



Monitoring of vegetation condition and drought in relation to climate change over Afghanistan from 1982 to 2015

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Abstract

Drought is a severe problem in Afghanistan, where more than 80% of the population relies directly or indirectly on agriculture and the livestock sector. Although the drought indices derived from remote sensing data have been used to monitor meteorological or agricultural drought, there are no indices that can suitably reflect the comprehensive information of drought from meteorological to agricultural aspects. The main objective of this study was to assess the vegetation condition of Afghanistan in terms of time and space scales. Our method is based on the use of data from the AVHRR Normalized Difference Vegetation Index (NDVI) from 1982 to 2015 and temperature and precipitation data from Modern Era Retrospective Analysis for Research and Applications (NASA's MERRA). The NDVI is the most helpful for characterizing the drought conditions in Afghanistan because of the low vegetation and severe drought. The seasonal values of TCI, NDVI, VCI, VHI, and PCI confirmed that Afghanistan suffered from severe drought in 1989, 2002, and 2007 and led the durations of severe drought. Spatial correlation is generated between NDVI, VCI, VHI, PCI, and TCI. The correlation between TCI and NDVI, VHI and NDVI showed a significantly negative correlation, while there was a significantly positive correlation between VHI and TCI, VHI and VCI, and TCI and PCI, which showed a good indication for the assessment of drought, especially for the agricultural regions of Afghanistan. It was confirmed that these indexes are a comprehensive drought monitoring indicator and a step toward monitoring climate change in Afghanistan, which will play a vital role in conducting studies on vegetation types, monitoring climate change, and drought in Afghanistan.

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1. Introduction

Drought is significantly associated with migration and food insecurity in Afghanistan. It is a creeping phenomenon and a slow-onset natural disaster that causes serious damages to the ecosystem services of the arid and semi-arid regions of Afghanistan (Razipoor et al., 2016) ^[27]. In the context of current global warming, the frequency of droughts is increasing worldwide, and climate models predict that the frequency of droughts will increase in the coming decades (Dai 2013; Schwalm *et al.* 2017) ^[3, 31]. Recently, IPCC (2014) reported that the increase in greenhouse gases in the atmosphere as a result of severe and prolonged droughts would occur in Afghanistan. The prolong drought trends has significantly influenced on frequency of drought (Forkel *et al.* 2013) ^[5]. One of the effects of climate change that simultaneously affects agricultural and water resources as well as the social and economic spheres over an extended period of time is drought. The global averaged ocean surface and land temperature have increased considerably at a rate of 0.85 °C during 1880-2012 (IPCC 2014) ^[10].

This natural event occurs in almost all climatic regions, although its characteristics are completely different from one region to another (Shahabfar *et al.* 2012; Mushore *et al.* 2019)^[32, 23]. Drought can be classified as meteorological, agricultural, hydrological, or social, depending on the environmental sectors affected (Peters 2003)^[25]. In general, monitoring of drought methods includes the vegetation index (VI), which uses a vegetation index which reflects the state of vegetation growth to be related to drought. Vegetation index such as NDVI (Tucker *et al.* 2005)^[35] and Vegetation Condition Index (VCI) were used world-wide (Kogan 1990)^[15]. the NDVI is most commonly used to analyze vegetation changes and its relationship to climate change and ecological dynamics (Tucker *et al.* 2005; He *et al.* 2015)^[35, 9]. Temperature and precipitation are the two most essential climatic factors that affect the vegetation trends (Piao *et al.* 2011)^[26]. Previous study found that the decline in the NDVI value in temperate regions during summer is linked to a significant decrease in summer rainfall (Xu *et al.* 2017)^[40]. Previous study found that the response of vegetation dynamics in the various ecosystems to climate change indicates that vegetation dynamics in recent decades are closely linked to climate change (Ren *et al.* 2020)^[29].

To find out the effect of droughts on vegetation is a complex climatic issue due to different vegetation types having different resistance to drought (Pasho *et al.* 2012)^[24]. Moreover, drought impacts under various vegetation species can be significant to evaluate a number of drought characteristics, such as drought severity and prevailing time-scales (Maherali and DeLucia 2001a, b)^[22]. The temperature condition index (TCI) can be an excellent symbol for assessment of drought phenomena and vegetation trends, which is obtained from AVHRR product (Pandey *et al.* 2007). The vegetation condition index (VCI) is another useful index for observing and assessing of vegetation and drought dynamics (Singh *et al.* 2003)^[33]. However, the occurrence of droughts does not correspond with variations in the vegetation greenness. The combination of the VCI and TCI makes a new technique called the Vegetation Health Index (VHI) (Wang *et al.* 2019)^[38]. The significant impact of drought is indicated by the close relationship observed between the drought index and the vegetation vitality index, primarily the NDVI.

The accessibility of remote-sensing data with broader spatial exposure has led researchers to capture the spatiotemporal dynamics of droughts and its relations on vegetation dynamics and crops production (Gouveia *et al.* 2008)^[7]. Different studies find out the effect of drought on the vegetation by using remote-sensing data (Lloret *et al.* 2007;

Gouveia *et al.* 2009)^[20, 8]. Among many remote sensing techniques based drought indices, the normalized difference vegetation index (NDVI)-based vegetation condition index (VCI) (Kogan and Sullivan, 1993; Kogan, 1995b)^[18, 16] and land surface temperature (LST)-based temperature condition index (TCI) (Kogan, 1995a; Uganai and Kogan, 1998)^[16, 37] are two useful tools for monitoring the intensity, duration and impact of drought on regional or global level (Singh *et al.*, 2003)^[33]. As a result, it makes more sense to take temperature into account when monitoring drought events, especially in light of global warming, in order to establish a trustworthy correlation between vegetation activity and drought. However, in the humid regions of high-latitude, where vegetation growth is primarily limited by lower temperatures which are opposite with low-latitude regions, using VHI to monitor drought conditions has to be undertaken with caution (Karnieli *et al.*, 2006)^[14].

As far as we are aware, no studies have been conducted in the Afghanistan region that specifically address the dynamics of vegetation and drought events in connection to climatic change. Moreover, the combined effects of temperature and precipitation on vegetation dynamics have not been studied in any previous studies. As we know, drought is a slow process which begins with rainfall deficit, then it leads to soil water deficit with a higher land surface temperature, and at last, the vegetation growth will be influenced by this process (Du *et al.* 2013)^[4]. Thus, in this study, we use AVHRR NDVI and derived vegetation dynamics on a seasonal basis by correlating the results with NASA's MERRA precipitation and air temperature for monitoring drought and vegetation dynamics over Afghanistan. This allows us to monitor the comprehensive drought, which is derived from rainfall, air temperature, and vegetation dynamics.

Study Area

Afghanistan spans over 650,000 km² and is situated between latitudes 2930–3840 North and longitudes 6030–7450 East (Fig.1). Extreme seasonal temperature fluctuations are common in the lowland plains of southern Afghanistan; the average summer temperature (June to August) rises to over 33 C, while the average winter temperature (December to February) is approximately 10 C. bordering China on a narrow length of mountainous territory in the northeast, Turkmenistan, Uzbekistan, and Tajikistan in the north, Iran in the west, and Pakistan in the south. The climate of the study area is semi-arid to arid, and protracted droughts are common in Afghanistan (ESCAP, 2012: 11 12; Shroder and Ahmadzai, 2016: 136-139).

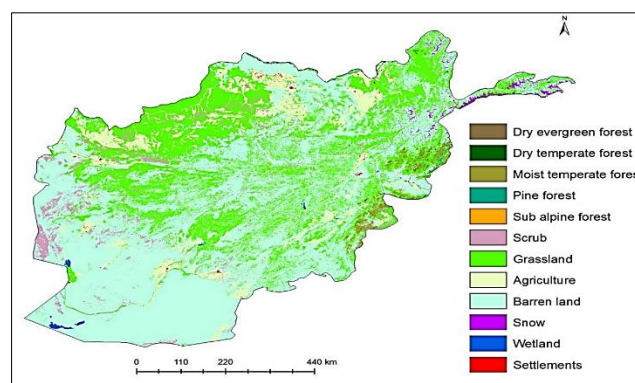


Fig 1: Land cover map of Afghanistan

Remote sensing data and processing

Monthly NDVI, rainfall, and temperature are used together for the analysis of the impact of drought and vegetation. Monthly matrix temperature and rainfall throughout the 1982 to 2015 analysis period were extracted from the AVHRR on the National Oceanic and Atmospheric Administration (NOAA) to monitor and assess the vitality of terrestrial vegetation (Xu *et al.* 2014) [41]. A successor of the GIMMS NDVI3g bimonthly dataset derived from the NOAA per AVHRR sensors (NDVI3g) at a partial and temporal resolutions are 0.083° and 15-day interval from 1982 to 2015, respectively. From the NDVI3g time series, NDVI values flagged as “good quality” were extracted for the analysis. This dataset is the longest available NDVI time series, suitable for monitoring long-term vegetation changes. NDVI3g accurately characterizes vegetation responses to climate variability (Tucker 1979) [36]. The long-term monthly average rainfall and temperature data were retrieved from Modern Era Retrospective Analysis for Research and Applications (NASA’s MERRA) at a spatial resolution of $0.5^\circ \times 9 0.5^\circ$. The climate datasets were rescaled to $0.0833^\circ \times 9 0.0833^\circ$ same resolution with NDVI. The temperature was retrieved at 2 m above ground. The VCI (Vegetation Condition Index) is an important sign for monitoring drought

stress on vegetation. The VCI was calculated according to the formulae explained by Kogan (1990,1995,1998):

$$VCI = \frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}$$

where PRC (precipitation), PRC max, and PRC min are the pixel values of precipitation and maximum and minimum of it, respectively, in the same month during 1982–2015.

$$PCI = \frac{PRC - PRC_{min}}{PRC_{max} - PRC_{min}}$$

where LST max and LST min are the maximum and minimum values of each pixel during 1982–2015.

$$TCI = \frac{LST_{max} - LST}{LST_{max} - LST_{min}}$$

The VHI (Vegetation Health Index) was calculated according to the formulae explained by Kogan (1998) of each pixel, respectively, in same month during 1982–2015.

$$VHI = 0.5(VCI)_{ijk} + 0.5(TCI)_{ijk}$$

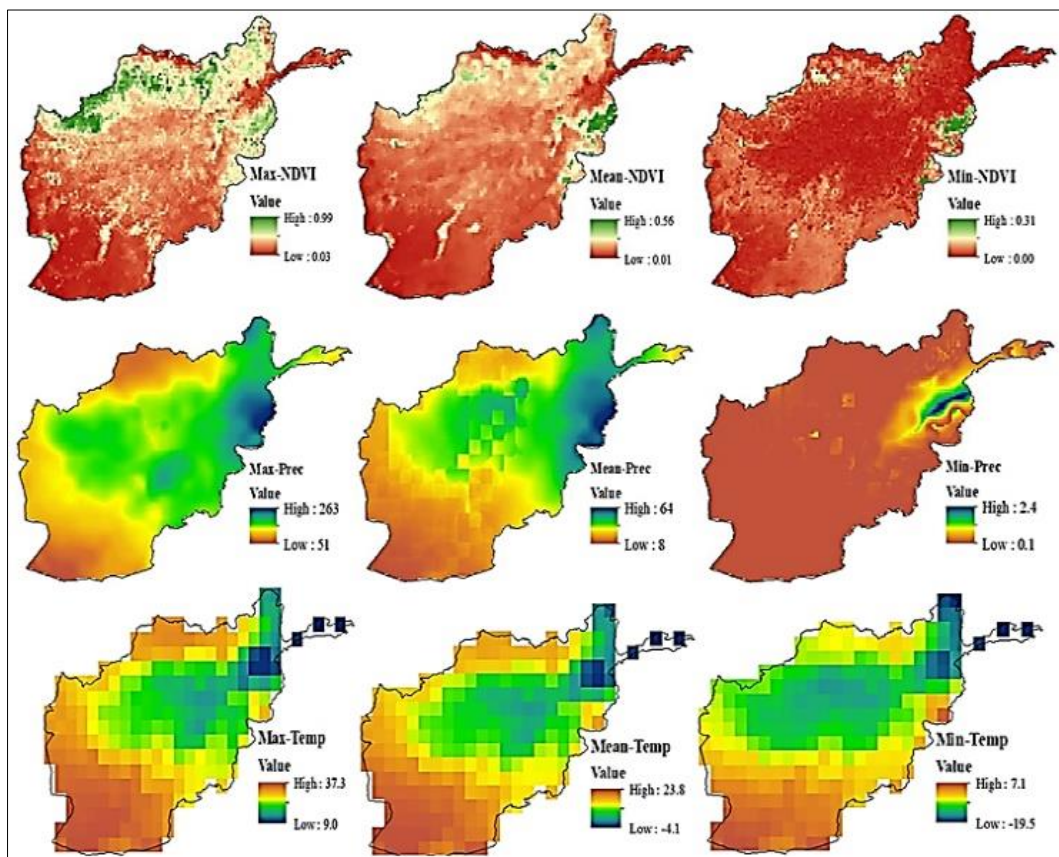


Fig 2: Maximum, mean and minimum (a) NDVI, (b) precipitation (mm) and (c) temperature ($^\circ\text{C}$) over Afghanistan during (1982-2015).

Results and Discussion

Monitoring Vegetation Dynamics and Trends Using AVHRR Data

Using NASA's MERRA rainfall and temperature data for the years 1982–2015, together with AVHRR NDVI data, the maximum, mean, and minimum precipitation, air temperature, and NDVI were determined for the entire country of Afghanistan. (Fig. 2) displays the air temperature,

NDVI values, maximum, minimum, and mean rainfall for spatial patterns over the entire manifestation period (1982–2015). The AVHRR data was used to confirm the maximum, minimum, and mean precipitation over the period of 1982–2015. The monthly rainfall rate was added to account for the entire year's maximum, minimum, and mean values. The northwest of Afghanistan typically contains the largest NDVI, which supports the coverage of agriculture and animal

husbandry (Fig. 2a). The map's indication of low NDVI activity is the agricultural area's location in the southern region According to (Reynolds *et al.* 2012) ^[28], remotely sensed NDVI data derived from AVHRR are frequently utilized as a trustworthy indicator of the presence, growth, and decline of terrestrial vegetation. Afghanistan has a very dry climate and, naturally, very little vegetation (Fig. 2b). The precipitation map makes it evident that Afghanistan's northeast receives the majority of the country's precipitation, with the southwest experiencing relatively low levels of precipitation. Fig. 2c displays the mean, minimum, and maximum air temperature. Temperature maps indicate that the southwest recorded the highest temperature, while Afghanistan and the northeast are clearly experiencing relatively low temperatures.

Monthly Trends of Key Vegetation and Climate Indices: TCI, VHI, NDVI, VCI, and PCI

In order to examine drought and vegetation growth historically, trends for monthly PCI, TCI, NDVI, VHI, and VCI values were calculated between 1982 and 2015. Each month's trends are shown in (Figs. 3, 4, and 5). The most popular vegetation indices for analyzing vegetation activity from remote sensing data are the NDVI and VCI (Wang *et al.*, 2001) ^[39]. According to the TCI, VHI, VCI, and PCI monthly trend ideals over Afghanistan, a severe drought was observed in 1989 and continued into 2002 and 2007, leading to an extreme drought condition during the 2003–2010 study years. There is only one primary severe drought phase (2003–2010) in the data that are presented with low PCI and TCI value, which affected most regions of South Asia (Fig. 5). Because of TCI changes over several months, as reported by Kogan (1998) ^[19], the VHI is not a spatially similar division. The VHI performs the best out of all the different drought indices because it combines vegetation growth and land

surface temperature to characterize drought trends (Figs. 4). Actually, a number of studies have evaluated growth and drought events using VHI, NDVI, and VCI (Khan *et al.* 2020; Jackson *et al.* 2010) ^[11]. From January to May, the NDVI dramatically dropped; from June to September, the NDVI gradually increased. The NDVI levels dropped even more after September starting in December. The various activities causing changes in growth are explained by the June monthly values of the VCI, NDVI, TCI, PCI, and VHI. There is broad consensus in the field regarding the VCI, which is a crucial indicator that can be used to assess how droughts affect vegetation (Amin *et al.* 2011; Xie *et al.* 2021) ^[1]. The VCI is a significant drought indicator that can be used to assess the impact of drought on agriculture land (Zhou *et al.* 2017) ^[42]. Changes in temperature and precipitation may have caused variations in the vegetation, which could be the cause of this shifting trend. This varied drought trend in response to temperature and precipitation may be a result of the flora's variations. According to Zhou *et al.* (2017) ^[42], South Asia's tendency toward drought frequency declined between 2003 and 2010, which is consistent with the excess results shown in Figs. 3 and 4. Afghanistan has enough warmth and precipitation at the beginning of February to promote the growth of vegetation. June, July, and August typically have the highest temperatures and the least amount of rainfall, which limits the growth of plants. The wilting of plants during the dry season is caused by high temperatures and little rainfall, especially in the southwest of Afghanistan. Human activities that can cause vegetation degradation are also linked to variations in the monthly drought indices. In conclusion, while there was a small variance in detail owing to the selection of different vegetation and drought indices, the spatial distribution and changing trends of vegetation and drought in Afghanistan are consistent with the earlier research work focused on the evaluation of the drought.

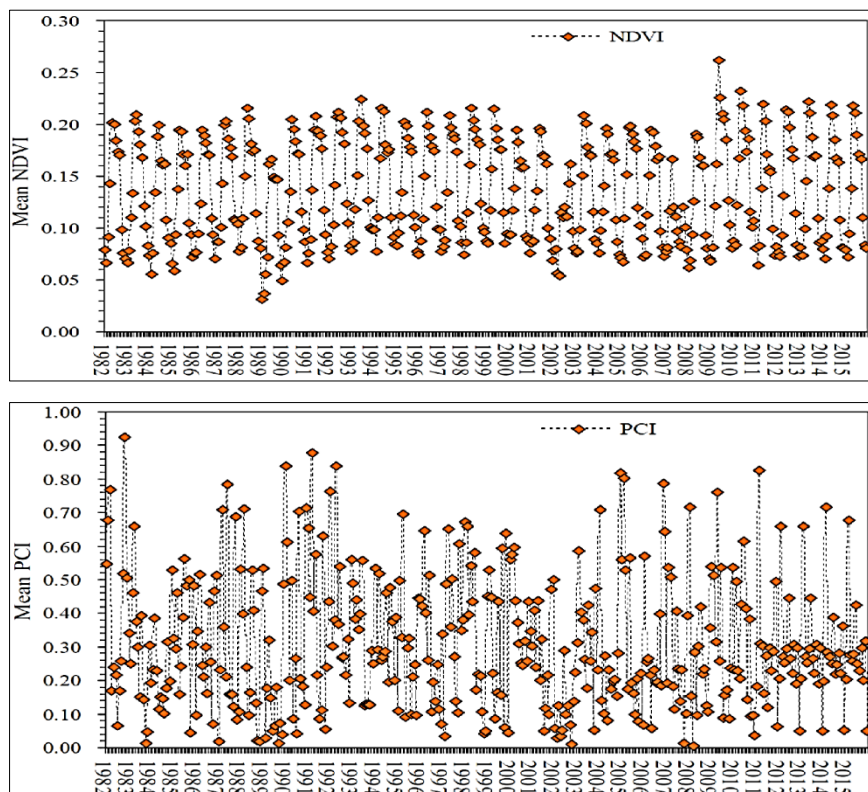


Fig 3: Variations for monthly NDVI (Normalized Difference Vegetation Index) and PCI (Precipitation Condition Index), over Afghanistan for the period of 1982 to 2015.

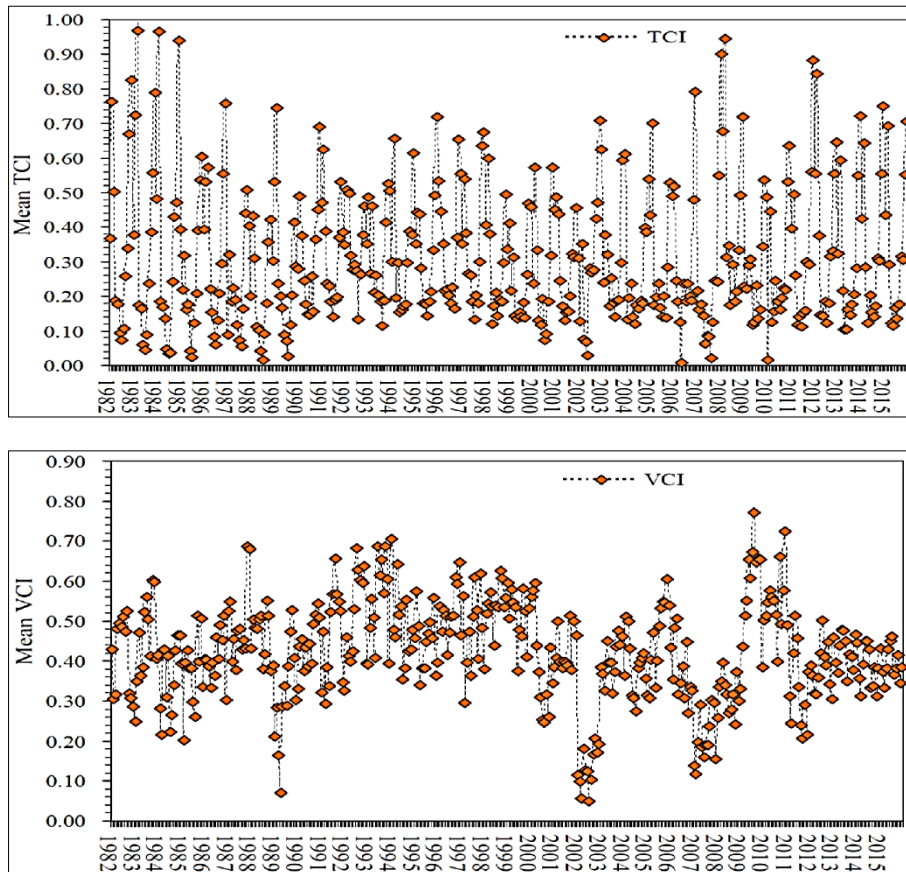


Fig 4: Variations for monthly TCI (Temperature Condition index) and VCI (Vegetation Condition Index), over Afghanistan for the period of 1982 to 2015.

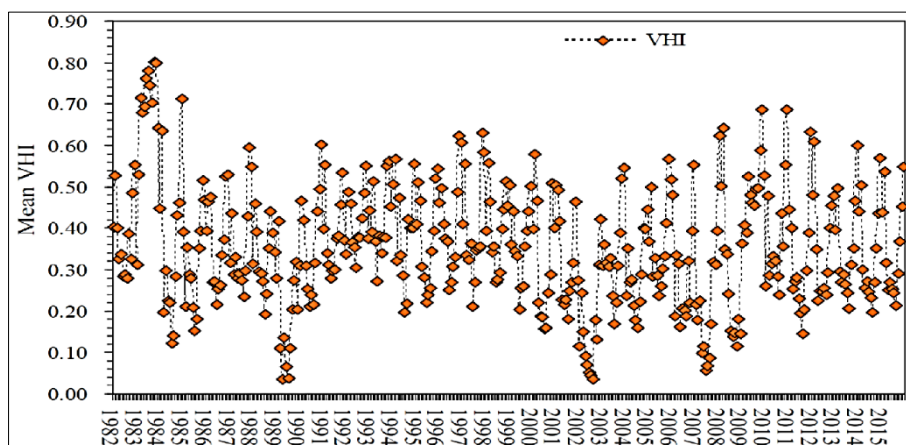


Fig 5: Variations for monthly VHI (Vegetation Health Index), over Afghanistan for the period of 1982 to 2015.

The Seasonal mean NDVI, VCI and PCI value distribution

The NDVI, a numerical sign for assessing vegetation, was first applied by Jain *et al.* (2010) [12]. Since the NDVI measurements by itself do not indicate whether the climate is dry or not. That being said, the difference between the current NDVI and normal circumstances may be used to describe how severe the drought is (Rouse *et al.* 1973) [30]. The seasonal mean NDVI and VCI in the current research was computed using the monthly AVHRR NDVI data. Low vegetation was indicated by the zero NDVI value, which is associated with a drying environment (Fig. 6). These NDVI seasonal average values were identified and assessed in order to classify Afghanistan's arid regions. The seasonal average maps of the NDVI provide a broader overview of the

dynamics of the vegetation from 1982 to 2015. The regions with low NDVI and declining trends in vegetation are those that were predicted to get less rainfall and had a severe water deficit environment. The NDVI seasonal average values are excellent markers for categorizing areas with deficiencies. The places affected by severe drought will be visible over Afghanistan. According to a previous study, NDVI correlates with variables that change with the climate, such rainfall and air temperature, and may be used to identify and categorize areas that are vulnerable to drought (Jain *et al.* 2010) [12]. According to some research, NDVI and VCI can be used to track drought occurrences since they correlate with changes in temperature and precipitation (Liu *et al.* 2015) [21]. The temporal map indicates that winter is beginning to evolve into

a particularly dry season in Afghanistan (DJF). However, there is enough water available for plants to flourish when the summer monsoon (JJA) normally begins. Therefore, the autumn season water stress (SON) is not noticeable, with the exception of southwest Afghanistan. (Fig. 6 and 8) display the NDVI and VCI seasonal average values. In Afghanistan, the summer season (JJA) has the greatest NDVI and VCI values. The distribution values of the NDVI and VCI indicate

an increasing tendency from spring (MAM) to summer (JJA), and again from autumn (SON) to winter (DJF), with the NDVI and VCI displaying bigger maximum values. According to Song *et al.* (2014) [34], Afghanistan has severe drought circumstances throughout the winter months. Additionally, Huang *et al.* (2015) found that the southwest region of Afghanistan experiences more severe drought conditions than the northwest region.

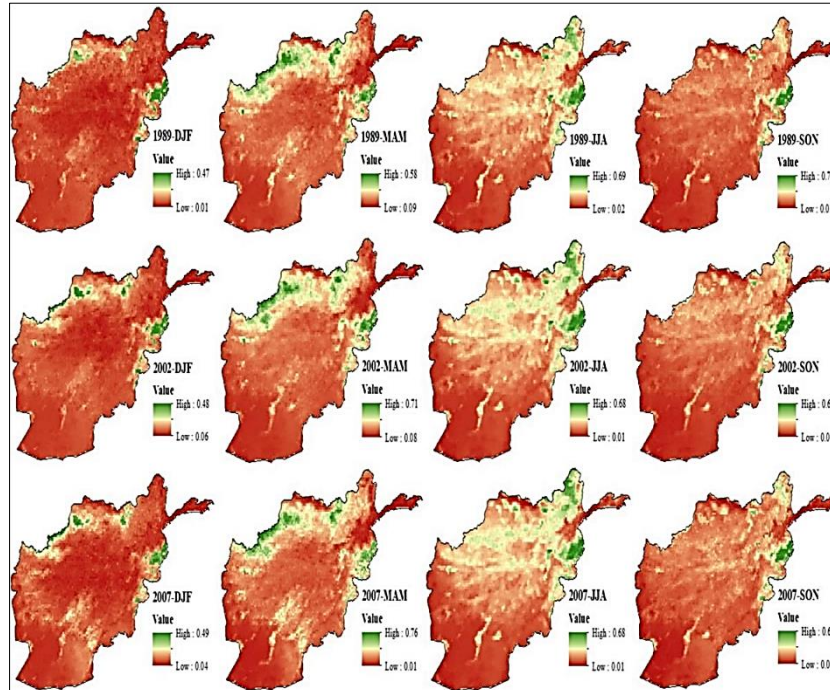


Fig 6: Spatial pattern of seasonal average NDVI values, DJF: Dec-Feb, MAM: Mar-May, JJA: Jun-Aug and SON: Sep-Nov, over Afghanistan during (1989, 2002, 2007).

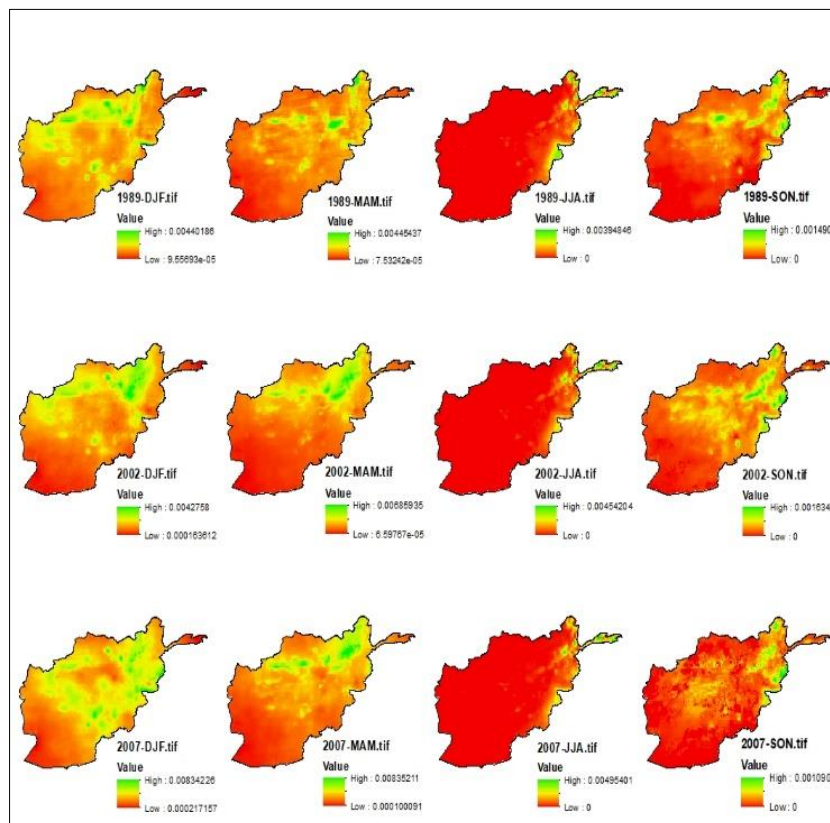


Fig 7: Spatial pattern of seasonal average PCI values, DJF: Dec-Feb, MAM: Mar-May, JJA: Jun-Aug and SON: Sep-Nov, over Afghanistan during (1989, 2002, 2007).

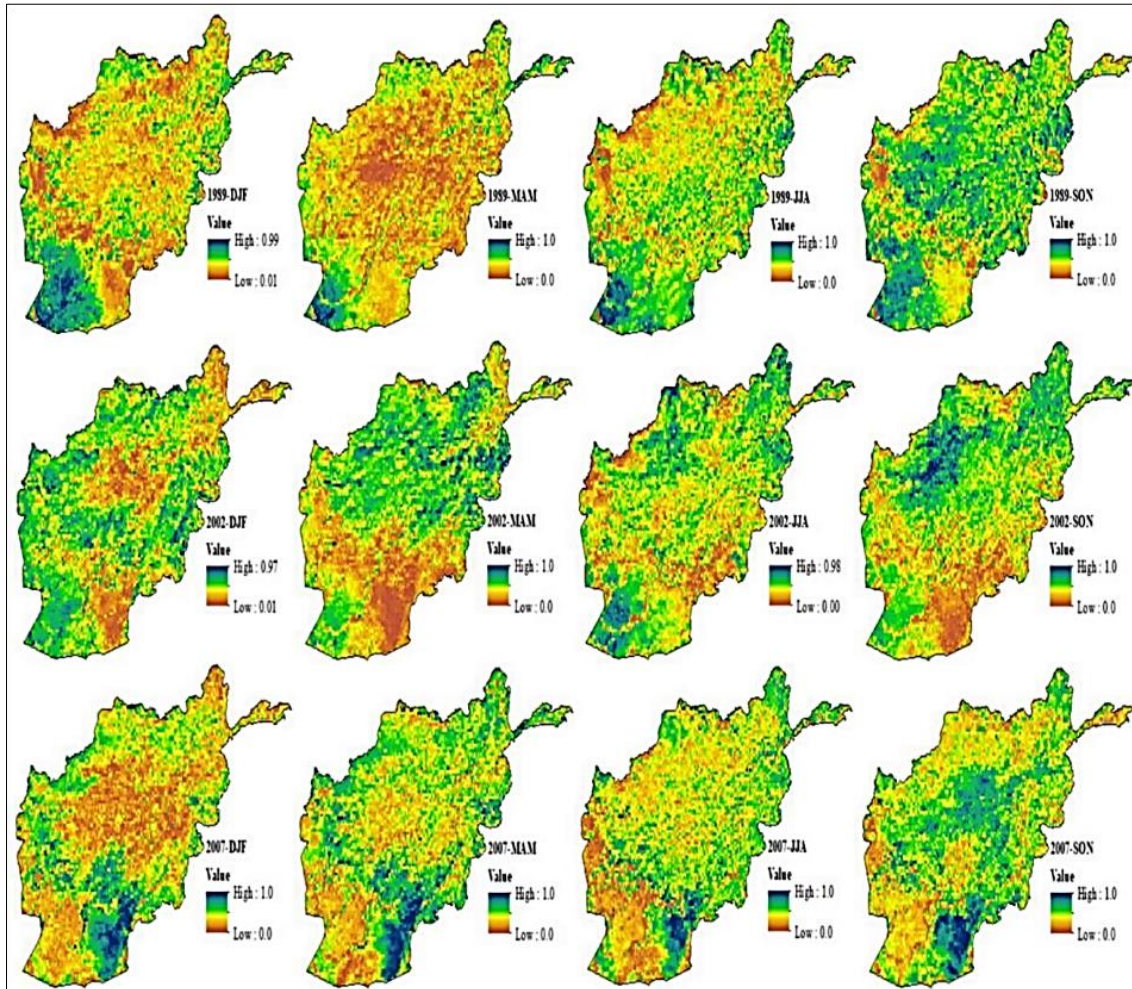


Fig 8: Spatial pattern of seasonal average VCI values, DJF: Dec-Feb, MAM: Mar-May, JJA: Jun-Aug and SON: Sep-Nov, over Afghanistan during (1989, 2002, 2007).

Seasonal relation of mean VHI and TCI

In remote sensing, the Temperature Condition Index (TCI) and vegetation Health Index (VHI) are crucial measurements for tracking drought conditions and evaluating the health of the vegetation. Vegetation Condition Index (VCI) and Temperature Condition Index (TCI), two crucial indicators, are included in the VHI. By measuring photosynthetic activity and biomass, the Normalized Difference vegetation Index (NDVI), a measure of vegetation health and vitality, is compared to other variables using VCI. However, TCI evaluates plants' thermal environment, emphasizing temperature anomalies and how they affect vegetation stress. By taking into account both moisture and temperature anomalies, these indicators when combined offer a thorough picture of the health of the vegetation (Kogan, 1995) [16]. Studies conducted in Afghanistan with VHI and TCI have shown how useful these approaches are for monitoring agricultural drought and evaluating the condition of vegetation in different areas. Afghanistan benefits greatly from the integration of VCI and TCI within the VHI

framework because of the country's diverse geography and variable climate (Ghulam *et al.*, 2007) [6]. Seasonal dynamics of VHI and TCI in Afghanistan are shown in (figs. 8 and 9) and show important trends. Precipitation is comparatively greater in the spring and early summer, which results in enhanced vegetation conditions supported by favorable VCI and mild TCI values. This leads to heightened VHI values. Summertime temperatures climb sharply, especially in (JJA), which frequently results in higher TCI readings. Lower VHI values indicate the beginning of drought conditions and increasing vegetative stress as a result of this temperature increase and less rainfall (Bhuiyan *et al.* 2008) [2]. An increase in VHI readings during the fall season may indicate a slight improvement in the health of the vegetation due to lower temperatures and infrequent rainfall. However, VHI levels may stabilize or drop over the winter, particularly in areas with significant snow cover, depending on the amount of snow cover and its effect on the plant's underneath it (Karnieli *et al.* 2010) [13].

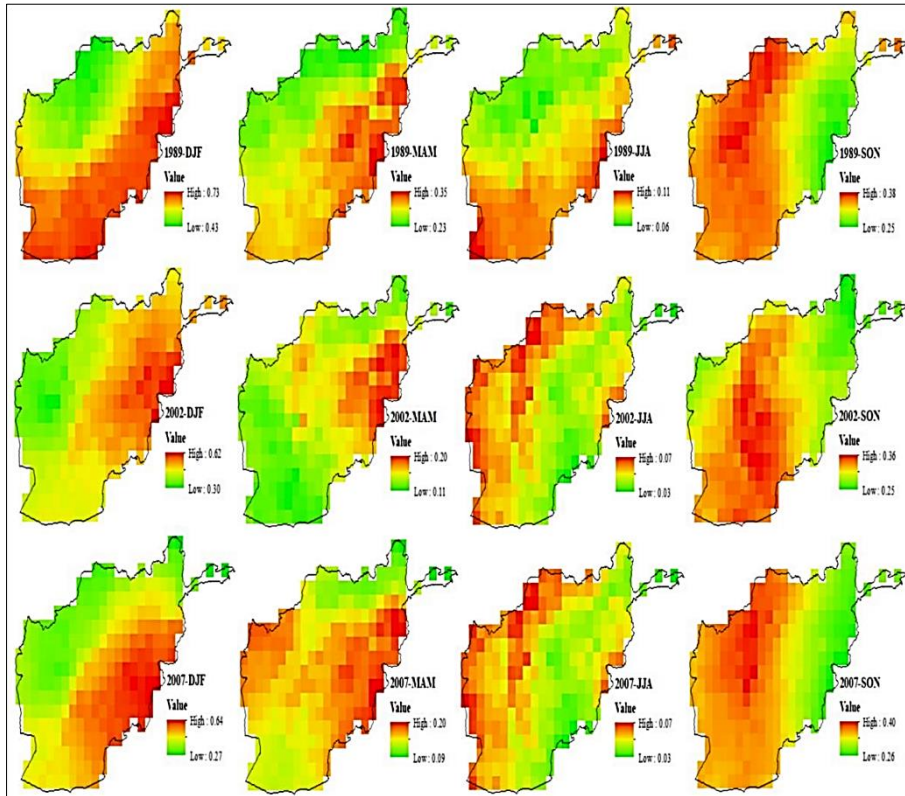


Fig 8: Spatial pattern of seasonal average TCI values, DJF: Dec-Feb, MAM: Mar-May, JJA: Jun-Aug and SON: Sep-Nov, over Afghanistan during (1989, 2002, 2007).

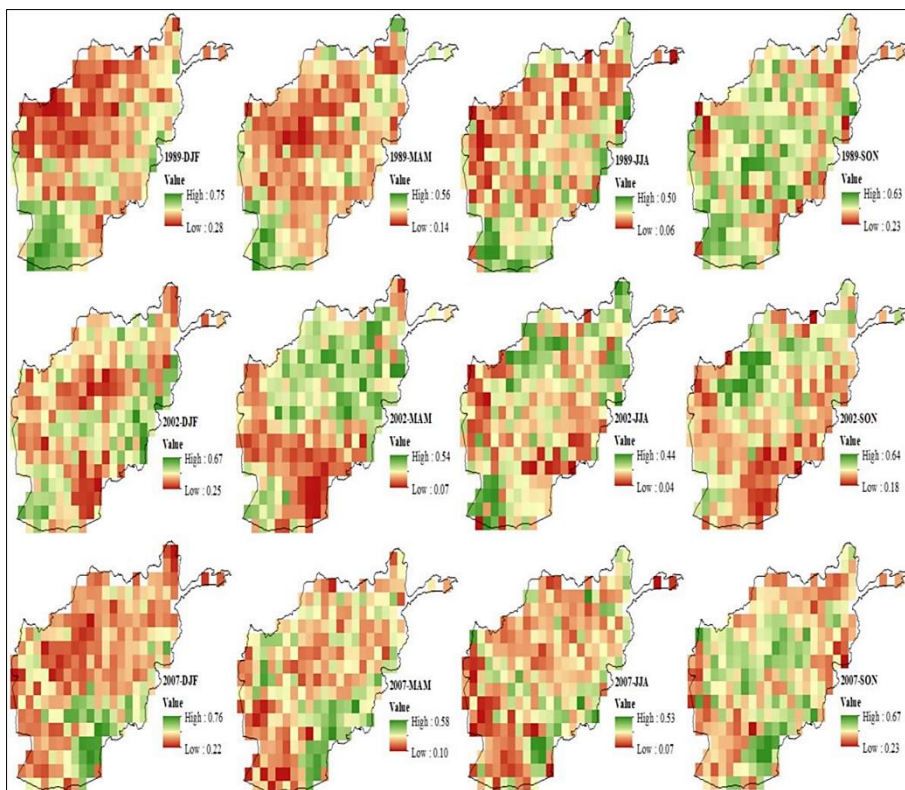


Fig 9: Spatial pattern of seasonal average VHI values, DJF: Dec-Feb, MAM: Mar-May, JJA: Jun-Aug and SON: Sep-Nov, over Afghanistan during (1989, 2002, 2007).

Principal Component Analysis and Regression Correlation
 Principle Component Analysis (PCA) entire variance from the data is characterized by the four principal component counts (Fig. 10). The vector in n-dimensional space that corresponds to the parameter's largest variation is represented

by the first component (PC1). Within this data set, the vector represented by the first component (PC1) is identified as accounting for 46.0% of the total variance, and the vector represented by the second component (PC2) is integrated with a plane perpendicular to the first component (PC1). In

the same plane of parameters, this vector represents the largest variation, accounting for 26.9% of the total variance (Fig. 10). The component load graph shows considerable groupings of VDI and VCI values, and VCI, VHI, and TCI values and NDVI, NAP, and VCI values. The regression relationship of the drought index is shown in Fig. 11. Significant positive correlations were observed between the

VHI and PCI, VCI and PCI indices, and NDVI and VCI. Furthermore, a considerable positive correlation was recorded among the TCI and PCI, while a considerable negative correlation was recorded among the VHI and NDVI, VCI, and PCI, and between NDVI and TCI, and PCI Climate indices

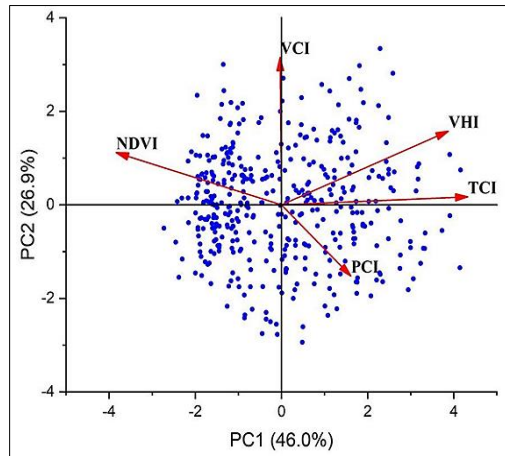


Fig 10: Principal component analysis of the drought indexes obtained by the Vegetation Health Index (VHI), Normalized Difference Vegetation Index (NDVI), Precipitation Condition Index (PCI), Temperature Condition Index (TCI), Vegetation Condition Index (VCI).

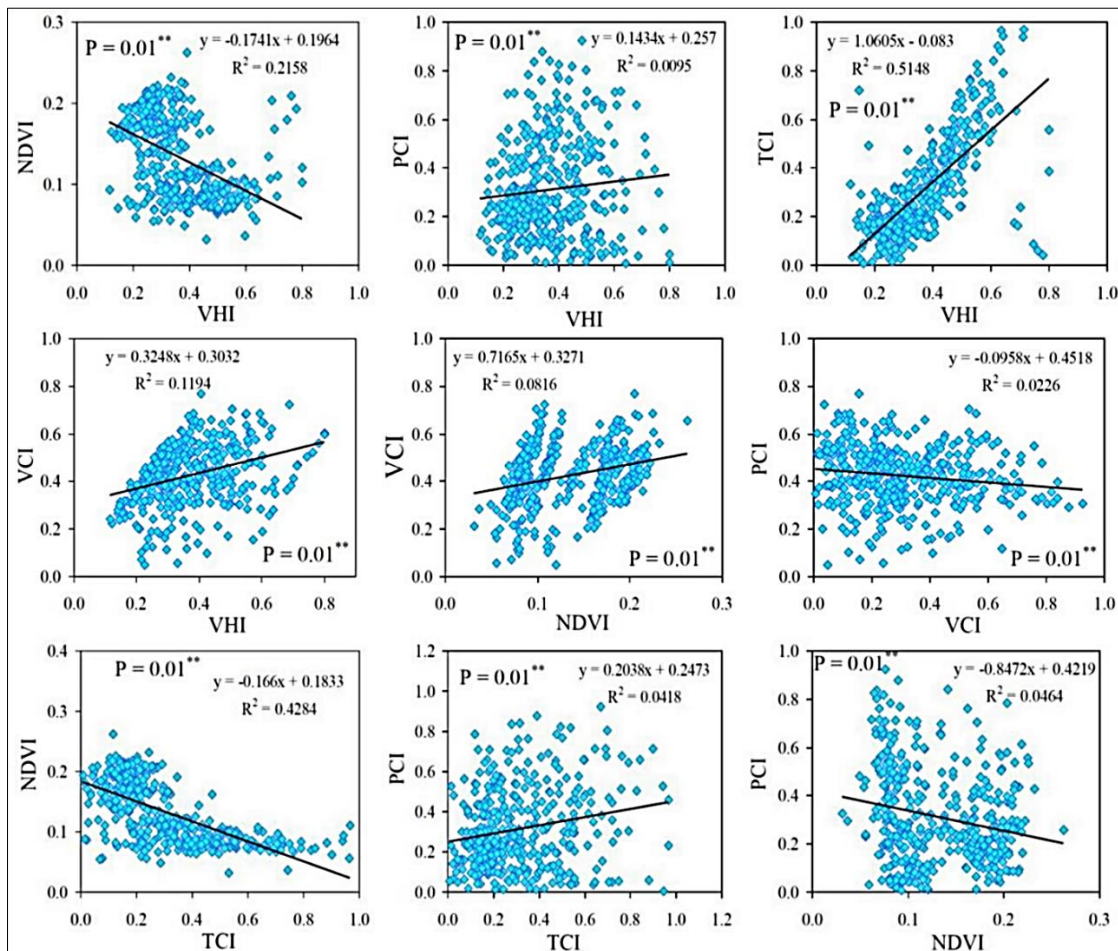


Fig 11: Regression relationships of the drought indexes obtained by the Vegetation Health Index (VHI), Normalized Difference Vegetation Index (NDVI), Precipitation Condition Index (PCI), Temperature Condition Index (TCI), Vegetation Condition Index (VCI).

Conclusion

The purpose of this study was to look into the spatiotemporal variations in drought and vegetation dynamics across Afghanistan. The NDVI is more useful in characterizing Afghanistan's drought situation because of the country's little vegetation and dry climate. While the NDVI, TCI, VHI, PCI, and VCI stay stable every month in September, improve once more in October, and then indicate a negative trend in December, they scaled fast from April to October. The NDVI, TCI, VCI, PCI, and VHI indices show that Afghanistan had drought in 1989 and 2002, with the worst drought pressure occurring in 2007. The NDVI, PCI, TCI, and VCI values are useful tools for reporting drought periods in different growing seasons when it comes to monitoring drought in Afghanistan. The seasonal values of the NDVI, PCI, TCI, and VCI attest to the fact that Afghanistan experienced severe droughts in 1989, 2002, and 2007. Seasonally-based spatial correlation between air temperature, precipitation, NDVI, VHI, and VCI is produced. It displays the drought index's regression relationship. There were considerable positive correlations found between the TCI and PCI indices. Additionally, a considerable negative connection was found between the VHI and NDVI, VCI and PCI, and between the NDVI and TCI and PCI climate indices, but a significant positive correlation was found between the VHI and PCI, VCI and PCI indices, and NDVI and VCI. The drought change trend from 1982 to 2015 was defined, with clear regional differences in the tendency of drought. In Afghanistan, there was a downward trend in the frequency of droughts between 1982 and 2015. Future studies should examine the relationship between drought and other climatic factors since droughts are also impacted by a wide range of other climatic factors.

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Authors' Contributions Abdul Basit: Data curation, investigation, software, methodology, Formal analysis, writing—original draft preparation. **Ali Shahzad:** formal analysis, validation, writing—review and editing. **Gul Amina:** writing—review and editing. **Khandakar Md Bappy:** writing—review and editing. **Hidayat Ullah:** writing—review and editing. **Zakria Zaheen:** writing—review. **Shawkat Ali:** writing—review and editing. **Muhammad Awais:** writing—review and editing. **Kalisa Wilson:** writing—review and editing. **Jiahua Zhang:** Supervise and writing—review. All authors have read and agreed to the published version of the manuscript.

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References

1. Amin MO, Jan A, Mehrdada R, Ali M, Reza AS. Drought monitoring methodology based on AVHRR images and SPOT vegetation maps. *J Water Resour Prot.* 2011;3:325-34.
2. Bhuiyan C. Various drought indices for monitoring drought condition in Aravalli terrain of India. *Proc SPIE.* 2008;7147:71470T.
3. Dai A. Increasing drought under global warming in observations and models. *Nat Clim Chang.* 2013;3(1):52-8.
4. Du L, Tian Q, Yu T, Meng Q, Jancso T, Udvardy P, *et al.* A comprehensive drought monitoring method integrating MODIS and TRMM data. *Int J Appl Earth Obs Geoinf.* 2013;23:245-53.
5. Forkel M, Carvalhais N, Verbesselt J, Mahecha MD, Neigh SRC, Reichstein M. Trend change detection in NDVI time series: Effects of inter-annual variability and methodology. *Remote Sens.* 2013;5:2113-44.
6. Ghulam A, Li ZL, Qin Q, Tong Q. Exploration of the relationship between crop condition and MODIS LAI/NDVI: A case study of an irrigated cropland. *Sensors.* 2007;7(9):1820-32.
7. Gouveia C, Trigo RM, DaCamara CC, Libonati R, Pereira JMC. The north temperate oceanic oscillation and European vegetation dynamics. *Int J Climatol.* 2008;28:1835-47.
8. Gouveia C, Trigo RM, DaCamara CC. Drought and vegetation stress monitoring in Portugal using satellite data. *Nat Hazards Earth Syst Sci.* 2009;9:185-95.
9. He B, Chen AF, Wang HL, Wang QF. Dynamic response of satellite-derived vegetation growth to climate change in the three north shelter forest region in China. *Remote Sens.* 2015;7:9998-10016.
10. IPCC. Climate change 2014: Mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press; 2014.
11. Jackson TJ, Cosh MH, Bindlish R, Starks PJ, Bosch DD, Seyfried M, *et al.* Validation of advanced microwave scanning radiometer soil moisture products. *IEEE Trans Geosci Remote Sens.* 2010;48(12):4256-72.
12. Jain SK, Keshri R, Goswami A, Sarkar A. Application of meteorological and vegetation indices for evaluation of drought impact: A case study for Rajasthan, India. *Nat Hazards.* 2010;54(3):643-56.
13. Karnieli A, Agam N, Pinker RT, Anderson M, Imhoff ML, Gutman GG, *et al.* Use of NDVI and land surface temperature for drought assessment: Merits and limitations. *J Clim.* 2010;23(3):618-33.
14. Karnieli A, Bayasgalan M, Bayarjargal Y, Agam N, Khudulmur S, Tucker CJ. Comments on the use of the vegetation health index. *Remote Sens Environ.* 2006;107:435-45.
15. Kogan FN. Remote sensing of weather impacts on vegetation in non-homogeneous areas. *Int J Remote Sens.* 1990;11(8):1405-19.
16. Kogan FN. Application of vegetation index and brightness temperature for drought detection. *Adv Space Res.* 1995;15(11):91-100.
17. Kogan FN. Droughts of the late 1980s in the United States as derived from NOAA polar-orbiting satellite data. *Bull Am Meteorol Soc.* 1995;76(5):655-68.
18. Kogan FN, Sullivan J. Development of global drought-watch system using NOAA/AVHRR data. *Adv Space Res.* 1993;13(5):219-22.
19. Kogan FN. A typical pattern of vegetation conditions in southern Africa during El Nino years detected from AVHRR data using three channel numerical index. *Int J Remote Sens.* 1998;19:3688-94.

20. Lloret F, Lobo A, Estevan H, Maisongrande P, Vayreda J, Terradas J. Woody plant richness and NDVI response to drought events in Catalanian (northeastern Spain) forests. *Ecology*. 2007;88:2270-9.
21. Liu XH, Zhang JH, Xu XH. Drought monitoring in Xinjiang by using MODIS-TVDI. *Remote Sens Inf*. 2015;30(02):111-5.
22. Maherali H, DeLucia EH. Influence of climate-driven shifts in biomass allocation on water transport and storage in ponderosa pine. *Oecologia*. 2001;129:481-91.
23. Mushore TD, Dube T, Manjowe M, Gumindoga W, Chemura A, Roustia I, *et al*. Remotely sensed retrieval of local climate zones and their linkages to land surface temperature in Harare metropolitan city, Zimbabwe. *Urban Clim*. 2019;27:259-71.
24. Pasho E, Camarero JJ, De Luis M, Vicente-Serrano SM. Factors driving growth responses to drought in Mediterranean forests. *Eur J Forest Res*. 2012;131:1797-807.
25. Peters E. Propagation of drought through groundwater systems-illustrated in the Pang (UK) and Upper-Guadiana (ES) catchments [Ph.D. Thesis]. Wageningen: Wageningen University; 2003.
26. Piao SL, Wang XH, Ciais P, Zhu B, Wang T, Liu J. Changes in satellite-derived vegetation growth trend in temperate and boreal Eurasia from 1982 to 2006. *Glob Chang Biol*. 2011;17:3228-39.
27. Razipoor ME. Assessing the vegetation condition of Herat Province, Afghanistan using GIS. *Appl Geol Geophys*. 2019;7(4):92-7.
28. Reynolds MK, Walker DA, Epstein HE, Pinzon JE, Tucker CJ. A new estimate of tundra-biome phytomass from trans-Arctic field data and AVHRR NDVI. *Remote Sens Lett*. 2012;3(5):403-11.
29. Ren SL, Li YT, Peichl M. Diverse effects of climate at different times on grassland phenology in mid-latitude of the Northern Hemisphere. *Ecol Indic*. 2020;113:106260.
30. Rouse JW, Haas RH, Schell JA, Deering DW. Monitoring vegetation systems in the Great Plains with ERTS. Third Earth Resources Technology Satellite Symposium, NASA SP-351. 1973;I:309-17.
31. Schwalm CR, *et al*. Global patterns of drought recovery. *Nature*. 2017;548(7666):202.
32. Shahabfar A, Ghulam A, Eitzinger J. Drought monitoring in Iran using the perpendicular drought indices. *Int J Appl Earth Obs Geoinf*. 2012;18:119-27.
33. Singh RP, Roy S, Kogan F. Vegetation and temperature condition indices from NOAA AVHRR data for drought monitoring over India. *Int J Remote Sens*. 2003;24(22):4393-402.
34. Song X, Li L, Fu G, Li J, Zhang A, Liu W, *et al*. Spatial-temporal variations of spring drought based on spring-composite index values for the Songnen Plain, Northeast China. *Theor Appl Climatol*. 2014;116(3-4):371-84.
35. Tucker CJ, Pinzon JE, Brown ME. An extended AVHRR 8-km NDVI dataset compatible with MODIS and SPOT vegetation NDVI data. *Int J Remote Sens*. 2005;26(20):4485-98.
36. Tucker CJ. Red and photographic infrared linear combinations for monitoring vegetation. *Remote Sens Environ*. 1979;8:127-50.
37. Unganai LS, Kogan FN. Drought monitoring and corn yield estimation in Southern Africa from AVHRR data. *Remote Sens Environ*. 1998;63(3):219-32.
38. Wang B, Xu G, Li P, Li ZB, Zhang YX, Cheng YT, *et al*. Vegetation dynamics and their relationships with climatic factors in the Qinling Mountains of China. *Ecol Indic*. 2019;108:105719.
39. Wang J, Price KP, Rich PM. Spatial patterns of NDVI in response to precipitation and temperature in the central Great Plains. *Int J Remote Sens*. 2001;22(18):3827-44.
40. Xu HJ, Wang XP, Yang TB. Trend shifts in satellite-derived vegetation growth in Central Eurasia, 1982–2013. *Sci Total Environ*. 2017;579:1658-74.
41. Xu G, Zhang H, Chen B, Zhang H, Innes JL, Wang G, *et al*. Changes in vegetation growth dynamics and relations with climate over China's land mass from 1982–2011. *Remote Sens*. 2014;6:3263-83.
42. Zhou L, Wu J, Mo X, Zhou H, Diao C. Quantitative and detailed spatiotemporal patterns of drought in China during 2001–2013. *Sci Total Environ*. 2017;589(1):136-45.

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