Research & Reviews: Journal of Botanical Sciences

e-ISSN:2320-0189
p-ISSN:2347-2308

Geospatial Observations Using Vegetation Temperature Condition Index for Drought Conditions Over the Cropland of Punjab, Pakistan

Jahangir khan[1] and Pengxin Wang[2]*

[1]Faculty of Computer Science and Information Technology, Sarhad University of Science and Information Technology, Pakistan

[2]College of Information and Electrical Engineering, China Agricultural University, Beijing, P.R. China

Short Communication

Received: 10/07/2018
Accepted: 10/09/2018
Published: 13/09/2018

***For Correspondence**

Pengxin Wang, College of Information and Electrical Engineering, China Agricultural University, Beijing 100083, P.R. China.

Tel: +92 313 5754578

E-mail: wangpx@cau.edu.cn

Keywords: Drought conditions, Wheat crop, Global climate, Soil moisture

ABSTRACT

The stochastic characterization of drought in the plain of Punjab (Pakistan) was strongly motivated by the fact that the reliance on precipitation data is not sufficient for drought monitoring, taking into account the lack of reliable and complete data, together with proper network information systems, particularly the lower availability of weather-stations in Pakistan. The Satellite observations reveal the study site in a spatio-temporal pattern with a near-real time index called vegetation temperature condition index (VTCI) to exhibit the drought conditions using EOS's satellite Aqua-MODIS NDVI and LST data products in response to drought and soil moisture, to reflect the agricultural and hydrological impact in the plain. The spatial and temporal observations represent mostly significant drought conditions in the northeast in contrast to centre and south with insignificant drought conditions for the winter wheat crop seasons in the year of 2004, 2006, 2008, 2010 and 2011 during 2003-2014 under both rainfed and irrigated conditions in the region. This divulges that the south and center of the plain expose to drought in contrast to the northeast with high occurrences of drought, whereas, the northeast indicates most of the normal conditions of drought in the plain. The study exhibits the temporal changes of the land surface drought conditions through the periods of 16 day to 12 month accumulative precipitation with a significant correlation of the VTCI time series values, varies with four periods (2003-2008, 2010, 2011-2014, 2003-2014) at five weather-stations during 2003-2014. This reveals the effectiveness of multi-year MODIS VTCI approach observations for the determination of warm and cold edges, drought monitoring and flood events in the given periods over the plain of Punjab. Results exemplify VTCI as the favorable index for the dry and wet condition during the winter wheat crop seasons.

INTRODUCTION

Observations of Spatio-Temporal Dynamics

The global warming causes the global climate changes, and Pakistan listed in number eight of the most ten affected countries from 1995-2014 in the world. The natural disasters in response to drought and flood are the most common and frequently occurring hazards in the regions and specifically over Pakistan in a recent couple of centuries due to environmental, climatic and ecosystem anthropogenic factors [1-6]. Drought is a complex phenomenon of environmental processes and considered as the stochastic nature of hazards with a prolonged scarcity and dearth character that results from the meager annual precipitation and superficial water contents through impacts on the agricultural, meteorological, hydrological and socio-economic with a potentially significant consequence. Drought is a prolonged event of insufficient rainfall with follow-on extensive damage to crops, resulting in loss of yield. Alike drought, flood is the world's costliest natural disasters due to extreme climate events under global warming conditions. The soil moisture had a significant role in retains of dry and wet spells in both rain-fed and irrigated conditions and key indicator of drought and flood. Therefore, this is obvious to monitor the dry and wet conditions in the region. In order to bridge the gap of the study site of the cropland of Punjab, Pakistan, a near-real-time drought monitoring approach termed as vegetation temperature condition index (VTCI) as well as geospatial near-real-time coupling (NRTC) approach was applied. The study employed the VTCI approach to incorporate the land surface temperature (LST) for the warm and cold edges, accompanied by well-dispersed, assembled index for determining the significance of drought conditions with normalized difference vegetation

e-ISSN:2320-0189
p-ISSN:2347-2308

index (NDVI). Hence, the current study utilizes the MODIS (Moderate Resolution Imaging Spectroradiometer) 16 day composited LST (MYD11A2) and NDVI (MYD13A2) data products located at https://lpdaac.usgs.gov/. The study site (Punjab) of (518 x 598) kilometers square stretches (28.42-32.98°N, 70.14-75.39°E) over the h24v05 and h24v06 grid plates. To determine the drought imagery and edges, we employed the Space-borne EOS's MODIS data products to acquire the land surface conditions during the winter wheat crop season in the cropland of the plain under rain-fed and irrigated conditions [7,8]. The VTCI integrate the NDVI and LST to determine the warm and cold edges as well as to investigate dry and wet conditions vigorously. The VTCI feature plots reside in LST-NDVI space is the most appropriate method for the determination of VTCI imagery as well as warm and cold edges in response to soil moisture. This study determines the multi-year's drought conditions as well as the warm edges (LST_{max}) and cold edges (LST_{min}) in response to soil moisture during 2003-2014 over the Plain.

The spatial and temporal observations of the VTCI imagery in the specified periods present the dry and wet conditions due to temporal changes of the land surface soil moisture conditions and demonstrate the irregular retreat states of warm and cold edges for the agricultural practices. This depend on variations in warm and cold edges expose the drought conditions due to weather extreme's uneven temperature from winter into summer in the Plain. The spatial and temporal observations in response reveal that the south and center of the plain expose to drought in contrast to the northeast with high occurrences of drought, whereas, the northeast indicates most of the normal conditions of drought in the plain. The drought conditions illustrate that during the 12 yr period of winter wheat crop seasons, in the year of 2004, 2006, 2008, 2010 and 2011 the decreased was calculated with 2500, 2588, 2438, 2846 and 2737 yield per hectare in KG's from the average yield production due to droughts under both rainfed and irrigated conditions in the Plain. Before and after the flood inception the wheat crop area was 6691.0 hectares in 2010-2011, whereas, in 2011-2012 it was decreased to 6482.9 hectares. This shows that the flood (2010) affects the area and the production and was decreased from 19.041 to 17.7389 million tonnes. With abovementioned drought and yield calculations, illustrates the insufficient irrigated practices in the plain and shows reliance on the seasonal rainfall during the winter wheat crop season in the plain of Punjab.

VTCI Times Series Calculations of Drought

The VTCI time series generalized characteristics of the drought exhibit the plain with respective weather-stations in three climate zones (south, center, and northeast). The south and center of the plain with low accumulative precipitation results insignificant VTCI values, whereas, in the northeast with adequate precipitation results in significant VTCI values. This disclose the effectiveness of multi-year MODIS VTCI approach observations for the determination of warm and cold edges, drought monitoring and flood events in the given periods over the plain of Punjab. In additions, the VTCI time series values indicates that the south and center of the plain shows lower VTCI values, due to the lack of rainfall, whereas, in the northeast had high VTCI values with adequate rainfall at five weather-stations and present a better response to recent precipitation. This demonstrates that the plain of Punjab is not only dependent on irrigated practices but also dependent on rainfall.

Validation of Drought

The study exhibits the temporal changes of the land surface drought conditions with its validation in the periods of 16 day to 12 month accumulative precipitation with the VTCI imagery time series values had a significant correlation values, varies for the four periods (2003-2008, 2010, 2011-2014, 2003-2014) at five weather-stations during 2003-2014. The relationship between VTCI values and total accumulative precipitation (TPCP) were very significant for short-time series in comparison to long-time series during 12 yr periods. The weigh correlation coefficients values between VTCI and accumulative precipitation decreases with the increase of time series during 2003-2014. This shows that the area witnessed the heavy rainfall and worst flood in the year of 2010 and presents the dry and wet spells with indistinct variation in the precipitation over the region in the 12 yr periods. And disclose that the VTCI values and cumulative precipitation had a significant relationship in different time periods. This demonstrates the VTCI near-real-time drought monitoring approach had the capability with different time scale and time series. This illustrates that the VTCI values had a very significant relationship with the precipitation and demonstrate that the VTCI not only rely on the recent precipitation, but it also correlates to elapsed/past precipitation as well as correlates to departure from normal precipitation (DPNP) anomaly. VTCI demonstrate the drought conditions using Aqua-MODIS NDVI and LST data products in response to drought and soil moisture, which reflects the agricultural and hydrological impact in the plain and shows that VTCI is favorable during the winter wheat crop seasons. Also, the NRTC approach signifies the relations of VTCI and cumulative precipitation in the validation of dry and wet conditions vigorously. This study reveals the effectiveness of VTCI approach for the determination of warm and cold edges, drought monitoring and flood detection in the given periods over the region.

DISCUSSION AND CONCLUSION

The possible suggestions and recommendations for this region due to climate changes threats to Asia and specific to the region in the form of higher temperature, drier conditions, and flooding. The policymakers necessitate focusing on this problem to safeguard the region from the natural disasters in any shape and established a mechanism for the extreme vulnerability impacts of temperature changes, heat extremes, precipitations, glacier melts, rivers and agriculture in the region like Punjab, Pakistan.

e-ISSN:2320-0189
p-ISSN:2347-2308

ACKNOWLEDGEMENTS

This work was supported by the National Natural Science Foundation of China (Grant No. 41371390).

REFERENCES

1. Thenkabail P and Gamage M. The use of remote sensing data for drought assessment and monitoring in Southwest Asia. Iwmi, Report No.85, Colombo, Sri Lanka: International Water Management Institute. Srilanka. 2004.
2. Dow K and Downing T. The atlas of climate change: Mapping the world's greatest challenge. University of California press. USA. 2016.
3. Dai A. Characteristics and trends in various forms of the Palmer drought severity index during 1900–2008. J Geophys Res Atmos. 2011;p:116.
4. Dai A. Increasing drought under global warming in observations and models. Nat Clim Change. 2012;3(1):52-58.
5. Kreft S, et al. Global climate risk index 2016: Who suffers most from extreme weather events, weather-related loss events in 2014 and 1995 to 2014. electronic version, Germanwatch Nord-Süd Initiative. 2015.
6. Glanemann N, et al. Climate change and trade networks. 6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines. 2017.
7. Harris R and Baumann I. Open data policies and satellite Earth observation. Space Policy. 2015;32:44-53.
8. Khan J, et al. Mapping MODIS LST NDVI imagery for drought monitoring in Punjab Pakistan. IEEE Access. 2018;6:19898-19911.