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ER Motiram T Bhendekar
Research Scholar, Department of Soil and Water Conservation Engineering, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Dr. Megha P Jagtap
Assistant Professor, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Dr. Madan S Pendke
Head &Associate Professor, Department of Soil and Water Conservation Engineering, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

ER Shashikant Mehetre
Thematic Programme Executive Natural Resource Management (TPE-NRM), BAIF Institute for Sustainable Livelihoods and Development, Nashik, Maharashtra, India

Corresponding Author:
ER Motiram T Bhendekar
Research Scholar, Department of Soil and Water Conservation Engineering, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Impact assessment of drought characteristics using NDVI, NDWI and NDDI parameters under treated micro watershed area using remote sensing and GIS application for Pre and Post watershed development Period

ER Motiram T Bhendekar, Megha P Jagtap, Madan S Pendke and ER Shashikant Mehetre

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Abstract
Droughts are one of the most catastrophic natural disasters on the planet which can be impacting millions of people in various ways of life like food security, economic losses, and migration of the community. The growing severity of droughts and their catastrophic effects on communities in India's semi-arid regions like Marathwada necessitate better drought monitoring and assessment systems strategies for Sustainable development of the peoples. Traditional mathematical methods like Standardized Precipitation Index (SPI), Palmer Drought Severity Index (PDSI), and Climate Moisture Index (CMI), etc., are used to analyse drought intensity.

In the present study, analysis of historical NDVI, NDWI and NDDI data from Dahegaon watershed of Gangapur Block of Ch. Sambhajinagar of period of 2014-2023 was conducted to identify patterns in drought characteristics change under Watershed development activities effect during pre development period (2014 to 2018) and post development period years (2019 to 2023). The satellite images for the years 2014 to 2023 were gathered at average annual of 365 day intervals, and remote sensing techniques were employed to calculate NDDI (normalized difference drought index) using NDVI (normalized difference vegetation index) and NDWI (normalized difference water index). The comparative analysis of NDVI, NDWI and NDDI interpreted greater change in extreme drought situations and developed regions goes to other classes of less impactful on agricultural and biological system than extreme drought situation. It was concluded that as per NDWI classification of about 1% area shows positive changes against drought. as per NDVI classification about 42% area shows positive changes against drought. As per NDDI classification Extreme drought reduces by 7%. Exceptional drought reduces by 5%. Mild, Moderate and severe drought increases by about 2.5%, 7% and 2.5% respectively. Hence 34% area shows positive changes against drought as per NDDI classifications. The study utilized remote sensing and GIS applications to investigate changes in drought characteristics over the spatial and temporal situations.

Keywords: Drought assessment, NDVI, NDWI, NDDI, watershed development

Introduction
In 2024, India's agriculture faced significant challenges due to extreme weather conditions, including droughts and excessive rainfall, which impacted both the area under cultivation and overall production. The total Kharif food grain production for 2024-25 was projected at 1,647.05 lakh metric tonnes (LMT), an increase of 89.37 LMT compared to the previous year. In India, contribution of rainfed production to nutritious cereals and pulses is about 84-87%, cotton- 60% and 77% in oilseeds and support 60% of livestock and 40% of human population. As of February 2024, approximately 26% of India's land area was affected by drought conditions, more than double the area affected the previous year. Notably, 9% of the land experienced extreme drought. By March 2024, the drought situation had escalated, with 125 districts across 23 states and union territories facing drought conditions. This intensification raised concerns about agriculture, water resources, and rural livelihoods.

The challenges of land degradation, water shortage, and droughts pose a threat not only to the global climate and environment but also to achieving Sustainable Development Goal (SDG)-2 (Zero Hunger) and SDG-13 (Climate Action). Spatial and temporal distribution of rainfall and the increase in extreme events are impacting the rainfed production systems in the country. While stability and enhancing cropping intensity is observed in irrigated systems, lower cropping intensity and higher risk are prevalent in rainfed systems. Marathwada region is traditionally a drought prone region. The region receives mean annual rainfall of 880 mm and major area comes under assured rainfall zone. In Marathwada region, out of total cultivated area of 57.94 lakh ha, 49.60 lakh ha area is rain fed. The South-West monsoon account for nearly 75% of the precipitation and exerts a strong influence on the kharif food grain production and the economy in terms of agricultural output, farmers income and price stability. The probability of erratic monsoon rains is about 40%.

Watershed management is a widely accepted approach which is effective and efficient in environment regeneration. Though several approaches have been tried and adopted in the past for integrated development of people and area, watershed approach offers certain distinct advantages - technologically, socio-economically, and philosophically. It is a shift from exploitation-oriented development to regeneration oriented development. Conservation of the basic resources like land and water is the first step in the process. A watershed is a living system governed by natural laws. The upper, middle, and lower reaches of a watershed are associated with different kinds of life support systems - agriculture, bio-mass, flora, livestock, fauna and people. They behave differently to flow or transmission of rainwater. They demand specific types of management practices and provide economic returns in specific ways. Watershed approach enables us to take care of this neglected lot of people, land, forests, and other elements of the ecology. The ultimate objective of watershed management is to improve the standard of living for the common man in the basin by increasing his earning capacity through increased productivity of land and water. Good farming practices, rational land use, and efficient management of soil water, crops and livestock results in sustained high yields, which provide the best basis for ensuring adequate returns to the farmer and the country as a whole. Employment generation from sustained use of regenerated land and water resources is far higher than that generated through the process of resource regeneration itself. Economic viability, management of technology and equity could be considered as three main indicators of success.

Aurangabad is the district headquarters situated in upper Godavari basin and in the extreme northwest of Marathwada region. It lies between 19°15' and 20 °40' N and 74°37' and 76°52'E. Major part of the district falls in Godavari basin with a small area in north eastern parts in Tapi Basin. Depending on the drainage and geomorphology, the district has been divided into 52 watersheds. Ground water has special significance for agricultural development in the district as 71% of irrigation is ground water based. The climate of the district is characterized by a hot summer and a general dryness throughout the year. December is the coldest month with the mean maximum temperature of 28.9 °C, while the mean minimum temperature is 10.3 °C. May is the hottest month with the mean maximum temperature of 39.8 °C and the mean minimum temperature of 24.6 °C. The Normal rainfall of the district for the period 1998 to 2022 is 581.7 mm [4].

A large area under the Chhatrapati Sambhajinagar district comes under scarcity rainfall zone of rainfed conditions, hence change in rainfall pattern causes a significant impact on the agricultural production of the study area. Chhatrapati Sambhajinagar district is one of the most severe and frequent drought-prone areas of marathwada region of Maharastra. The interval of drought events in the study area was every 4-5 years, which has declined to 3 year return period in the last three decades. Watershed management is a widely accepted approach which is effective and efficient in environment regeneration by technologically, socio-economically, and philosophically sound. As per GSDA in Marathwada region irrigation wells depth increases > 60 feet's Groundwater level depletion > 1 m and 247 villages, groundwater draft has exceeded recharge in September 2022. As per IMD region have Average annual rainfall 750 mm. 60 blocks have rainfall deficient, and 15 blocks have deficient < 20%. Average rainfall is 44 per cent below normal under drought Years. Two important cash crops such cotton and sugarcane are severely affected due to capital input and cultivation cost and crop failed successively. Marathwada has 70 sugar mills. Total water required for sugarcane cultivation is 4,300 million cubic metres. Impact assessment is the systematic identification of the effects - positive or negative, intended or not - on individual households, institutions, and the environment caused by a given watershed development activity or programs. The main object of the study is to assess the impact of watershed development activities on combat the drought situation of study area through the assessment of NDVI, NDWI and NDDI indexes related to the drought.

Materials and Methodology

Details about the Study Area

The proposed study will be undertaken in Dahegaon watershed in Gangapur block of Aurangabad district. It consists of 14 villages covering 7097 ha and 2347 household. It lies between 19.764 N and 19.658 N and 75.101E and 75.177 E. The study area is falling in Survey of India topographical map 47 M/2 and 47 M/1.out of 14 villages the 4 villages are in upper reach, 6 villages are in middle reach and remaining 5 villages are in lower reach. The project area consists of watersheds with streams joining Shivana River near 'Nathsagar dam' at Paithan in Godavari basin. The upper reach portion villages are facing lower productivity due to degradation and water scarcity. The watershed area comprises relatively low-lying areas. The productivity of agriculture especially in rain fed areas depends on the temporal and spatial distribution of rain. As per the Watershed Atlas of India the watershed area falls under 4E4C3 contains total 12 micro catchments.

Climate of The study area always face scarcity conditions, as the scarcity of water is observed in the dry period because there is scanty rainfall, uncertainty and unevenness of rainfall. Mean average annual rainfall of the study area was 770mm. (WALMI Aurangabad). The ground water occurs under water table and semi confined to confined conditions in Deccan Trap Basalt. The major part of the Study area is covered by black cotton soil or 'Regur' formed by the weathering of Deccan Trap Basalt, The soils in the region are deep black, medium shallow (NBSS &LUP). The predominant soil in the region is Vertisol (Black cotton soil). It is rich in plant nutrients such as lime, magnesia, iron and alkalises. Under rainfed agriculture, major kharif crops of the region are sorghum, cotton, pigeon pea, green gram, black gram, pearl millet and soybean, whereas major rabi crops are rabi sorghum, safflower, chickpea and sunflower etc.

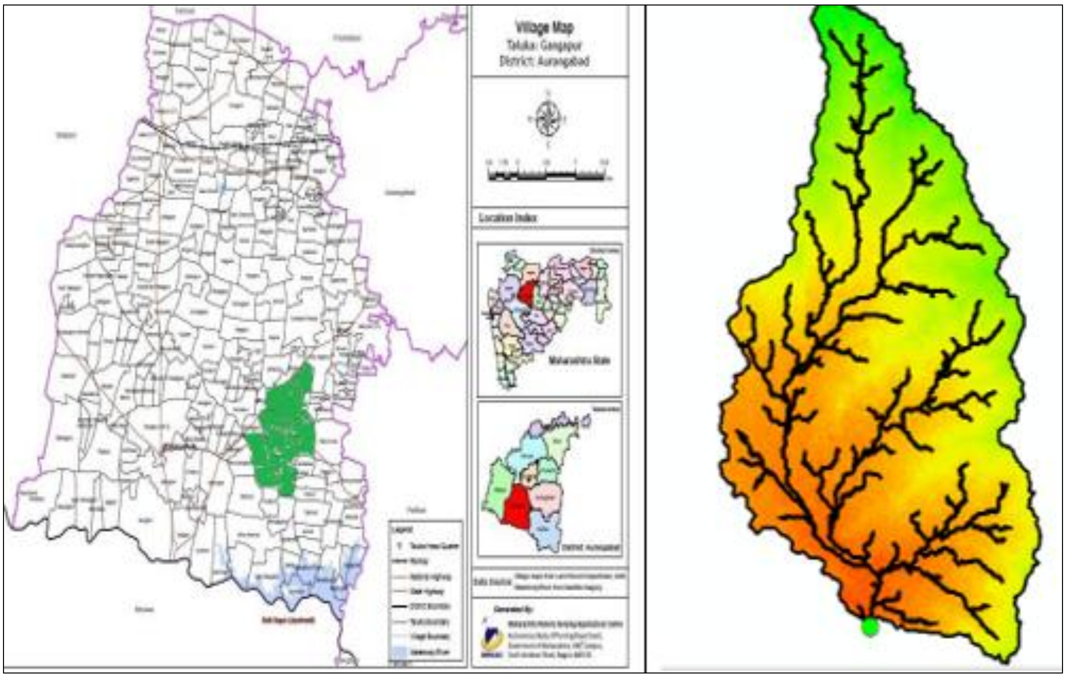

Fig 1: Location map of the Dahegaon watershed (study area)

Data Collections

Satellite data

This study utilized satellite data of year 2014 to 2023 derived from USGS Earth Explorer (NASA LPDAAC Collection), one of the open source satellite data sources. The number of LANDSAT-8 LANDSAT/LC08/C02/T1_TOA images used for analysis. The image having cloud cover less than 10% is used for this analysis. Atmospheric correction is neglected in the analysis because Landsat 8's sensor design minimizes atmospheric interference. When studying relative comparisons within similar images, the impact of atmospheric effects is often consistent, and correction may not significantly improve results. This sensor design inherently reduces atmospheric influences, allowing for reliable quantitative results without extensive correction procedures. Landsat 8 Collection 2 Tier 1 calibrated top-of-atmosphere (TOA) reflectance. Calibration coefficients are extracted from the image metadata. for details on the TOA computation. Landsat scenes with the highest available data quality are placed into Tier 1 and are considered suitable for time-series processing analysis. Tier 1 includes Level-1 Precision Terrain (L1TP) processed data that have well-characterized radiometry and are inter-calibrated across the different Landsat sensors. The geo-registration of Tier 1 scenes will be consistent and within prescribed tolerances [<=12 m root mean square error (RMSE)]. All Tier 1 Landsat data can be considered consistent and inter-calibrated (regardless of sensor) across the full collection. See more information in the USGS docs. The T1_RT collection contains both Tier 1 and Real-Time (RT) assets. Newly-acquired Landsat 7 ETM+ and Landsat 8 OLI/TIRS data are processed upon downlink but use predicted ephemeris, initial bumper mode parameters, or initial TIRS line of sight model parameters. The data is placed in the Real-Time tier and made available for immediate download. Once the data have been reprocessed with definitive ephemeris, updated bumper mode parameters and refined TIRS parameters, the products are transitioned to either Tier 1 or Tier 2 and removed from the Real-Time tier. The transition delay from Real-Time to Tier 1 or Tier 2 is between 14 and 26 days. Landsat datasets are federally created data and therefore reside in the public domain and may be used, transferred, or reproduced without copyright restriction.

Software Used

NDVI, NDWI and NDDI requires for Drought analysis using Landsat 8 satellite data was carried out in the Arc-GIS software package (ArcGIS 10.8.2) and google earth engine. Using these software, all drought-classified indices for the Dahegaon Watershed were derived, the class-wise area was computed, and thematic maps were created for visual comparisons.

Methods

The data were processed using image analysis and GIS software. The satellite images were collected free from USGS and Google earth engine and image analysis done by using GIS. The calculation of the top of atmosphere (TOA), layer stacking, extraction of areas of interest, computation of the band indices for producing the spectral differences between the ground features, and cloud masking for the Landsat imageries were included during the pre-processing [12]. The Data Re-sampling method was carried out to ensure comparability between the Landsat data from 2014-2023 (with a spatial resolution of 30m). Re-sampling is method for changing the spatial scale of data to a common resolution, in this study, 10m, so that they can be properly compared.

Normalized difference vegetation index (NDVI) Details

Normalized difference vegetation index (NDVI) Drought Severity can be evaluated using remote sensing as the crop plants' reflectance features vary due to physiological and morphological changes resulting from water stress in plants and soil. The normalized difference vegetation index (NDVI) is the normalized reflectance difference between the two spectral bands, i.e., near-infrared (NIR) and visible red bands is used mainly for monitoring vegetation of earth's surface. The normalized difference vegetation index (NDVI) is a modest graphical indicator that can be cast off to evaluate vegetation cover over the earth's surface using the remote sensing technique. It is based on the known radiation properties of plants, using visible (red) and near-infrared (NIR) radiation. The concept of NDVI was given by Deering and Tucker [1]. NDVI calculated using equation (1)

$$NDVI = \frac{NIR(Band8) - Red(Band4)}{NIR(Band8) + Red(Band4)} \quad \ldots\ldots (1)$$

NDVI-Based Drought Classification

Table 1: Drought categories based on NDVI classes

NDVI values	Drought severity classes
− 1.0 to − 0.3	Severe drought
− 0.3 to 0	Moderate drought
0 to 0.3	Mild drought
0.3 to 1.0	No drought

Normalized difference water index (NDWI):

NDWI is derived from two channels, i.e. NIR and Shortwave Infrared (SWIR) channels; absorption of SWIR radiation respond to deviations in both the water content, whereas reflectance of NIR radiation is related to spongy mesophyll in vegetation canopies. In Landsat 8, there are two SWIR bands with wavelengths of 1640 nm and 2130 nm. The 1640 nm band is affected by environmental factors like water vapour and aerosol, while the 2130 nm band is least affected by the atmosphere, mainly by ozone and Rayleigh scattering. Hence, NDWI derived with SWIR 2130 nm is more beneficial in extracting the vegetation water status and in drought detection [1]. NDWI calculated using equation (3)

$$NDMI = \frac{NIR(Band8) - SWIR(Band11)}{NIR(Band8) + SW\ IR(Band11)} \quad \ldots\ldots (2)$$

Drought categories based on NDWI classes as below [2]

NDWI-Based Drought Classification

Table 2: Drought categories based on NDWI classes

NDWI values	Drought severity classes
-1 to 0.2	Extreme drought
0.2 to 0.3	Moderate drought
0.3 to 0.4	Mild drought
0.4 to 0.5	Moderate moisture content
0.5 to 1.0	Very high moisture content

Normalized Difference Drought Index (NDDI) details:

Normalized Difference Drought Index (NDDI) is used for drought monitoring. This index is the combination of the above two NDVI and NDWI indices. NDDI is the ratio of the difference between NDVI and NDWI to the sum of NDVI and NDWI bands. NDDI is the more sensitive indicator for drought than the NDVI and NDWI indicators [1]. Where the maximum value of NDDI indicates drought conditions at the same time NDVI and NDWI become low. In contrast, the minimum NDDI value indicates no drought or non-water scarcity conditions. When NDDI becomes low, NDVI and NDWI values increase, indicating high vegetation with sufficient water.

The formulas for calculating the NDDI indices are presented in Equations 3, as below: [8]

$$NDDI = \frac{NDV\ I - NDMI}{NDV\ I + NDMI} \quad \ldots\ldots\ldots (3)$$

NDDI-Based Drought Classification

On the basis of classification of calculated NDDI values the drought can be categorized into seven drought severity levels based on predefined threshold values. The classification is as follows:

Table 2: Drought categories based on NDDI classes

NDDI Range	Drought Classification	Brief Description	Implications
< -1	Waterbodies	lakes, small stream, rivers, well etc.	water sources for irrigation purposes
-1 to 0.2	No Drought (Wet Conditions)	This range indicates optimal moisture levels, with healthy vegetation and sufficient water availability.	Favourable conditions for agricultural activities, robust crop growth, and minimal water stress.
0.2 to 0.3	Mild Drought	Early signs of moisture deficiency begin to appear, with slight reductions in soil moisture and minor stress on vegetation.	Potential for minor impacts on crop yields; irrigation may be necessary to supplement natural precipitation.
0.3 to 0.4	Moderate Drought	Noticeable moisture deficits lead to visible stress on vegetation, including wilting and reduced growth rates.	Significant decline in crop productivity; water restrictions may be implemented, and there is an increased risk of wildfires.
0.4 to 0.5	Severe Drought	Severe lack of moisture results in extensive damage to vegetation, with widespread browning and potential loss of plant life.	Major agricultural losses are expected; water shortages become critical, affecting both human consumption and ecological systems
0.5 to 1	Extreme Drought	Extreme moisture scarcity causes catastrophic impacts on vegetation and water resources, with most plant life unable to survive.	Widespread crop failure; severe water crises affect communities and wildlife, leading to emergency measures and potential displacement.
>1	Exceptional Drought	Anomalously high NDDI values exceeding 1 are uncommon and may indicate data anomalies or extreme conditions not typically observed	Requires careful analysis to determine underlying causes; may necessitate immediate and unprecedented intervention strategies.

Each category represents a progressive decrease or increases in vegetation and moisture availability, indicating increasing or decreasing drought severity. The drought classification is applied to monitor regional drought patterns and support decision-making for water resource management, agriculture, and climate adaptation strategies. The results help policymakers implement drought mitigation measures efficiently.

Results and Discussion

NDVI Estimation

As per the NDVI drought Classification for the study area the ten year Data of NDVI was collected using Landsat-8 imagery. The average mean of first five year (2014-2018) was consider as pre development period NDVI and the average mean of last five year (2019-2023) was consider as Post development period NDVI (as shown in table 3).

Table 3: Pre &Post-Watershed Development Period NDVI classes (2014-2023)

Classes	NDVI Value	Pre NDVI	Post NDVI	% CHANGE
Mild drought	-1 to - 0.3	6954.09	5090.05	-26.26
Moderate and other class drought	-0.3 to + 0.3	51.07	10.96	-0.56
No drought	+ 0.3 to +1	91.85	1996.00	26.83
Total Area		7097.01	7097.01	0

It was found that for pre development period (2014-1018) total area under mild drought and having NDVI values between -1 to -0.3 was over on 6954.09 ha out of total 7097.01 ha area. And the same class for post development (2019-2023) having value spread over 5090.05 ha. it means that mild drought decrease by 26.26%. For pre development period (2014-1018) total area under Moderate and other class drought and having NDVI values between -0.3 to -0.3 was over on 51.07 ha out of total 7097.01 ha area. And the same class for post development (2019-2023) having value spread over 10.96 ha. it means that Moderate and other class drought decrease by -0.56%. For pre development period (2014-1018) total area under No drought class and having NDVI values between -+ 0.3 to +1 was over on 91.85 ha out of total 7097.01 ha area. And the same class for post development (2019-2023) having value spread over 1996.00 ha. it means that No drought class increase by 26.83%. Hence it was concludes that asper NDVI classification mild drought area may be totally converted into no drought class.

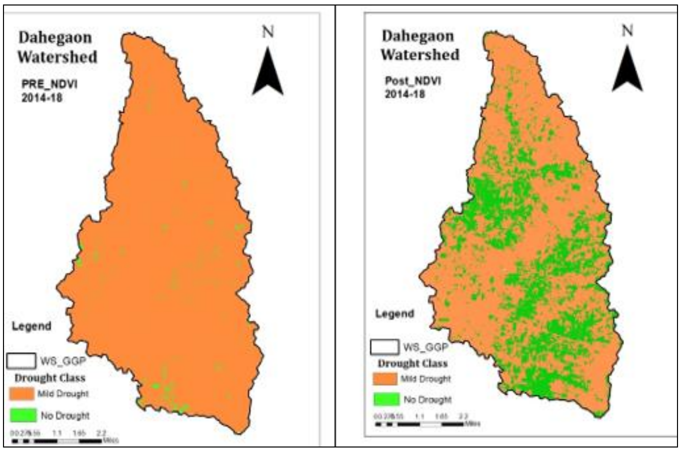

Fig 2: Pre & Post-Watershed Development Period NDVI classes (2014-2023)

NDWI Estimation

As per the NDWI drought Classification for the study area the ten year Data of NDWI was collected using Landsat-8 imagery. The average mean of first five year (2014-2018) was consider as pre development period NDWI and the average mean of last five year (2019-2023) was consider as Post development period NDWI (as shown in table 4).

Table 4: Pre &Post -Watershed Development Period NDDI classes (2014-2023)

Classes	NDWI Value	Pre NDWI	Post NDWI	% change
Extreme drought	-1 to + 0.2	7033.34	7001.20	-0.45
Moderate drought	0.2 to 0.3	2.19	5.51	0.05
Mild and other drought	0.3 to +1	61.48	90.30	0.40
Total Area		7097.01	7097.01	0

It was found that for pre development period (2014-1018) total area under extreme drought and having NDWI values between -1 to +0.2 was over on 7033.34 ha out of total 7097.01 ha area and the same class for post development (2019-2023) having value reduces over 7001.20ha. It means that extreme drought decrease by -0.45%.

For pre development period (2014-1018) total area under moderate drought and having NDWI values 0.2 to 0.3 was over on 51.07 ha out of total 7097.01 ha area and the same class for post development (2019-2023) having value spread over 5.51 ha. it means that Moderate drought decrease by -0.05%.

For pre development period (2014-1018) total area under Mild and other drought class and having NDWI values between + 0.3 to +1 was over on 61.48 ha out of total 7097.01 ha area. And the same class for post development (2019-2023) having value spread over 90.30 ha. it means that Mild and other drought increase by 0.40%. Hence it was concludes that asper NDWI classification extreme drought area may be totally converted into mild drought class and moderate class.

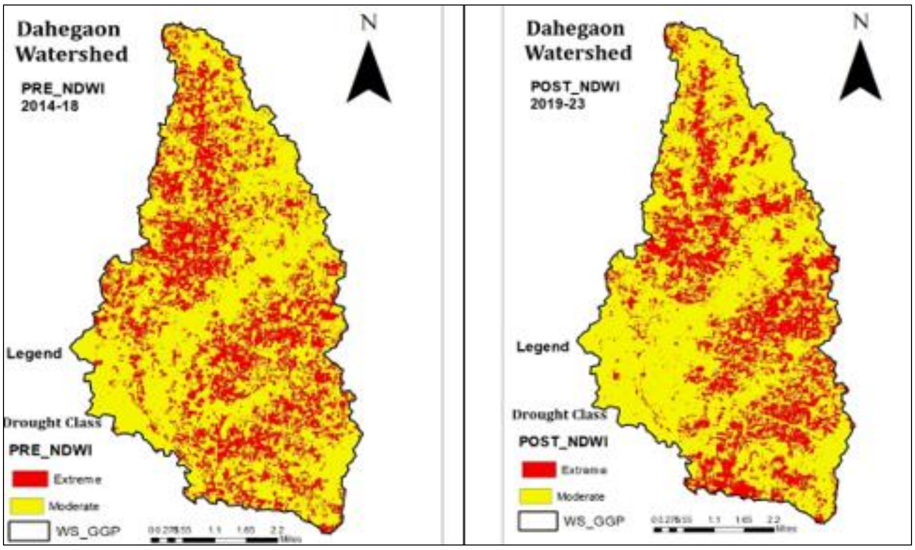

Fig 3: Pre &Post -Watershed Development Period NDWI classes (2014-2023)

NDDI estimation

The Normalized Difference Drought Index (NDDI) was classified into seven classes for 2014 to 2023 on area of 7096 ha. Out of seven classes two were out-of-range values. Drought maps prepared for comparison for pre development period (2014 to 2018) and post development period years (2019 to 2023) are presented in Table 5 & 6.

Table 5: Pre -Watershed Development Period NDDI classes (2014-2018)

Parameters		Years				
Classes	**NDDI Values**	**2014**	**2015**	**2016**	**2017**	**2018**
Waterbody	<- 1	0.18	0.53	0.55	1.56	1.84
No Drought	-1 to +0.2	6.3	7.74	28.19	42.83	21.26
Mild Drought	0.2 to 0.3	102.6	59.38	156.7	301.3	202.4
Moderate Drought	0.3 to 0.4	600.4	209.9	480	728.6	728.8
Severe Drought	0.4 to 0.5	1453	426.4	927.3	1111	1322
Extreme Drought	0.5 to +1	3974	3550	4413	4253	3864
Exceptional Drought	>+1	960.7	2843	1091	659.6	956.2
Total Area		7097	7097	7097	7097	7097

Table 6: Post -Watershed Development Period NDDI classes (2019-2023)

Parameters		Year				
Classes	**NDDI Values**	**2019**	**2020**	**2021**	**2022**	**2023**
Waterbody	<- 1	3.77	4.2	12.44	11.63	5.89
No Drought	-1 to +0.2	17.47	18.18	103	50.5	54.18
Mild Drought	0.2 to 0.3	82.47	115.2	573.8	384.8	613.2
Moderate Drought	0.3 to 0.4	196.1	477.5	1569	1477	1650
Severe Drought	0.4 to 0.5	391.7	1008	1443	1727	1542
Extreme Drought	0.5 to +1	5060	4250	2787	2903	2521
Exceptional Drought	>+1	1346	1224	609.4	542.7	710.6
Total Area		7097	7097	7097	7097	7097

This analysis observed that during Pre-development period (2014 to 2018) the area (ha) under Waterbodies, No drought, mild, moderate, severe and extreme and exceptional drought was different than that of and post development period years (2019 to 2023). The average area under each classes under pre development period spread as Waterbodies 0.93 ha, No drought 21.26 ha, mild drought 164.46 ha, moderate drought 549.52 ha, severe drought 1047.89 ha and extreme drought 4010.81 ha and exceptional drought 1302.08 ha (table 7).

After the development activities of watershed development program the above average classes changes abruptly and they are founds as the average area under each classes under Post development period spread as Waterbodies 7.59ha, No drought 48.67ha, mild drought 353.88ha, moderate drought 1073.99ha, severe drought 1222.30 ha and extreme drought 3504.15ha and exceptional drought 886.22 ha. And over year under each class for each year can be shown in table 7.

This analysis observed that during Pre-development period (2014 to 2018) the area (ha) under Waterbodies, No drought, mild, moderate, severe and extreme and exceptional drought was shows decreasing trends except waterbodies have increasing trends than that of post development period years (2019 to 2023). The Waterbodies increase by 0.094%. The No drought area increases by 0.386%, the mild drought area increases by 2.669%, the moderate drought area increases by 7.390%, the severe drought area increases by 2.458% by the extreme drought area decreases by 7.139% and exceptional drought area decreases by -5.858%. The above area shown in the figures and table below: Hence it was found that extreme drought reduce by up to 7%.

Table 7: Percentage changes in Pre and Post Watershed Development NDDI Area.

Drought Classification	Per development Period area (ha)	Post development Period area (ha)	Percentage Area increases%
Waterbody	0.932	7.586	0.094
No Drought	21.264	48.67	0.386
Mild Drought	164.46	353.884	2.669
Moderate Drought	549.522	1073.994	7.390
Severe Drought	1047.892	1222.302	2.458
Extreme Drought	4010.806	3504.152	-7.139
Exceptional Drought	1302.134	886.422	-5.858
Total Area	7097.01	7097.01	0.000

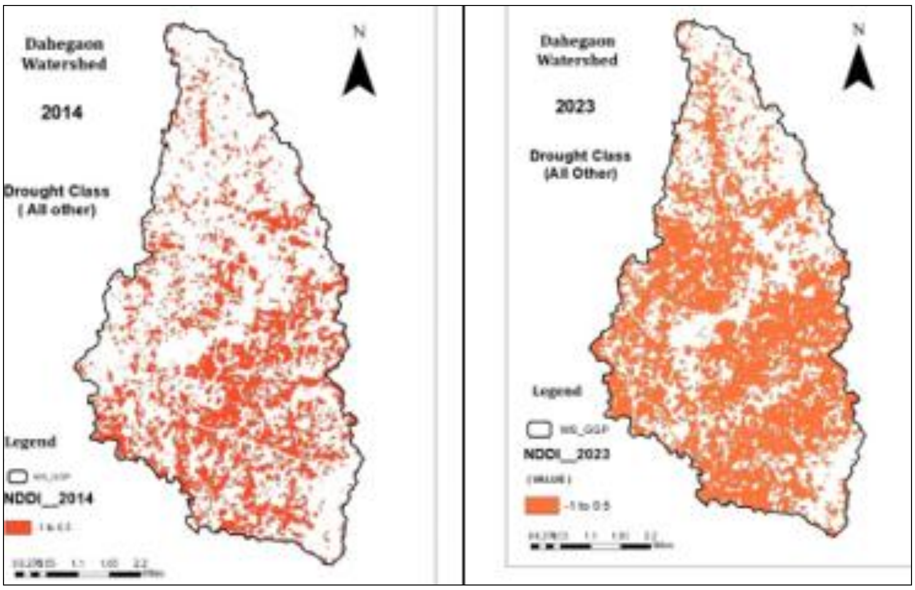

Fig 4: Percentage changes in Drought Classes using NDDI values except Extreme

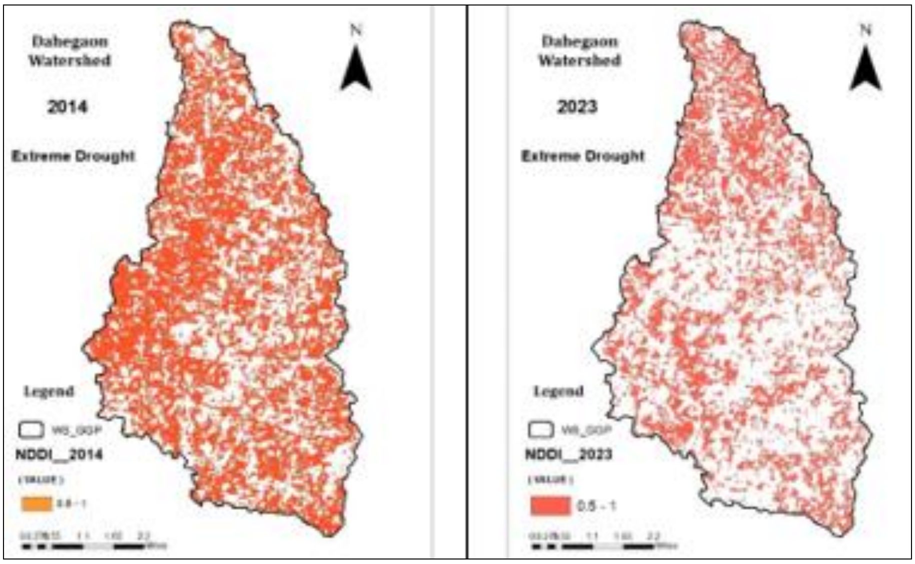

Fig 5: Percentage changes in Extreme Drought Classes using Classes using NDDI values.

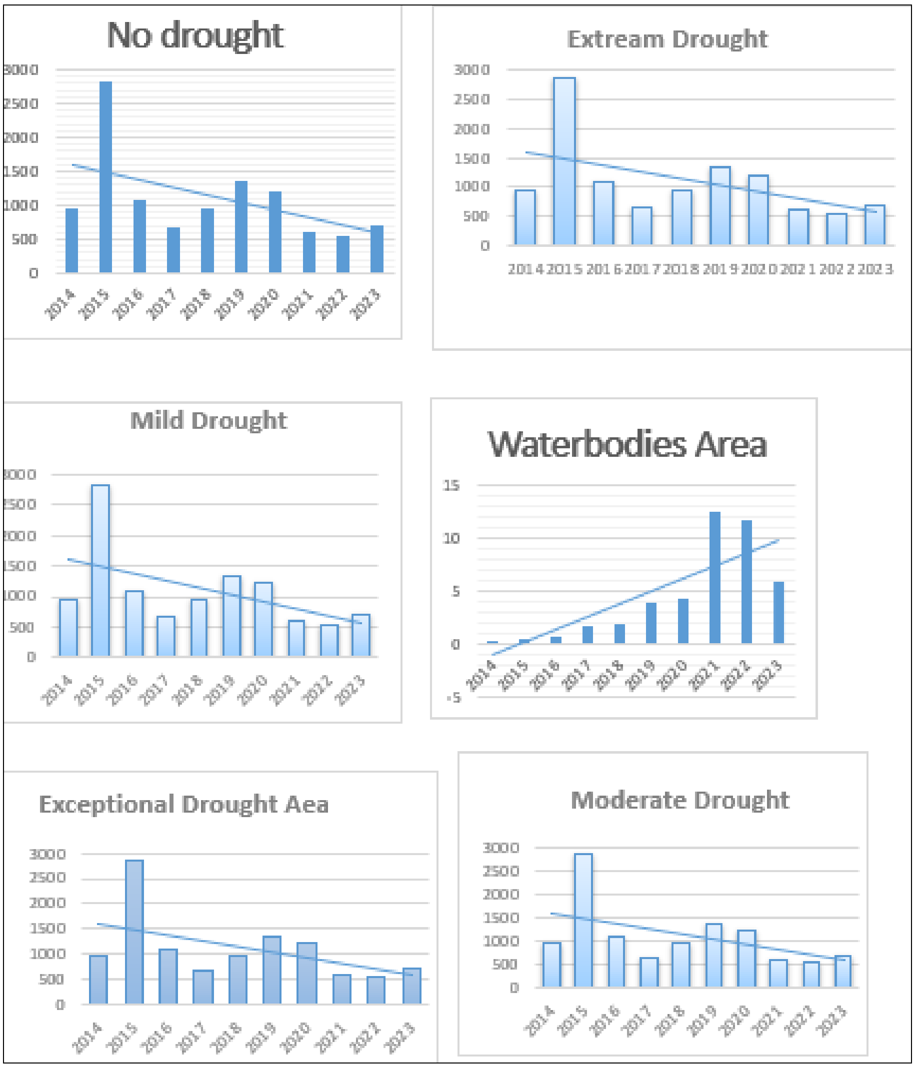

Fig 6: Trend analysis of all drought Classes using NDDI values.

Conclusion

It was concluded that as per NDWI classification Extreme drought reduces to -0.45%. And mild and moderate drought increase's by 0.45%. Hence as per NDWI classification of about 1% area shows positive changes against drought.

As per NDVI classification mild drought reduces by 26% and moderate and other droughts increase's by 26%. Hence as per NDVI classification about 42% area shows positive changes against drought.

As per NDDI classification Extreme drought reduces by 7%.

Exceptional drought reduces by 5%. Mild, Moderate and severe drought increases by about 2.5%, 7% and 2.5% respectively. Hence 34% area shows positive changes against drought as per NDDI classifications.

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