Vol. 22, No. 2, pp. 284-290 (2022)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in

Short Communication

Characteristics of Meteorological and Agricultural Drought of Hazaribagh District, Jharkhand

CHANDAN KUMAR GUPTA[1]*, A. WADOOD[1], RAMESH KUMAR[1], PRAGYAN KUMARI[1], SHIV MANGAL PRASAD[2] AND DIPAK KUMAR GUPTA[3]

[1]*Department of Agrometeorology and Environmental Science, Birsa Agricultural University, Kanke, Ranchi-834006, Jharkhand*
[2]*ICAR-NRRI, Central Rainfed Upland Rice Research Station, Hazaribagh-825301, Jharkhand*
[3]*ICAR-Indian Agricultural Research Institute-Jharkhand, Gauria Karma, Hazaribagh-825405, Jharkhand*

ABSTRACT

Drought is most widespread natural disaster for agriculture and ecosystem as whole. Further, in recent decades, drought severity has increased in some regions due to precipitation decreases or increases in the atmospheric evaporative demand. Assessment and monitoring of drought in a region is very crucial for reducing its negative impacts on agriculture. Therefore, in this study block level characterization of agricultural and meteorological drought for Hazaribagh district was done using 35 years of daily rainfall data (1983-2017) and IMD criteria. The intensity and frequency of drought varied among the blocks of Hazaribagh district. The occurrence of mild drought was more frequent (7-14 drought years in 35 years) while severe drought was very less frequent (1-2 drought years in 35 years) in the Hazaribagh district. Similarly, late monsoon agricultural drought was more frequent (5-9 droughts in 35 years) followed by early (3-10 droughts in 35 years) and mid (1-6 droughts in 35 years) monsoon drought. Almost all blocks of Hazaribagh were affected by drought, however intensity and frequency of occurrence was relatively higher in Chauparan, Barhi and Karedari blocks.

Key words: Drought, Hazaribagh, Blocks, Rainfall

Introduction

Drought is one of the most widespread and common natural disasters (Yao *et al*., 2018). It is a creeping phenomenon triggered by a deficiency of precipitation that progressively holds an area over time and can be persisted for a long time (Niaz *et al.,* 2022). Drought has severe effects on weather-related events, natural ecosystems, economy, agriculture, and environment. It can endanger the production of agriculture and animal husbandry, worsen the ecological environment, and even expose human to the risk of disease (Yusa *et al.,* 2015; Kala *et al.,* 2017; Ruwanza *et al.,* 2022). The immediate impact of drought is on crop production and livelihood of farmers and agricultural workers. Drought leads to delayed crop sowing, poor crop growth and less than normal crop sown area due to inadequate soil moisture availability ultimately leading to decrease in crop yield with a strong impact on livelihood opportunities (Sai *et al.,* 2016). Further, precipitation is extremely vulnerable to global warming, and its pattern has changed over many regions in recent decades due changes in precipitation and atmospheric evaporative demand (Vicente-Serrano *et al.,* 2020). The percentage of dry areas in

*Corresponding author,
Email: chandanguptabau@gmail.com

the world has increased by approximately 1.74% per decade during 1950–2008 (Dai, 2011). In a study, Bisht *et al.* (2019) has reported increasing trend in severity, duration, occurrences, and length of drought in India under warming climate scenarios. Furthermore, it exhibits substantial spatial and temporal variability in various climates and regions. Almost every year one or the other region of the India is affected by drought in varying intensities. Out of 142-million-hectare net sown area in India about, two-thirds is reported to be vulnerable to drought conditions (Sai *et al.,* 2016). Thus, drought can affect agriculture, communities and environments worldwide in several ways. Therefore, a comprehensive understanding, assessment and monitoring of drought characteristics in a region is very important and crucial for reducing its vulnerability to the negative impacts of drought. The present study characterised the meteorological and agricultural draught at a spatial scale of block level for entire Hazaribagh district of Jharkhand.

Material and methods

Study area

Hazaribagh district lies between 23.5°-24.40° N Latitude and 85.1°-85.9° E Longitude in an area of about 4310.33 km^2. It is sixth largest districts in terms of area in the state and it forms the central portion of the North Chotanagpur Division of Jharkhand state. It falls under agro-climatic sub-zone IV (Central and North Eastern Plateau Zone of Jharkhand). The district comes under tropical monsoon region. The minimum annual temperature of the district varied from 15.3°C to 20.6°C with 19.5°C average minimum temperature while maximum annual temperature varied from 27.4°C to 31.1°C with 29.3°C average maximum temperature. Soil is acidic in nature with sandy loam to loamy sand in texture and its nitrogen content varied from 280-445 kg ha^{-1} (Gupta *et al.,* 2020). The Hazaribagh district has 16 blocks, however, rainfall data was available only for 10 blocks and hence only 10 blocks were studied in this study.

Rainfall data and its analysis

Daily rainfall data for a period of 35 years (1983-2017) of 10 blocks of the district were collected from District Statistical and Agricultural office, Hazaribagh, Director of Economics & Statistics, Ranchi and CRURRS Hazaribagh and were analysed for the purpose of the present study. The detail analysis of rainfall for meteorological and agricultural drought were done using a software Weather cockver. 1 & 1.5. The criteria adopted by India Meteorological Department (IMD) was used for classifying drought. The meteorological drought years were classified as mild, moderate and severe drought years when rainfall deficit was upto 25, 26-50 and > 50 per cent, respectively. India is a monsoon dependent nation for agriculture and most of the precipitation occurs through south-west monsoon. Therefore, agricultural drought was classified for *kharif* season and was defined as at least four consecutive weeks receiving less than half of normal rainfall when the normal weekly rainfall is 5 mm or more. Agricultural droughts were analysed for three critical periods i.e. early season drought (22-28 standard meteorological week (SMW)), mid-season drought (29-35 SMW) and late season drought (36-42 SMW).

Result and Discussion

Meteorological drought

The intensity and frequency of meteorological drought varied among the blocks of Hazaribagh district (Table1, Fig. 1). During the observed period (35 years), the district experienced 16-20 drought years of different intensities, viz., mild, moderate and severe. The mild drought was most frequent (7-14 drought years in 35 years) and accounted for 41-82% of total drought years during 1983-2017 among the blocks (Fig. 1). Among studied blocks, Barkatha, Hazaribagh and Bishnugarh having 14, 14 and 13 mild drought years in 35 years respectively were most affected by mild drought (Fig. 1). Consecutive mild drought years occurred for five times in Barkatha (1988-89, 1992-93, 2000-01, 2011-12 and 2016-17) and two times in Hazaribagh (1988-89 and 2003-04). Among the blocks, occurrence of moderate drought ranged from 3-10 drought years (18-59% of total drought years) during 1983-2017. Moderate drought was most frequent in Barkagaon block with 10 drought years during 1983-2017(59% of total drought years) followed by Ichak block with 8 drought years (42% of total drought years). In both

Table 1. Frequency and intensity of meteorological and agricultural drought in various blocks of Hazaribagh district during 1983-2017

Blocks	Meteorological drought					Agricultural drought					
	No drought	Mild drought (years)	Moderate drought (years)	Severe drought (years)	Total drought (years)	Early drought		Mid drought		Late drought	
						Frequency	Duration (weeks)	Frequency	Duration (weeks)	Frequency	Duration (weeks)
Barhi	17.0	11.0	6.0	1.0	18.0	6.0	5.17 (4-7)	5.0	4.8 (4-9)	9.0	4.9 (4-11)
Barkagaon	18.0	7.0	10.0	0.0	17.0	6.0	4.83 (4-6)	4.0	5.0 (4-8)	8.0	4.75 (4-6)
Barkatha	18.0	14.0	3.0	0.0	17.0	3.0	5.33 (4-6)	2.0	5.5 (4-7)	7.0	4.7 (4-7)
Bishnugarh	18.0	13.0	4.0	0.0	17.0	6.0	4.5 (4-7)	1.0	8.0	7.0	4.5 (4-5)
Chauparan	16.0	12.0	6.0	1.0	19.0	10.0	4.3 (4-5)	6.0	6.3 (4-11)	8.0	4.6 (4-7)
Churchu	18.0	12.0	4.0	1.0	17.0	4.0	4.5 (4-6)	4.0	4.5 (4-6)	9.0	4.3 (4-9)
Hazaribagh	17.0	14.0	4.0	0.0	18.0	5.0	4.6 (4-6)	3.0	4.3 (4-5)	5.0	4.4 (4-5)
Ichak	16.0	11.0	8.0	0.0	19.0	9.0	4.6 (4-7)	1.0	6.0 (4-6)	9.0	4.8 (4-7)
Katkamsandi	15.0	11.0	7.0	2.0	20.0	6.0	4.5 (4-6)	5.0	4.2 (4-5)	5.0	4.0
Keredari	16.0	12.0	6.0	1.0	19.0	8.0	5.625 (4-11)	3.0	4.3 (4-5)	7.0	4.3 (4-5)
Min	15.0	7.0	3.0	0.0	17.0	3.0		1.0		5.0	
Max	18.0	14.0	10.0	2.0	20.0	10.0		6.0		9.0	
Mean	16.9	11.7	5.8	0.6	18.1	6.3		3.4		7.4	
SD	1.0	1.9	2.0	0.7	1.0	2.1		1.6		1.4	

Note: value in parentheses is range of weeks

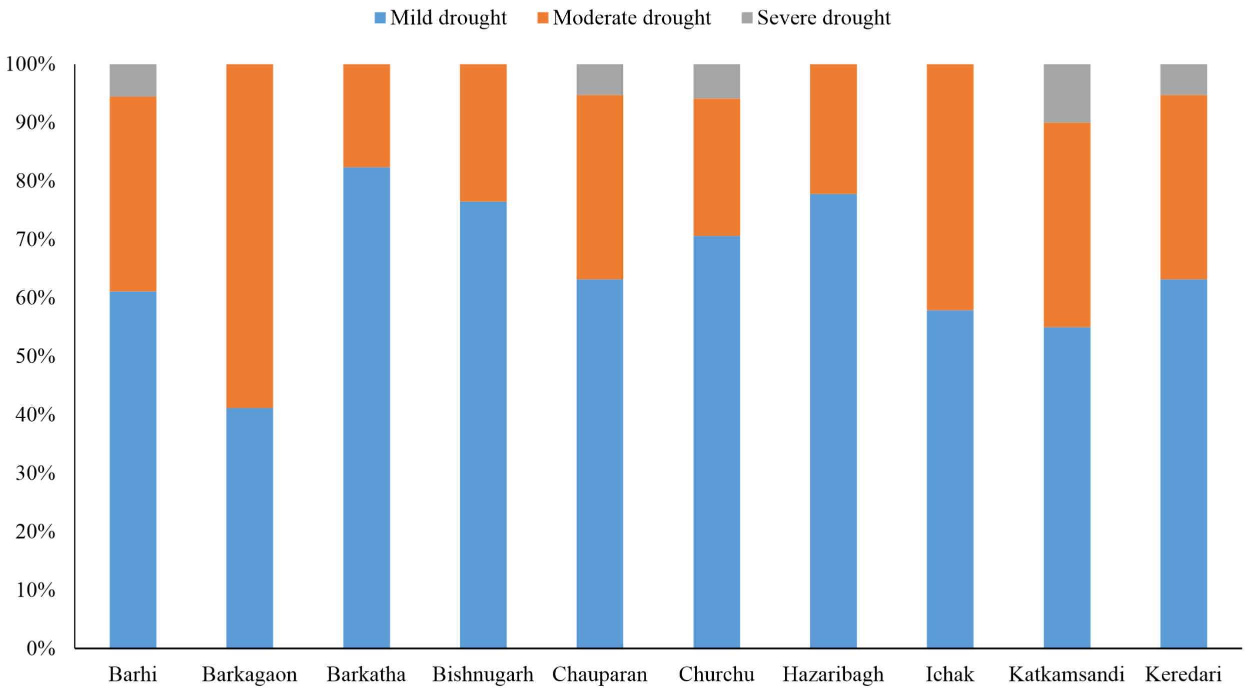

Fig. 1. Percentage share of mild, moderate and severe meteorological droughts in the various blocks of Hazaribagh district

of these block, consecutive drought years was occurred only once (Barkagaon: 2002, 2003 and 2004; and Ichak 1992-93) during the study period. The occurrence of severe drought was rare (1-2 drought years in 35 years) and was observed in five stations among which Katkamsandi experienced twice and Barhi, Chauparan, Churchu and Keredari experienced once in 35 years. No consecutive severe drought was occurred in any of the studied block during the study period. Among the meteorological droughts, mild meteorological drought is common in Jharkhand. Similar result has been also reported by Tiwar *et al*. (2007), however their study lack block level variation in meteorological drought. Tiwari *et al*. (2007) characterized meteorological drought for the drought prone Hazaribagh district using annual and monsoon seasonal rainfall data for a period of 80 years (1913-1992) and drought classification of India Meteorological Department. Similar to our study, they also reported "mild drought" as common meteorological drought in Hazaribagh. Kumari *et al*. (2014) also characterise meteorological droughts for Palamau district of Jharkhand using 56 years (1956-2011) rainfall data and similar methodology and reported that Palamau region experienced 32 drought years out of which 16 were mild, 15 moderate and one severe accounting for 29%, 27% and 2%, respectively. However, their study also lacks block level variation in meteorological drought. In the present study, the observed variation in occurrence of meteorological drought among the blocks was mainly due to spatial variation in amount and frequency of rainfall among the blocks (Gupta and Kumar, 2018; Gupta *et al*., 2020).

Agricultural drought

The agricultural drought in Hazaribagh district was found to occur in all the three spells. The early, mid and late stage of agricultural drought occurs during 22–28 SMW, 29–35 SMW and 36–42 SMW respectively. All the blocks were highly affected by late season drought followed by early season drought (Table 1, Fig. 2). The late monsoon agricultural drought was more frequent (5-9 droughts in 35 years) followed by early (3-10 droughts in 35 years) and mid (1-6 droughts in 35 years) monsoon drought. The percentage share of late drought ranged from 31-58% while 23-47% and 5-31% for early and mid-season agricultural drought respectively among the

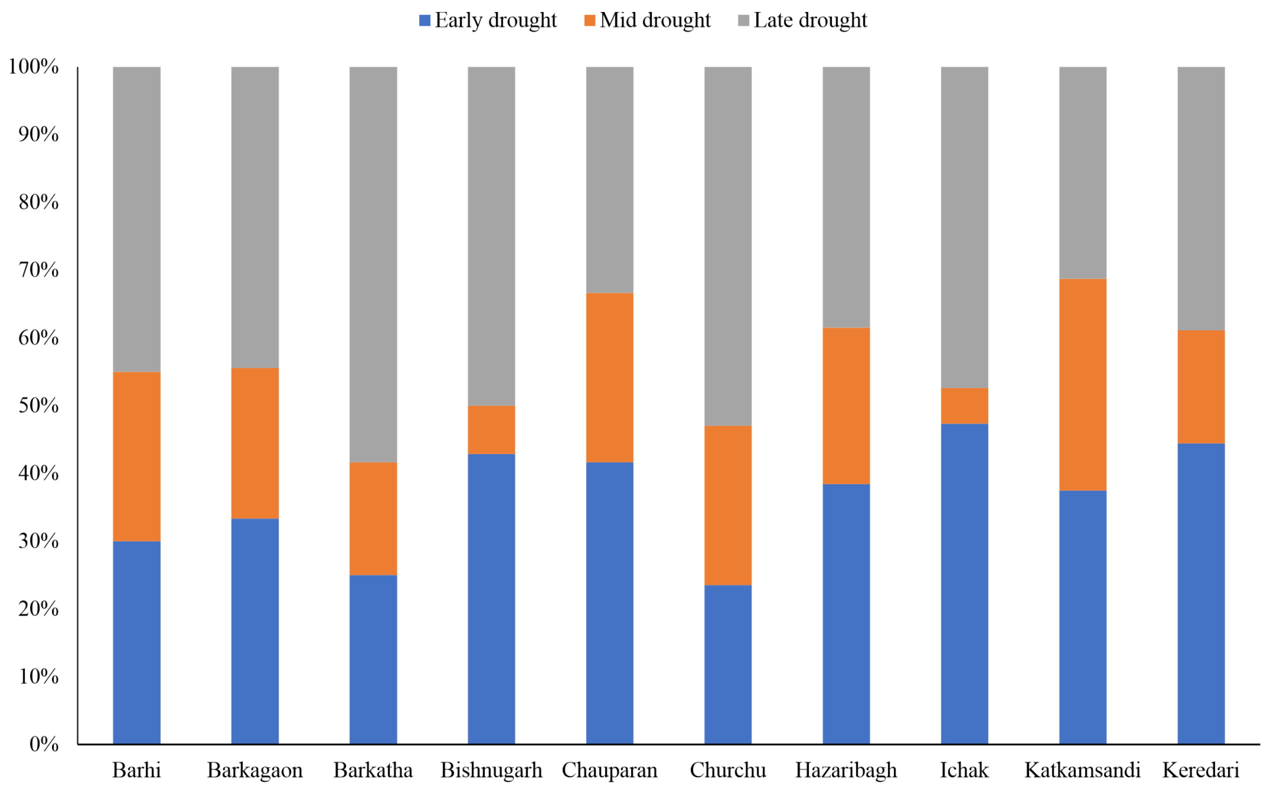

Fig. 2. Percentage share of early, mid and late monsoon season agricultural drought in various blocks of Hazaribagh district

blocks (Fig. 2). All together, the occurrence of these three agricultural droughts (i.e. early, mid and late season drought) was not found in any years and any blocks during 1983-2017, while occurrence of two meteorological droughts in a year i.e. early-mid, early-late and mid-late was also rare and was found to occurs in 1-4 years in 35 years of the study. Among the blocks, Barhi block observed highest number of two consecutive agricultural droughts in a year followed by Chauparan. Barhi faced, early-mid drought in 1983, early-late drought in 1986, early-late drought in 2005 and mid-late drought in 2009. While, Chauparan faced early-late drought in 1983, mid-late drought in 2010 and early-late drought in 2015. The length of drought period varied from 4-11 weeks and was longer for mid-season agricultural drought compared to late and early drought (Fig. 3). Among the blocks, Chauparan, followed by Barhi, Ichak, Karedariand katkamsandi were most agricultural drought affected blocks of Hazaribagh district. The frequency of early drought was found highest in Chauparan (10 early droughts in 35 years) followed by Ichak (9 early droughts in 35 years) and Karedari (8 early droughts in 35 years). Chauparan, Barhi and Katkamsandi were most affected blocks by mid-season drought, while almost all blocks were affected by late season drought. Among the blocks, Chauparan faced all three types of meteorological drought most frequently. Thus, the early stage agricultural drought is of a great concern in Chauparan, Ichak and Karedari and cause delay in land preparation, sowing and early vegetative crop growth. While, late season drought was being a great concern for all the blocks and can leads to crop failure. Technological intervention can benefit the crops if drought occurs at mid-, early, or late season rather than throughout the crop growth stage (Rane and Minhas, 2017). Adoption of soil moisture conservation practices, conservation agriculture involving mulching and intercultural practices and selection of drought tolerant and short duration variety can be helpful in elevating the effect drought (Nagaraja and Ekambaram 2015; Rane and Minhas, 2017; Ranjan *et al*., 2020; Pathak *et al*., 2021).

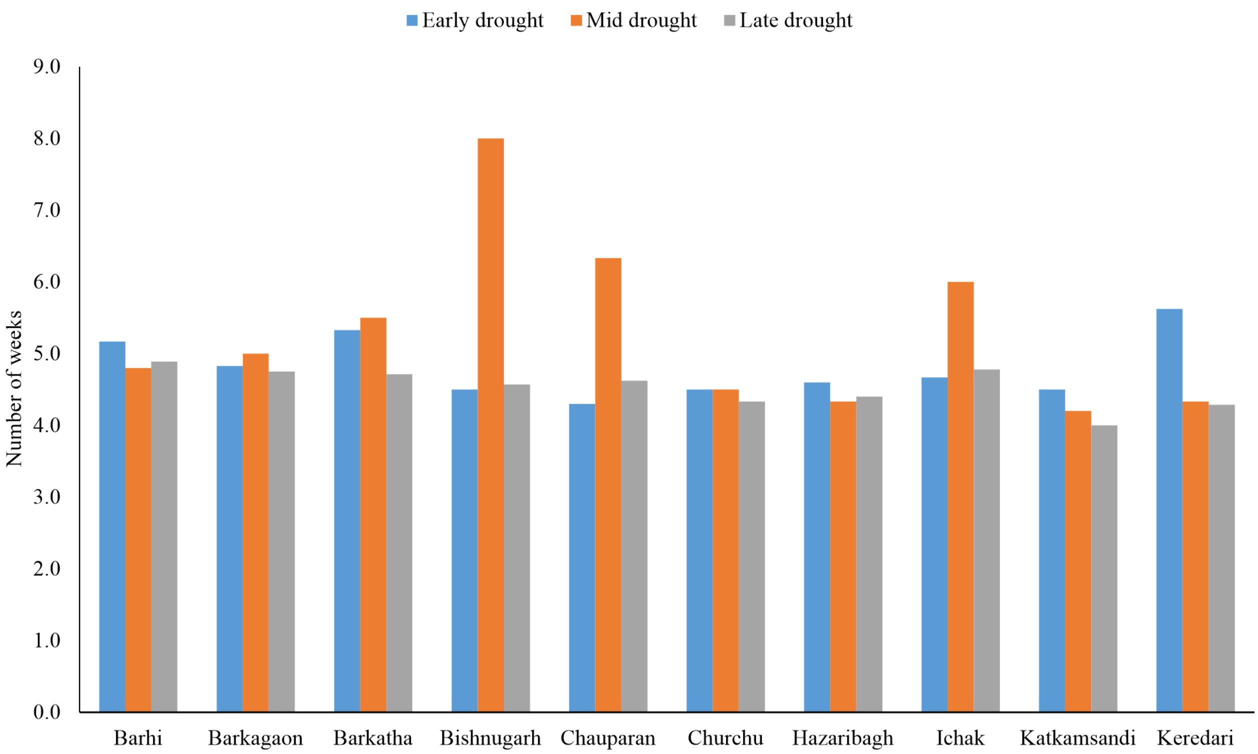

Fig. 3. Duration of early, mid and late monsoon season agricultural drought in various blocks of Hazaribagh district

Conclusions

All the studied blocks of Hazaribagh district faced drought, however, severe drought was least frequent. The early stage (22–28 SMW) agricultural drought which coincide with land preparation, sowing and early vegetative crop stage, is of a great concern for ensuring the good crop stand in Chauparan, Ichak and Karedari. Therefore, in these blocks creation of assured irrigation facility for nursery raising or dry sowing without irrigation is recommended. The third spell of agricultural drought i.e. late season drought was found in all the blocks. This occurs in 36–42 SMW and coincided with the active reproductive stage of kharif crops. Therefore, short duration variety must be recommended in the Hazaribagh district.

References

Gupta, C.K. and Kumar, R. 2018. Rainfall variation and trend analysis of Garhwa district, Jharkhand: An assessment of spatial and seasonal variability. *Journal of Pharmacognosy and Phytochemistry 7*(5): 2143-2145.

Gupta, C.K., Wadood, A., Kumar, R., Kumari, P. and Prasad, S.M. 2020. Effect of Topo-sequence on Physical and Chemical Soil Properties of Hazaribagh, Jharkhand. *Journal of Agricultural Physics* **20**(1): 82-86.

Kala, C.P. 2017. Environmental and socio-economic impacts of drought in India: lessons for drought management. *Applied Ecology and Environmental Sciences*. **5**(2): 43–48.

Kumari, P., Ojha, R.K., Wadood, A. and Kumar, R., 2014. Rainfall and drought characteristics for crop planning in Palamau region of Jharkhand. *Mausam* **65**(1): 67-72.

Nagaraja, B. and Ekambaram, G. 2015. A critical appraisal of integrated watershed management programme in India. *IOSR-JHSS* **20**: 17-23.

Niaz, R., Tanveer, F., Almazah, M., Hussain, I., Alkhatib, S. and Al-Razami, A.Y. 2022. Characterization of meteorological drought using monte carlo feature selection and steady-state probabilities. *Complexity*, *2022*. https://doi.org/10.1155/2022/1172805

Pathak, H., Srinivasarao, C.H. and Jat, M.L. 2021.

Conservation agriculture for climate change adaptation and mitigation in India. *Journal of Agricultural Physics* **21**(1): 182-196.

Rane, J. and Minhas, P.S. 2017. Agriculture drought management options: scope and opportunities. *Abiotic Stress Management for Resilient Agriculture*: 51-72.

Ranjan, R., Pramanik, M., Tiwari, S., Kumar, M. and Yadav, R. 2020. Rain water harvesting in non-arable land using staggered trenching in semi-arid climate of Bundelkhand. *Journal of Agricultural Physics* **20**(1): 69-74.

Ruwanza, S., Thondhlana, G. and Falayi, M. 2022. Research progress and conceptual insights on drought impacts and responses among smallholder farmers in South Africa: A review. *Land* **11**(2): 159. https://doi.org/10.3390/land11020159

Sai, M.S., Murthy, C.S., Chandrasekar, K., Jeyaseelan, A.T., Diwakar, P.G. and Dadhwal, V.K. 2016. Agricultural drought: Assessment & monitoring. *Mausam* **67**(1): 131-142.

Tiwari, K.N., Paul, D.K. and Gontia, N.K. 2007. Characterization of meteorological drought. *Hydrology* **30**(1-2): 15-27.

Vicente-Serrano, S.M., Quiring, S.M., Pena-Gallardo, M., Yuan, S. and Dominguez-Castro, F. 2020. A review of environmental droughts: increased risk under global warming?. *Earth-Scienc Reviews* **201**: 102953.

Yao, N., Li, Y., Lei, T. and Peng, L. 2018. Drought evolution, severity and trends in mainland China over 1961–2013. *Science of the Total Environment* **616**: 73-89.

Yusa, A., Berry, P., Cheng, J.J., Ogden, N., Bonsal, B., Stewart, R. and Waldick, R. 2015. Climate change, drought and human health in Canada. *International Journal of Environmental Research and Public Health* **12**(7): 8359-8412.

Received: 18 September 2022; Accepted: 28 December 2022