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ASSESSMENT OF CLIMATIC AND ANTHROPOGENIC FACTORS AFFECTING VEGETATION OF THREE DISTRICTS OF PUNJAB, PAKISTAN

Abstract

To assess the greenery dynamics, the relationship between population changes and variation in normalized difference vegetation index (NDVI) was observed. For this purpose, three major metropolitan cities (Bahawalpur, Sahiwal, Gujranwala) of Punjab, Pakistan were studied. Land-satellite images of these cities from year 1981 to 2020 were processed to extract the NDVI data of forty years; the value of NDVI falls between 1 to -1. Data of climatic variables (temperature, rainfall, humidity, wind) and anthropogenic factors (population, population growth-rate) were also collected. This study quantified the fact that population increase is significantly reducing vegetation(NDVI).

Keywords: NDVI, Population, Climate, Punjab, Pakistan

Introduction

Vegetation is believed to be the primary source of oxygen and eliminates carbon dioxide from the ambiance; not only important to human environment but also paves a way for the sustainable long term health. It is also important to regulate numerous key functions in the biosphere and has a major role in maintaining biogeochemical cycles, sustaining local and global energy balance. It is also necessary for world economy specially in using the fuels for energy. Global wood, food and paper production is also reliant on extent of vegetation. Greenery of any area has significant effect on global environment and climate change (Sun et al., 2015).

Systematic investigation on impacts of temperature, air, rainfall on vegetation in Pakistan is very rare. This study was the first effort towards bridging this gulf. Based on the spot greenery data and meteorological data from the Pakistan Meteorological Department (PMD), the object of this research was to find the influences of environmental factors and population on vegetation. To do this, a study was carried out with NDVI, climatic and anthropogenic data over part of Bahawalpur, Sahiwal

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and Gujranwala over 40 years. In specific, vegetation presentation, vegetation changes, climate changeability and spatial and temporal sensitivity of vegetation changing aspects to climate variability is also be analyzed. In the framework of this study, vegetation presentation is consistently down with the time (Roerink et al., 2003). The rapid growth in population in Bahawalpur (bwp), Sahiwal (swl) and Gujranwala (grw) during the years 1981 to 2020 and changing in climate (temperature, rainfall, humidity and wind speed has resulted in the degradation of vegetation described by NDVI resources in terms of vegetation changes and land cover changes, decline in biodiversity and affected the greenery within above mentioned three districts of Punjab Pakistan (Riaz et al., 2017).

The objectives of the study were to generate a multiyear (1981-2020) data of NDVI of three locations in Punjab, Pakistan and to analyze and compare spatio-temporal vegetation pattern of three locations using NDVI approach. The main climatic factor responsible for vegetation changes in these locations was also identified; hence the root cause behind recurrent vegetation changes is point pointed hereby in this research work.

Methodology

Three districts, Gujranwala, Sahiwal and Bahawalpur of Punjab selected as study sites; all three districts are situated in Punjab Pakistan. Gujranwala situated in upper and Sahiwal center while Bahawalpur lower Punjab respectively. All three selected regions are divisional headquarters as well as also districts headquarters. Distance between Bahawalpur to Sahiwal and Sahiwal to Gujranwala is almost 250 KMs. According to WRS, the path of Bahawalpur is 150 and row is 040, the path of Sahiwal is 150 and row is 39 whereas path of Gujranwala is 149 and row is 38.

From the website USGS through Landsat collection-1 level-1(Landsat 1-5 MSS C1 level 1; Landsat 4-5 TM C1 Level -1, Landsat 7 ETM+ C1 Level-1, Landsat 8 OLI /TIRS C1 Level 1), forty finest quality, clearest images without cloud from (1981 to 2021; in June of each year) of each city (40x3 = 120 images in total) were downloaded. After downloading images, to infer Natural Difference Vegetation Index (NDVI), ERDAS 2014 software was utilized. The area of all downloaded 120 images was very big. First thing was to crop the required area. For this purpose, the shape file of three districts was added, required bands were added in the stack layer. Images were saved. To measure the NDVI of images, in raster data unsupervised classification was opened and stack images were loaded in NDVI. In this way, NDVI image was downloaded. In the next phase, NDVI values were used as X variable in this study. For NDVI values ARCRGIS 10.5 software was used. NDVI image was added in ARCRGIS and then opened layer properties and histograms were opened which was showed different values of NDVI like minimum NDVI, maximum NDVI, mean NDVI along with standard deviation (Waiyasusri, 2021). In this way, NDVI minimum, maximum, mean and standard deviation values were noted every year. Following the method of Chen et al. (2019) along with some modifications, the data quality will be improved using ArcGIS 10.5 to replace any abnormal value with value of nearest neighbors. The calculated results of NDVI in

a value between -1 and +1. Climatic variable such as temperature, wind, humidity, rainfall of these three locations were also collected form an authentic source from 1981 to 2021; anthropogenic variable such population and population growth rate was also taken from the reliable source.

Obtained data was statistically analyzed. For this purpose, after descriptive statistics expressed in box-plot figures, analysis of variance test (ANOVA) was applied to all studied variables. Autoregressive integrated moving average (ARIMA) methodology was used to forecast the NDVI and population up to 2071. Multiple linear regression model was also applied to detect the potent factors affecting NDVI.

Results

Boxplot (Figure 1) is the graphical expression of five-digit data summary such as minimum, maximum (upper and lower whisker), median (middle line), lower 25% (lower line of box) and upper 75% (upper line of box). The box length expresses 50% distribution of the data. In the figure 1, box plot of each variable for three cities are presented separately in a single graph contain three boxplots. Higher the difference among five-digit summary values, different the box position will be in the graph.

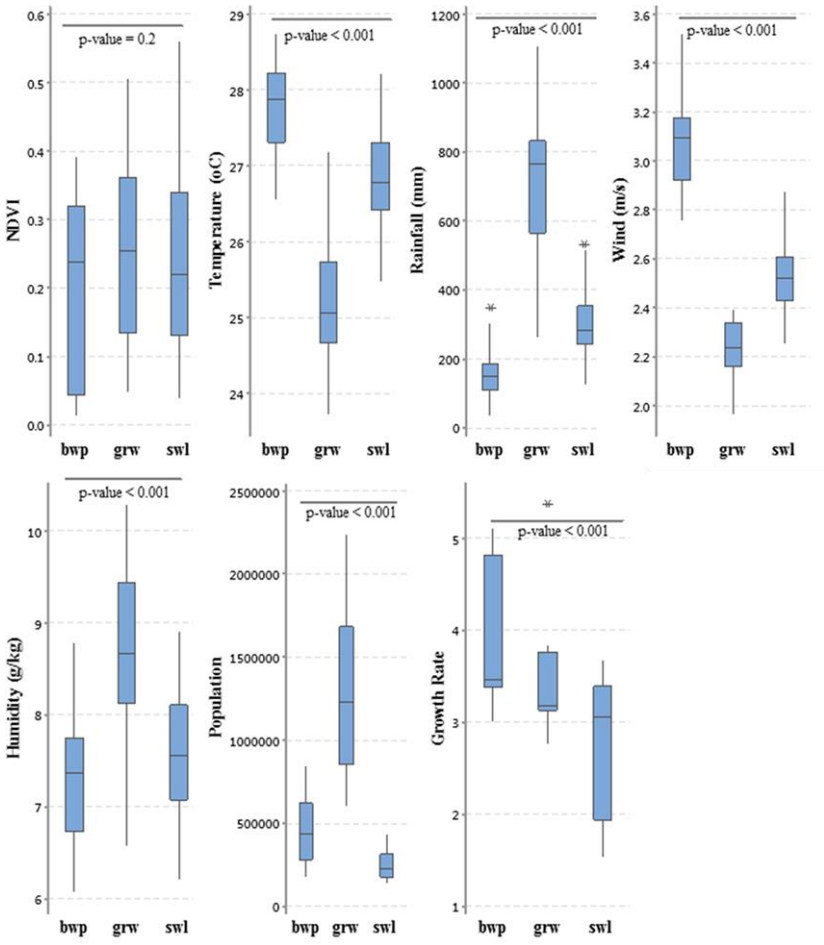

Figure 1. Boxplot comparison of three cities for each of the seven variables

Regarding univariate analysis, city was the one factor assumed affecting the change in temperature, rainfall, wind, humidity, population, growth rate of population and NDVI. The difference in ranges of these attributes is tested using analysis of variance technique. A nominal factor, city with two degree of freedom was actually tested. It was noticed that greenery was not different (non-significant p-value >.05) in all three cities. While the other parameters were significantly different (p-value < 0.001) among all three cities (Table 1). This shows that these cities are facing different geological and environmental conditions.

Table 1. Analysis of variance (ANOVA) of seven studied variables with respect to three cities

	Effects			Error			F	p-value
Variables	SS	df	MS	SS	df	MS		
NDVI	5.89E-02	2	2.94E-02	2.11E+00	117	1.81E-02	1.63	0.2
Temperature	1.35E+02	2	6.77E+01	5.21E+01	117	4.45E-01	152.21	<0.001
Rainfall	6.36E+06	2	3.18E+06	2.05E+06	117	1.76E+04	181.18	<0.001
Wind	1.41E+01	2	7.07E+00	2.29E+00	117	1.95E-02	361.71	<0.001
Humidity	4.07E+01	2	2.03E+01	7.14E+01	117	6.11E-01	33.31	<0.001
Population	2.40E+13	2	1.20E+13	1.10E+13	117	9.37E+10	128.32	<0.001
Growth Rate	3.27E+01	2	1.63E+01	5.08E+01	117	4.34E-01	37.65	<0.001

SS: Sum of squares; **df:** Degree of freedom, **MS:** Mean square

Using ARIMA model, we predict here in figure 2, the population and NDVI changes upto 2071. The values of 1981 and 2020 are actually recorded values while the values of 2071 for three locations are predicted values and anyone can detect a clear-cut difference from 1981 to 2021 and from 2021 to 2071 in NDVI and population. We see that as population increases the vegetation (NDVI) decrease massively (Figure 2).

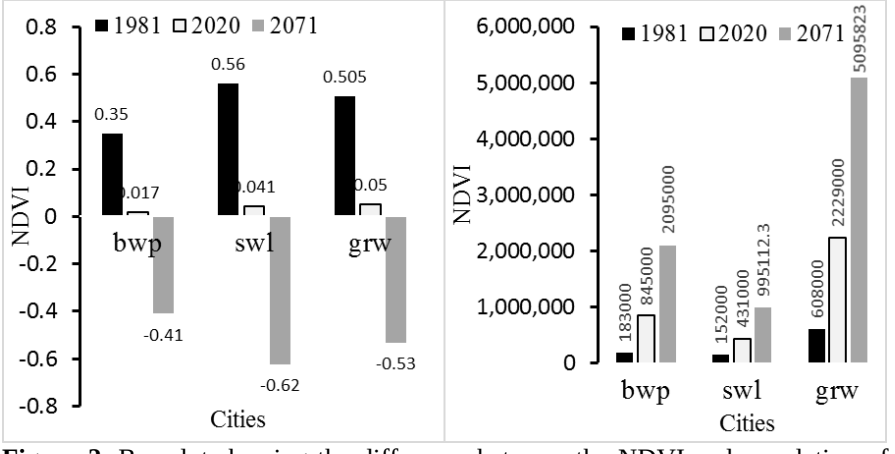

Figure 2. Bar plot showing the difference between the NDVI and population of three cities (bwp: Bahawalpur, swl: Sahiwal; grw: Gujranwala) in the years 1981, 2020 and 2071

On the basis of multi-collinearity diagnostics using variance inflation factor (VIF) estimates, a set of predictor variables was taken to predict NDVI. Independent variable such as temperature was excluded from the model due its higher (> 5.0) VIF. After standardization, model was generated with five (rainfall, wind, humidity, population, and growth) independent predictors and one dependent variable that is

NDVI. These five predictors explained 68 percent variation in NDVI and the model was overall significant (p-value <.0001) with adjusted mean square 0.3 and F-value 52.17 while the root mean square error (RMSE) was 0.0761 (Table 2). Except growth rate, all other variables including intercept were significantly (p-value <.0001) affecting the NDVI. Most important was rainfall (Beta 0.2) and humidity (Beta -0.0133). By unit increase in rainfall, NDVI is also increased by 0.2 times and NDVI is decreased 0.133 times if humidity increases by one unit. Population has also negative impact on NDVI by 0.072 times (Table 2).

Table 2. Multiple regression analysis model along with multi-collinearity statistics (VIF) analysis of variance of the regression parameters. Durbin-Watson Statistics = 1.182

Term	Coefficient	SE Coef.	T-Value	P-Value	VIF
Constant	0.229	0.007	32.98	< .0001	
Rainfall	0.2	0.015	13.1	< .0001	4.78
Wind	0.034	0.013	02.66	.009	3.28
Humidity	-0.133	0.013	-10.58	< .0001	3.26
Population	-0.07	0.01	-07.15	< .0001	2.08
Growth Rate	0.004	0.009	0.49	.627	1.34
Source	df	Adj SS	Adj MS	F-Value	p-Value
Regression	5	1.51201	0.302402	52.17	< .001
Rainfall	1	0.99492	0.994918	171.65	< .001
Wind	1	0.04087	0.04087	7.05	< .009
Humidity	1	0.64912	0.64912	111.99	< .001
Population	1	0.29659	0.296587	51.17	< .001
Growth	1	0.00137	0.001373	0.24	.627
Error	114	0.66079	0.005796		

Adjusted R^2 of the model: 68.25%; **Coef. :** Coefficients; **VIF:** Variance inflation factor; **Adj SS:** Adjusted sum of squares; **Adj MS:** Adjusted mean squares; **df:** degree of freedom

Discussion

All the human beings inhale oxygen and in natural environment, trees are the only source of producing oxygen. What is more important than that carbon dioxide gas is released through exhalation and the same gas is the product of all the procedures of burning fuel. The vegetation described by NDVI consume this gas for their respiration and photosynthesis (Thompson et al., 2013). The long-term decrease of vegetation as showed by NDVI is a symbol of degradation (Kalisa et al, 2019) Where there strikes a balance between trees and human population, the quality of air ameliorates for breathing/respiration. As the level of population is going up in

cities, the expansion of residential colonies is more to be seen. For this, trees are/vegetation is rooted up. Resultantly, the air in cities is no healthier to inhale. This situation becomes worse when there are no trees planted on either side of the road and in streets. The slap in the face is that no parks and grounds are set up to make up for the loss of trees. In Gujranwala, Sahiwal and Bahawalpur, the average size of a house is of 5 marla where it is impossible to plant trees. Consequently, the atmosphere is saturated with pollution.

The rudimentary unit of the environmental survival is vegetation. An expert has remarked if the earth holds the status of 'Mother earth', for life, the trees existing on it bear the rank of father. This year, in Pakistan, a campaign naming 'Plant for Pak' is on move. The training and motivation to plant trees must be inculcated in students at primary schools, high schools and colleges. Moreover, the students of Madrasahs should also be trained to plant trees (Sun et al., 2015). Pakistan is included among those countries which have the ratio of 4-5 trees per capita. Unfortunately, this is the lowest level of plantation drive. Pakistan follows 8 countries ahead which have the lowest level of plantation i.e. Pakistan holds the 9th position with least production of trees. Trees are the biggest source of manufacturing oxygen and also they consume the hazardous and pollution causing gases like carbon dioxide. So it becomes evident that the more the per capita production of trees is, the cleaner the air will be. If the websites offering weather news are consulted, the air quality of Pakistan is tagged with the words like 'poor' or 'very poor'. Research unravels that the total number of trees in the world equals 3 trillion but before the spike in human population on the globe, this number was known to be double i.e. 6 trillion. Regarding population, Pakistan, with an increase of 50 lac in population per annum is the 3rd biggest country of the world and as regards environmentally polluted countries, Pakistan, India and Bangladesh are considered on the top of the list.

Conclusion

This study intended to identify the impacts of climate and population on vegetation change by the application of geo-spatial data analysis. We observed that the variation in NDVI is highly related to population change. Vegetation the root cause of life is threatened by our unplanned urbanization. This increase in population directly or indirectly affecting many other anthropogenic factors. Mass flow toward big cities is due to the availability of facilities of health and education but this crowed is totally unsupervised and compelling the future life of upcoming generations at risk due to the massive decrease in NDVI as is predicted in the preset research.

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