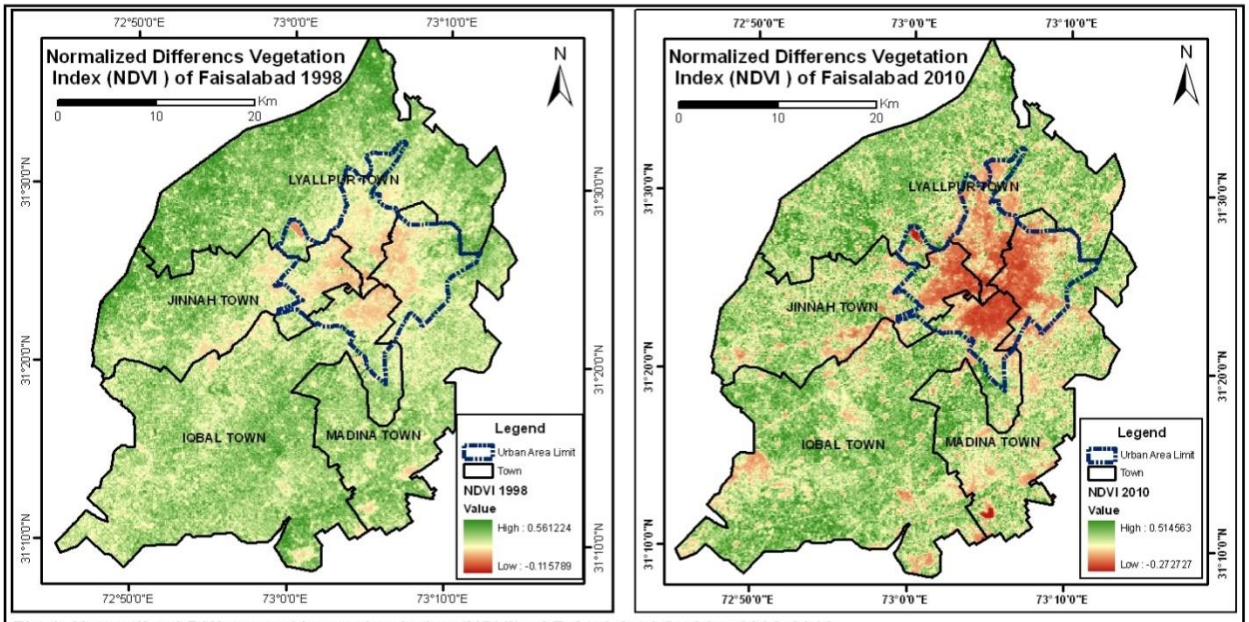


Fig.4: Normalized Difference Vegetation Index (NDVI) of Faisalabad Saddar 1998-2010

The fig. 6 for 2010 shows lower assessment of this quantity in few towns. Hence, revealing that the Faisalabad city has experienced a loss of vegetate cover and biomass since 1998 to 2010. Heaving a look on the maps make it clear that the value of NDVI is high in those towns which were rural in nature and their population is engaged in agricultural activities. The rural urban fringe of the city also faces the similar trend as compared to older portion future growth and development directions in the study area Faisalabad Saddar. In the developing and the areas heaving high population density especially in Faisalabad city, a low NDVI index has been observed. The biomass and vegetal cover has shown general decreasing trends in all four towns of Faisalabad since 1998 to 2010. In general, the study area and it's all sub units either towns or union councils are showing decreasing trends of NDVI. Figure 6 shows change detection using NDVI model for Faisalabad Saddar. NDVI model was applied upon ETM+ images (Figure 4) and further change detection technique was used for extraction of potential agricultural sites in Faisalabad Saddar.

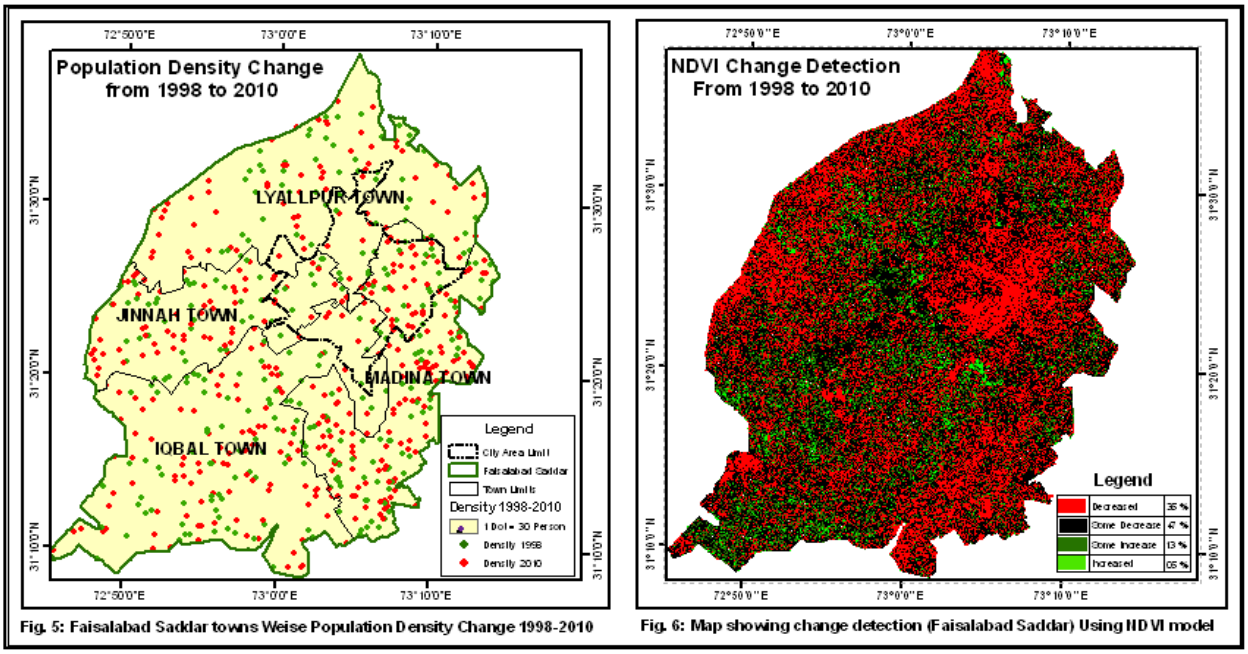


Fig. 5: Faisalabad Saddar towns Weise Population Density Change 1998-2010

Fig. 6: Map showing change detection (Faisalabad Saddar) Using NDVI model

Conclusion: The study has indicated the potential use of remote sensing data in studying vegetation changes. In this study LANDSAT images were used satisfactorily for the identification of vegetation. It's observed that the area under vegetation changed during 1998- 2010 remarkably. Decrease in vegetation has been as a result of anthropogenic activities in the study area. In conclusion for detecting changes in areas based on a subject e.g. population increase, vegetation etc., over a period of years both spatial and in quantitative way, integrating remote sensing data and GIS techniques will be useful**.** In conclusion, Population density pattern has significant impact on vegetation cover in urban areas. The current research used the Normalized Difference Vegetation Index (NDVI) in the rapidly growing region of Faisalabad's four urban Towns from 1998 to 2010, to appraise changes in patterns of vegetation cover. Consequences of research pointed out changes in NDVI values. Different agents of change outcome land cover at different scales road density, Population density and other anthropogenic factors were vital drivers of both positive and negative NDVI changes. The chief causes for this are the clearance of agricultural lands in the earlier period and there is still a danger to the residual urban aboriginal vegetation which might be destroy in future for the reason of new residential design. The common trend of population expansion and density is from interior city areas towards all the aforementioned towns. This can be argued that with the growth and expansion of city and increase in its population density the green nature of these areas have been abridged. Finally it can be accomplished from this study that, urbanization and urban sprawl is one of the most significant and vital subject which is faced by all developing countries like Pakistan. It is the requirements of the time to tackle it connecting all stakeholders like general public, corporate sector and NGO's, and not only the decision makers of any urban ecosystem. To facilitate these conservative measurers remote sensing data can play a vital role in both monitoring the land use changes and sustainable urban planning. In conclusion, this study has demonstrated that monitoring vegetation cover by using vegetation indices could lead to a better understanding of environmental phenomena and may improve our knowledge about global climate change and the greenhouse effect.

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REFERENCES

Ahmad, F. A Review of remote sensing data change detection: Comparison of Faisalabad and Multan Districts, Punjab Province, Pakistan. J. Geography and Regional Planning, 5(9):236-251 (2012).

Bhaskar, P. Urbanization and changing green spaces in Indian cities; case study city of Pune. International J. Geology, Earth and Environmental Sciences, 2(2):148-156 (2012).

Brian, D. W., L. E. Stephen and H. K. Jude. Analysis of time-series MODIS 250m vegetation index data for crop classification in the U.S Central Great Plains. Remote Sensing of Environment, 108:290–310 (2007).

CDGF, *Pre-Feasibility Study for Urban Transport and Industrial Waste Management Faisalabad.* Faisalabad: City District Govt. Faisalabad, Pakistan (2010).

Chen, J. Y. and Q. J. Tian. Vegetation classification based on high-resolution satellite image. J. Remote Sensing, 11(2): 221–227(2007).

Clarke, J. I. Population Geography. Pergamon, Press New York. p.28 (1972).

Dennison, P. E. and D. A. Roberts. The effects of vegetation phenology on endmember selection and species mapping in southern California chaparral. Remote Sensing of Environment, 87(2&3):123- 135 (2003).

Dhorde, A. A., A. Dhorde, and G. Joshi. Population calibrated land cover impervious surface coefficients for Upper Bhima basin. Intl. j. Geomatics and geosciences, 2(4):1027-1047 (2012).

ESRI., Arc GIS 9.2 Desktop Help Using the NDVI Process [Online], Environmental Systems Research Institute, Inc. Available: http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?TopicName=Using%20the%20NDVI%20process [Accessed 15 December 2012] (2008).

Filippi, A. and J. Jensen. Fuzzy learning vector quantization for hyper spectral coastal vegetation classification. Remote Sensing of Environment, 100(4): 512–530 (2006).

Gao, B. C. NDWI-A Normalized Difference Water Index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment, 58: 257-266 (1996).

Gibson, P. G and C. H. Power. Introductory Remote Sensing: Digital Image processing and Applications, Rutledge. New York, p. 127 (2000).

GOP, District Census Report of Faisalabad 1998: Population Census Organization, Statistics Division, Govt. of Pakistan, Islamabad (2000).

GOP, Punjab development statistics: Bureau of Statistics, Govt. of Punjab, Lahore (2010).

Hashemi, S. A. Investigation of Relationship between Rainfall and Vegetation Index by Using NOAA/AVHRR Satellite Images. World Applied Sciences J., 14(11):1678-1682 (2011).

Jensen, J. R. Introductory digital image processing: A remote sensing perspective, Pearson Prentice Hall, New Jersey (2005).

Karaburun, A. Estimation of C factor for soil erosion modeling using NDVI in Büyükçekmece watershed, Ozean. J. Applied Sci., 3(1):77-85 (2010).

Lillesand, T. M. and R. W. Kiefer. Remote Sensing and Image Interpretation, fifth edition.John Wiley & Sons, Inc., New York, New York (2004).

Mallinis, G., N. Koutsias, M. T. Strati and M. Karteris. Object-based classification using Quick bird imagery for delineating forest vegetation polygons in a Mediterranean test site. ISPRS J. Photogrammetry & Remote Sensing, 63(2008):237–250 (2008).

Marzluff, J. M. and K. Ewing. Restoration of fragmented and scapes for the conservation of birds: A general framework and specific recommendations for urbanizing landscapes. Restor. Ecol., 9:280–292 (2001).

Morawitz, D. F., T. M. Blewett, A. Cohen and M. Alberti. Using NDVI to assess vegetative land cover change in central Puget Sound. Environmental Monitoring and Assessment, 114: 85–106 (2005).

Purevdorj, T. S., R. Tateishi, T. Ishiyama and Y. Honda. Relationships between percent vegetation cover and vegetation indices. Intl. J. Remote Sensing, 19(18):3519−3535 (1998).

Rouse, J. W., R. H. Hass, J. A. Schell and D. W. Deering. Monitoring vegetation systems in the Great Plains with ERTS. In: Proceedings of the Third ERTS Symposium, December 1973 (Goddard Space Flight Center), Washington, DC: NASA, pp. 309–317, NASA SP-351. (1973).

Shirazi, S. A. Spatial Analysis of NDVI and Density of Population: A Case Study of Lahore Pakistan. Science International, 24(3): 323-328 (2012).

Sesnie, S. E., P. E. Gessler, B. Finegan and S. Thessler. Integrating Landsat TM and SRTM-DEM derived variables with decision trees for habitat classification and change detection in complex neotropical environments. Remote Sensing Environment, 112: 2145-2159 (2008).

Tapia, R., A. Stein and W. Biiker. Optimization of sampling schemes for vegetation mapping using fuzzy classification. Remote Sensing of Environment, 99: 425–433(2005).

United Nations. *World urbanization prospects the 2009 revision highlights*. New York: Population division, Department of Economic and Social Affairs, United Nations, ESA/P/WP/215. (2010).

Vitousek, P. M. Beyond global warming: Ecology and global change. Ecology, 75:1861–1876(1994).

Wang, J., P. M. Rich and K. P. Price. Temporal responses of NDVI to precipitation and temperature in the central Great Plains, USA. Intl. J. Remote Sensing, 24(11): 2345–2364 (2003).

Waqar, M. M., J. F. Mirza, R. Mumtaz and E. Hussain. Development of New Indices for Extraction of Built-Up Area & Bare Soil from Landsat Data. Open Access Scientific Reports, 1(1):01-04 (2012).

Yang, C. C., S. O. Prasher., P. Enright., C. Madramootoo., M. Burgess., P. K. Goel, I. Callum, Application of decision tree technology for image classification using remote sensing data. Agricultural Systems, 76(3): 1101–1117 (2003).

Yang, Z., P. Willis and R. Mueller. Impact of band-ratio enhanced AWIFS image to crop classification accuracy, The Future of Land Imaging Going Operational, The 17th William T. Pecora Memorial Remote Sensing Symposium, Denver, Colorado (2008).