Contrasting Responses of Water Use Efficiency to Drought Stress across Two Different Forest Types of India

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PRESENTED AT:

AGU FALL MEETING
Chicago, IL & Online Everywhere
12–16 December 2022

SCIENCE LEADS THE FUTURE

INTRODUCTION

What exactly is Forest Drought?

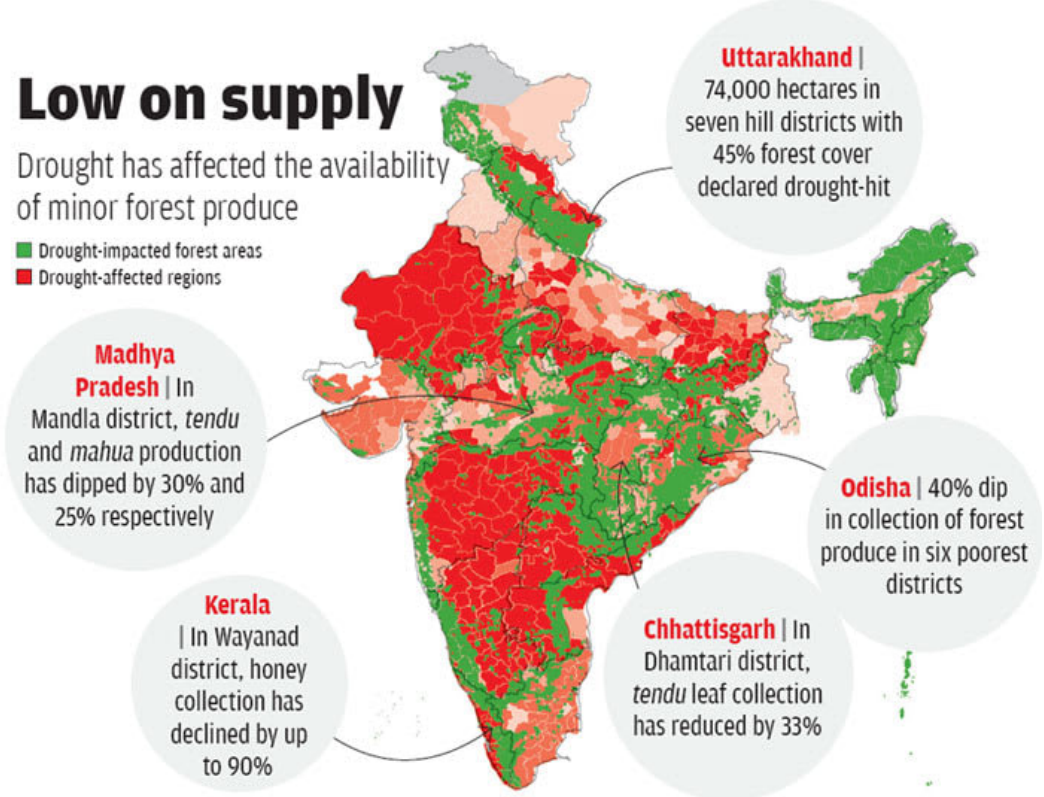
To put it simply, a "drought" is an extended period of below-average precipitation, which has consequences for forest dynamics.

Effects of Forest Drought

- When plants don't have enough water, their stomata usually close to save water and keep their water potential from getting too low.
- Climate change, marked by long spells of drought and extreme rainfall in different parts of the country, has caused substantial impacts on forest ecosystems. This is causing shifts in the **vegetation types, phenology, and reproductive biology of various trees, shrubs, and herbaceous plant species**.
- Extensive drought stress can diminish carbon stores, disrupt hydraulic systems, and even cause death.
- Forest ecosystems are hard to watch for the effects of drought because they are made up of many different species and structures. Different tree species in an ecosystem may have varying physiological responses to drought.
- Severe droughts can cause trees to lose their growth and vitality permanently, which can lead to their death. This can increase the amount of fuel in a forest, which can raise the risk of wildfires.

CONCEPT IN INDIA

According to a report in **"DownToEarth," more than 100 million Indians have seen their way of life affected by prolonged dry spells in the country's forests.**



An Article showing India simply does not acknowledge forest drought (https://www.downtoearth.org.in/news/forests/a-forest-drought-no-one-is-talking-about-54947)

DATA USED

SPI calculation

- **CHIRPS data with 5.5 km resolution from 1981-2020**

Estimated WUE

- **ECOSTRESS data with 70 m Spatial resolution from 2018-2020**

But For comparison only drought stress year (2019) is taken

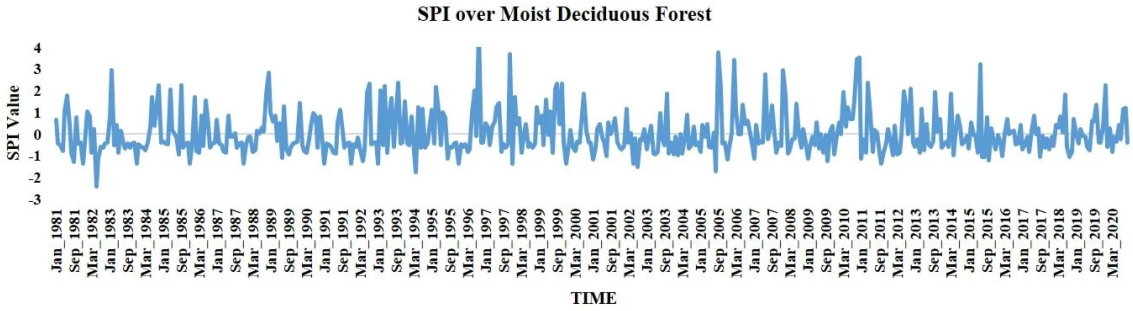
Study Area

Two contrasting forest sites are chosen.

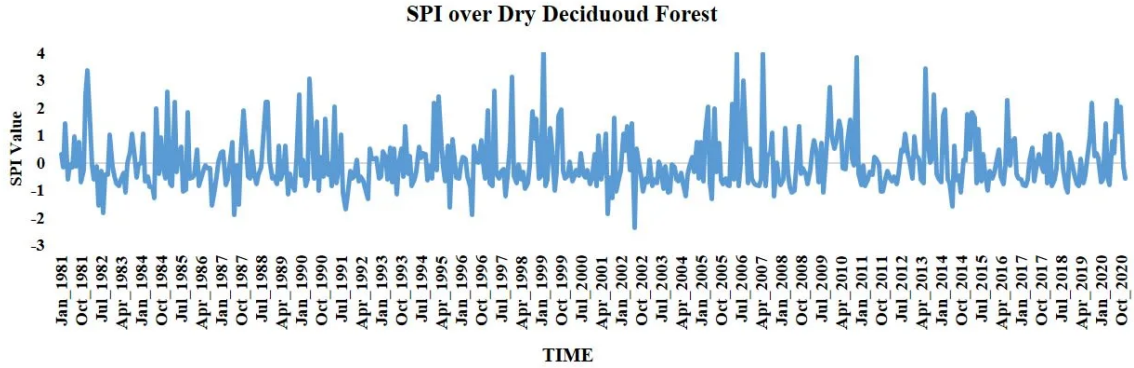
- Moist decisuous forest(MDF) point location from Uttarakhand
- Dry deciduous forest(DDF) point Chattishgarh

RESULT

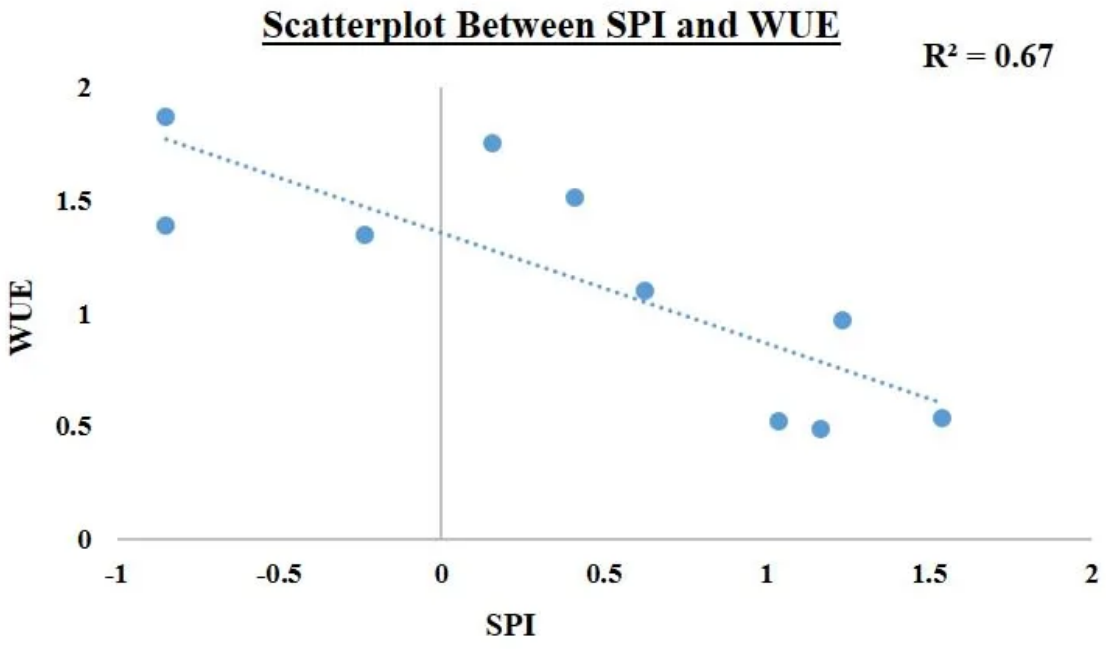
1. Trend of SPI over MDF of Uttarakhand



2. Trend of SPI over DDF of Chatttishgarh

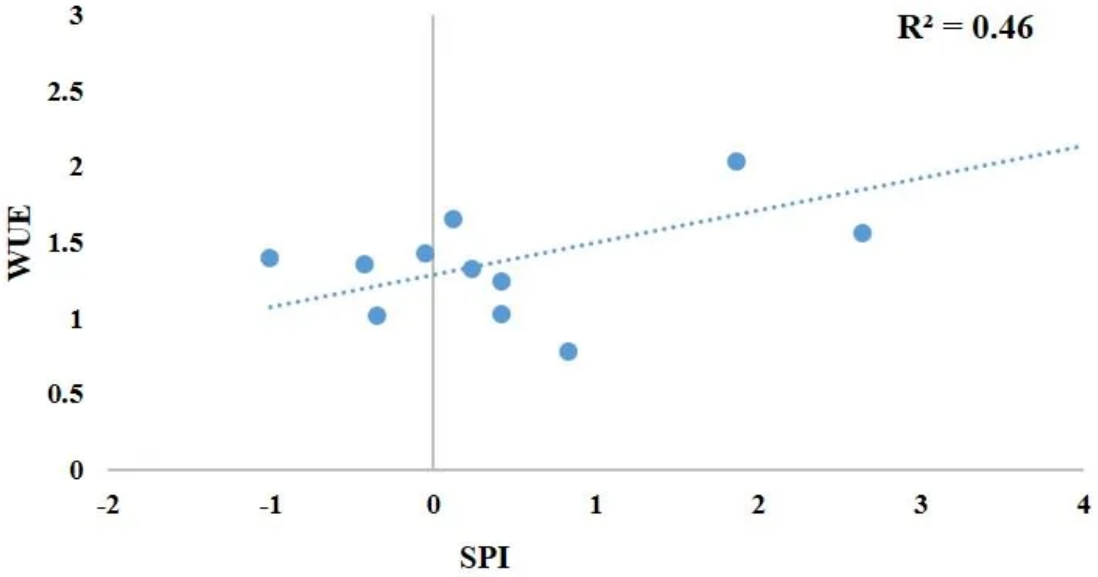


3. Relation Between SPI and WUE over MDF



4. Relation between SPI and WUE over DDF

Scatterplot Between SPI and WUE



FINDING & CONCLUSION

FINDINGS

This study's findings include the identification of dry spells with a negative SPI value and the responses of these two forest types during periods of stress and non-stress. 2019 (February to July) was the most stressful period for DDF, with a -2.03 SPI value, while 2019 (March to October) and 2020 (April to December) were the most stressful periods for MDF, with a -1.32 SPI value. During drought stress, the WUE in MDF ranges from 1.79 to 2.95 gC Kg^{-1} H_2O, whereas it ranges from 0.93 to 1.89 gC Kg^{-1} H_2O in DDF. In moist and dry deciduous forests, a significant positive correlation with a coefficient of determination (R^2 =0.67) and a modest positive correlation (R^2 =0.46) was detected between SPI & WUE, respectively.

CONCLUSION

DDF has already gotten used to living in a dry climate and has increased its ability to handle the stress of drought. This suggests that GPP is not too sensitive to drought. Because they don't have enough leaves, which change the evapotranspiration (ET) rate, these plants can't use more water properly during wet years. In most instances, excessive water on soil leads to soil evaporation. ET's sensitivity is mostly responsible for the weakly positive correlation between WUE and SPI. In contrast, the GPP of MDF responds swiftly to changes in water availability. Plants with deeper roots survive drought stress substantially better. The ET dominates the WUE in DDF, but the GPP dominates the WUE in MDF, according to the results of these investigations. In addition to these factors, the amount of nutrients, the strength of the sun's rays, and the speed of the wind all have a big impact on this phenomenon.

AUTHOR INFORMATION

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ABSTRACT

Forest drought is an intermittent perturbation of the hydrological cycle that has a substantial effect on the forest ecosystem's **water use efficiency(WUE).** This study is limited to two distinct forest types in India, namely moist deciduous forest(MDF) of Uttarakhand & dry deciduous forest(DDF) of Chhattisgarh. Daily CHIRPS data were employed to predict the drought stress to evaluate the **Standardized Precipitation Index (SPI)**from 1981-2020. The WUE data were collected from **ECOSTRESS L4 WUE**, which was already calculated at a daily time-step and has been taken for the study area for the period of 2018 to 2020.

This study's findings include the dry spell identification with a negative SPI value and the response of these two forest types during periods of stress and non-stress. 2019 (February to July) was the stress period for DDF with a highest -2.03 SPI value, whereas 2019 (March-October) and 2020 (April-December) was the stress season for MDF with SPI value of highest -1.32. During drought stress, the WUE in MDF ranges from 1.79 to 2.95 gC Kg^{-1} H_2O, whereas it ranges from 0.93 to 1.89 gC Kg^{-1} H_2O in DDF. In moist and dry deciduous forests, a significant positive correlation with a coefficient of determination (R^2 =0.67) and a modest positive correlation (R^2 =0.46) was detected between SPI & WUE, respectively.

DDF is already acclimated to a dry climate and has increased drought stress resistance, suggesting drought susceptibility of GPP is relatively low. In addition, these plants cannot successfully utilize additional water during wet years due to their poor leaf coverage, which changes the evapotranspiration (ET) rate. Excessive water on soil leads to bare soil evaporation in most cases. The slight positive association between WUE and SPI is primarily due to the sensitivity of ET. In contrast, the primary productivity (GPP) of MDF responds rapidly to changes in water availability. During drought stress, plants with deeper roots endure significantly better. Based on these studies, this is concluded that the ET dominates the WUE in DDF, whereas the GPP dominates the WUE in MDF. In addition to these factors, the nutrients availability, the solar radiation intensity, and the wind velocity all play a significant role in this phenomenon.