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Research Paper

Linkage between the vegetation indices and climate factors over Haryana

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ABSTRACT

Present study was an attempt to study the relationship of Normalized Difference Vegetation Index (NDVI) and Leaf Area Index (LAI) with climatic parameters (maximum temperature, minimum temperature, relative humidity, rainfall, wind speed and aerosol optical depth) over the Indian state of Haryana using MODIS derived vegetation indices on monthly and yearly values for the time period from 2010 to 2020. The values of correlations coefficients of NDVI and LAI with climatic variables varied with the months, the nature of their variation was similar for two indices. During summer season the correlation values were maximum while these were minimum during rainy season. The overall correlation analysis revealed that the rainfall and relative humidity were positively correlated with NDVI and LAI, while the remaining climate variables had negative impact on the NDVI and LAI.

Key Words: Rainfall, NDVI, LAI, Aerosol

Climate/Weather parameters, especially temperature and precipitation, play an important role to influence the vegetation change/growth, distribution, and carbon budget (Adams *et al*., 2010). The vegetation growth/dynamics is inevitably affected by the climate change and its in-dices are commonly used to track the growth and dynamics of vegetation in an environment. The agricultural production is affected due to variation in degree of heat and water stress caused by weather changes (Fiwa *et al*. 2014; Zhao and Li 2015). The higher average temperature is responsible directly to harm crop physiological processes within less radiation interception and less biomass production.

Although, the climate and vegetation feedback for greening Earth is well recognized but greening-to-browning reversals are anticipated to occur in the future (Huang *et al*. 2019). This process is totally depending on the future climate change which affects the vegetation dynamics and functions (Xia *et al*. 2014). The efficiently and conveniently monitoring of vegetation indices by remote sensing technology is extremely beneficial for reporting the vegetation changes around the world. The normalized difference vegetation index (NDVI) and leaf area index (LAI) is commonly used worldwide to obtain the status of surface vegetation for a larger extent at present (Chu *et al*. 2019; Guo *et al*. 2014). MODIS time series NDVI datasets was used to detect greenness regeneration over western Rajasthan and the Gujarat region of India (Koyel Sur *et al,* 2018).

Revadekar *et al*. (2012) demonstrated the seasonally climate variability (specially precipitation and rainfall) impact on the NDVI over Indian region during 1981–2010. They found that the NDVI values are minimum during the hot weather conditions (March to May) and its value increased in the onset summer monsoon season (June-September), specially over the southern parts of India due to natural water availability. Present study is an attempt to establish a linkage between the vegetation indices such as NDVI and LAI with climate factors on monthly time scale.

MATERIAL AND METHODS

Study area

Haryana state is situated in the northwestern part (semi-ar-

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id and arid climate) of Indian region with geographic extent with latitudes from 27° 37' to 30° 35', and longitudes from 74° 28' to 77° 36', and with elevation ranges from 700 to 3600 feet above mean sea level. Primarily, it is agricultural state and mostly, crops are cultivated twice in a year, mainly rice and cotton in monsoon season and wheat in the post monsoon season (winter). Good quality and enough irrigation facilities with water sourced from canal and groundwater resources are also available in this state. The climatic condition of Haryana state is hot in the summer (April to June) and cold in the winter (December to January) with the pleasant months of spring in between throughout the year.

Data retrieval

The daily gridded (0.25°x 0.25° and 0.5°x 0.5°) weather variables, namely, rainfall, maximum and minimum temperatures were downloaded from the India Meteorological Department (IMD) for the time period of years 2010 to 2020 over the spatial extent of Haryana state. The other climate variables, namely, relative humidity (RH), and wind speed (WS) were downloaded from the NASA's Prediction of Worldwide Energy Resources (NASA power) for same time period (2010 to 2020) at 0.5°x 0.5°. The MODIS sensor derived daily aerosol optical depth at 550 nm gridded at 1° x 1° were downloaded from GIOVANNI (Goddard Earth Sciences Data and Information Services Centre) for the time period from January 2010 to December 2020.

The MODIS sensor produced vegetation indices namely NDVI and LAI on 8 and 16 days intervals at various spatial resolutions were also obtained. These, vegetation indices are derived from atmospherically-corrected reflectance in the red, near-infrared, and blue wavebands with less canopy-soil variations to characterize the global range of vegetation states and processes (Ichii *et al*. 2002). The lower values of the NDVI indicates that the moisture stressed vegetation, while the higher values of the NDVI show the healthy and green vegetation. The MYD13A1 Version 6 product of MODIS mission provides vegetation Indices values with the spatial resolution of 500 meter. This product consists the two primary vegetation indices layers namely NDVI and EVI (Enhanced Vegetation Index). The vegetation indices NDVI has been extracted for the time period January 2010 to the December 2020 form the available MODIS product (MYD13A1) for the present analysis. The MODIS sensor derived product namely MCD15A2H version 6 level 4 having two vegetation variables are fraction of photo synthetically active radiation (FPAR), and leaf area index (LAI) with spatial resolution of 500 meter in 8-day composite. The MCD15A2H algorithm consider the best pixel available from all the acquisitions of both MODIS sensors located on NASA's Terra and Aqua satellites from within the 8-day period

Analysis

The time series of the monthly and yearly vegetation indices (NDVI and LAI) and climate variables (Rainfall, maximum temperature, minimum temperature, relative humidity, and wind speed) were constructed by averaging land-point grid values and spatial average values over the Haryana state. The temporal variations of vegetations indices and climate variables on monthly as well as yearly basis were obtained. The correlation analysis was carried out between vegetation indices and climate variables on monthly and yearly basis to understand the relationship between each vegetation indices with all the climate variables, separately. The Pearson correlation method is used for the computation of the correlation coefficients with the 5% significance level.

The Pearson correlation coefficients have been calculated between the vegetation indices and climate variables.

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{(x_i - \bar{x})^2 (y_i - \bar{y})^2}}$$

Where, r_{xy} is the value of Pearson correlation coefficients between variables x (vegetation variable) and y (climate variable) with sample size n. The value of r_{xy} varies from -1 to +1. The index i represent the ith month, and ith year for the computation of correlation coefficients on monthly and yearly basis, respectively.

RESULTS AND DISCUSSION

Correlation of NDVI and LAI with climate variables on monthly scale

Fig. 1 represents the Pearson correlation coefficients values between NDVI and climate variables for every month. The rainfall and relative humidity showed the positive impact on the NDVI, while the maximum and minimum temperature, and wind speed showed the negative impact on the NDVI. The AOD showed sometimes negative or some-times positive impact on the NDVI. During the rabi season (mid-November to mid-May), the correlation coefficients between NDVI-rainfall, and NDVI-relative humidity was found positive increasing trend and it attends higher value in the April month and afterwards it slightly decreases. The correlation coefficients between the NDVI-maximum temperatures, NDVI-minimum temperature, NDVI-wind speed, was found negatively increasing trend during the rabi season crops cycle. Similar trends were obtained in correlations with LAI (Fig. 2). Vegetation cover is one of the important factors in ecology to know the relationship between vegetation cover and link it to different atmospheric variables such as temperature and humidity (Wedyan *et al*, 2022).

The rainfall and relative humidity show lower impact on LAI than NDVI. It means, the leaf area of the vegetation is not increasing in the same manner with the rainfall and humidity but the greenness of the vegetation is increases effectively with the rainfall and humidity. The climate variables show lower negative impact to reduce the leaf area than the greenness of the vegetation. The relationship between temperature and vegetation cover was of inverse in nature. The correlation strength was weak between temperature and vegetation and strong between vegetation and relative humidity. The relationship was positive too between vegetation cover and relative humidity (Wedyan *et al,* 2022).

Overall correlation analysis

Table 1 shows the cumulative impact of climate variables

Table 1: The Pearson correlation coefficients (r) and Spearman correlation coefficients (rs) among climate variables and vegetation indices at the significance level 0.05% on monthly and yearly basis.

Vegetation indices →	**NDVI**		**LAI**	
Climate variables↓	Monthly (r/rs)	Yearly (r/rs)	Monthly (r/rs)	Yearly (r/rs)
Rainfall	0.215/0.238	0.480/0.464	0.039/0.021	0.454/0.418
Maximum temperature	-0.551/-0.601	-0.416/-0.282	-0.317/-0.490	-0.501/-0.355
Minimum temperature	-0.327/-0.231	-0.201/-0.215	-0.203/-0.224	-0.259/-0.127
Relative humidity	0.559/0.671	0.582/0.518	0.348/0.455	0.612/0.600
Wind speed	-0.599/-0.517	-0.431/-0.373	-0.444/-0.510	-0.498/-0.545
Aerosol optical depth	-0.261/-0.259	0.104/0.118	-0.468/-0.469	-0.019/-0.209

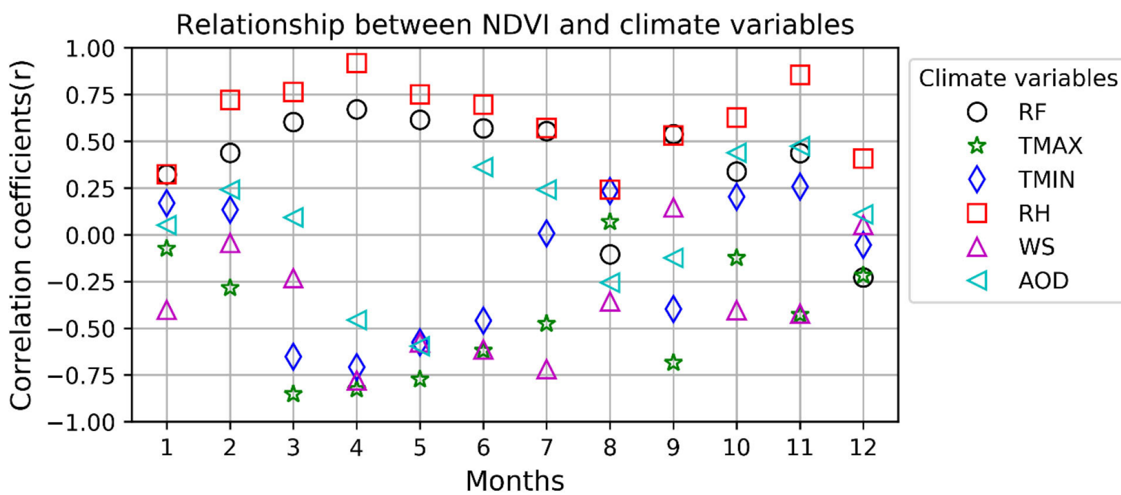

Fig. 1: Pearson correlation coefficients between monthly NDVI and climate variables

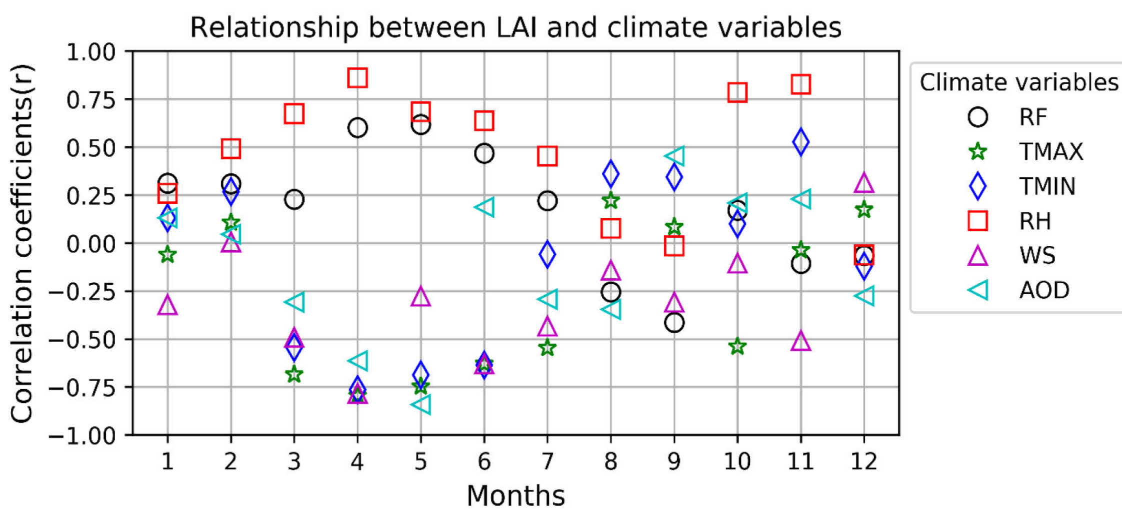

Fig. 2: Pearson correlation coefficients between monthly LAI and climate variables

(RF, TMAX, TMIN, RH, WS, and AOD) on the NDVI and LAI for monthly and yearly basis. The mean of whole datasets was taken on monthly and yearly basis individually. The Pearson correlation coefficients were computed between yearly mean of the vegetation indices and climate variables for the computation of cumulative value of the correlation coefficient on monthly and yearly basis. The Pearson and spearman correlation coefficient of NDVI and LAI was positive with rainfall and relative humidity on monthly as well as yearly while temperature, wind speed and aerosol had negative correlation with NDVI and LAI.

CONCLUSIONS

The MODIS sensor derived NDVI and LAI during the years 2010–2020 has been analyzed to examine its temporal variability on monthly and yearly basis. The correlation between NDVI-climate and LAI-climate showed the distinct behavior in crop growing months and non-crop growing months of a year. The rainfall and relative humidity show the positive and significant impact on the NDVI and LAI, while the maximum and minimum temperature, and wind speed, show the significant negative impact on the variation of NDVI and LAI on monthly/yearly time scale.

Conflict of Interest Statement: The author(s) declare(s) that there is no conflict of interest.

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REFERENCES

Adams, L., Albright, G., Belshe, K., Boyd, J.D., Brown, M.R., Bryant, C., Coleman, R**.**, Cowin, M., Douglas, K., Grueneich, D.M., & Spivey-Weber, F. , Horton, M.B., Kawamura, A.G., Jamison, B., McCamman, J., Movassaghi, M., Nichols, M., Ryan, N., Snow, L., Tuttle, C., (2010). Climate Action Team, Biennial Report, pp-126.

Chu, H., Venevsky, S., Wu, C., and Wang, M. (2019). NDVI-based vegetation dynamics and its response to climate changes at Amur-Heilongjiang River Basin from 1982 to 2015. *Sci. Total Environ., 650*:2051-2062

Fiwa, L., Vanuytrecht, E., Wiyo, K. A., and Raes, D. (2014). Effect of rainfall variability on the length of the crop growing period over the past three decades in central Malawi. *Clim. Res.*, *62*(1): 45-58.

Guo, L., Wu, S., Zhao, D., Yin, Y., Leng, G., and Zhang, Q. (2014). NDVI-based vegetation change in Inner Mongolia from 1982 to 2006 and its relationship to climate at the biome scale. *Adv. Meteorol., 7 (2)*: 148-151

Huang, M., Piao, S., Ciais, P., Peñuelas, J., Wang, X., Keenan, T.F., Peng, S., Berry, J.A., Wang, K., and Mao, J. (2019). Air temperature optima of vegetation productivity across global biomes. *Nat. Ecol. Evol., 3 (5)*:772-779

Ichii, K., Kawabata, A., and Yamaguchi, Y. (2002). Global correlation analysis for NDVI and climatic variables and NDVI trends: 1982-1990. *Int. J. Remote Sens.*, *23*(18): 3873-3878.

Koyel Sur, Rucha Dave and Prakash Chauhan, (2018). Spatio - temporal changes in NDVI and rainfall over Western Rajasthan and Gujarat region of India. *J. Agrometeorol.,* 20 (3) : 189-195. https://doi.org/10.54386/jam.v20i3.541

Revadekar, J. V., Tiwari, Y. K., and Kumar, K. R. (2012). Impact of climate variability on NDVI over the Indian region during 1981–2010. *Int. J. Remote Sens.*, *33*(22), 7132-7150.

Wedyan G. Nassif, Farant H. S. Lagenean and Osama T. Al-Taai. (2022). The correlation strength was weak between temperature and vegetation and strong between vegetation and relative humidity. *J. Agrometeorol*., 24 (2):138-145. https://doi.org/10.54386/jam.v24i2.1581

Xia, J., Chen, J., Piao, S., Ciais, P., Luo, Y., and Wan, S. (2014). Terrestrial carbon cycle affected by non-uniform climate warming. *Nat. Geosci.*, *7*(3): 173-180.

Zhao, D., and Li, Y. R. (2015). Climate change and sugarcane production: potential impact and mitigation strategies. *Int. J. Agron.*, *12* (2): 184-189.