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Detecting Agricultural Drought-Prone Areas Over Marathwada Region by Using Soil Moisture Index

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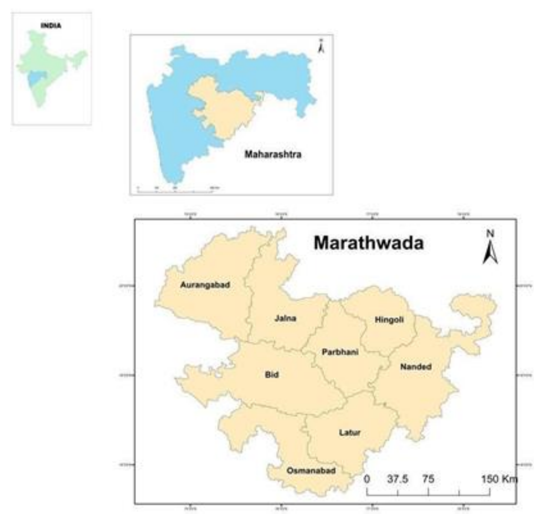
Abstract ***Drought is a prolonged period of abnormally low precipitation that results in a water shortage, significantly impacting the environment, agriculture, economies, and communities. The middle part of Maharashtra that is (Marathwada), India has been facing critical conditions due to the droughts from last few years. The condition is occurs due to irregular mansoon and uneven rainfall. As climate change continues to alter weather patterns, proactive measures, such as improved water conservation techniques, sustainable land management practices, and resilient agricultural systems, will be essential in addressing the challenges posed by drought. Drought severity refers to the intensity and impact of drought conditions in a specific region over time. It is assessed using various indicators and classification systems that quantify how severe a drought is based on environmental, agricultural, hydrological, and socioeconomic factors. The present study of drought is mainly focuses on the methodology of Normalized difference vegetation index (NDVI), Land surface tempreture (LST) and Soil moisture index (SMI). By using various surface and metrological parameters and past 30 years of weather data, these value has been concluded and maps generated by using QGIS software. Calculations are also done by using QGIS.***

I. INTRODUCTION

Drought is natural phenomenon that can be occur in any part of the world, but its severity and frequency are influenced by various climatic, geographical, and human factors. Droughts can manifest in different forms, including meteorological drought, agricultural drought, hydrological drought, and socioeconomic drought, The impacts of drought can be devastating, leading to crop failures, food insecurity, loss of livestock, water shortages for drinking and sanitation, and economic losses in agriculture and related industries. The causes of drought are multifaceted, encompassing natural climatic variability, such as changes in atmospheric circulation patterns and phenomena like human-induced factors like climate change, deforestation, and unsustainable water management practices. As global temperatures will rise and weather patterns become increasingly unpredictable, the frequency and intensity of droughts are projected to increase, posing significant challenges for water resources management and food security. Addressing drought requires a comprehensive understanding of its causes and effects, as well as proactive measures for mitigation and adaptation. By fostering a greater awareness of drought and its implications, communities can better prepare for and respond to this critical environmental challenge.



Study area Marathwada Region

II. LITERATURE

The study on the Soil moisture index for the marathwada region in Maharashtra, India offers a comprehensive approach to assessing and responding to drought condition. To analyzed the soil moisture index TOA (top of atmosphere), BT (brightness temperature), NDVI (normalized difference vegetation index), PV (proportion of vegetation), E (emissivity) these are vital parameter. The data from USGS, Google Earth can be imported to QGIS software to making it extremely user friendly. Soil moisture index spanning from 2013 to 2015. This highlights urgent need for effective drought management strategies and adaptation measures to safeguard agricultural productivity and livelihoods in the region Overall, this study contributes to knowledge and understanding of drought in the central part of Maharashtra, India, and provides valuable insights for policymakers and stakeholders in implementing strategies to mitigate the impacts of drought on agriculture, economy, society, and the environment.

III. APPROACH METHODOLOGY

To measured the Soil moisture index following steps are involved:

- Normalised Difference Vegetation Index (NDVI): NDVI effectively captures the presence and health of green vegetation. Higher NDVI values (ranging 0.2 to 0.9) indicate denser and the healthier vegetation, while lower values to suggest sparse or the stressed vegetation. NDVI helps mitigate some atmospheric effects since it uses both visible (RED) and near-infrared (NIR) bands

NDVI is derived as under:

NDVI = (NIR-Red) / (NIR +Red)

- Proportion of Vegetation: The proportion of vegetation is a vital metric for understanding ecological health, guiding conservation efforts, and managing natural resources. By employing a combination of remote sensing techniques and ground-based assessments, researchers and land managers can gain valuable insights into the state of vegetation in any given area.

Proportion of vegetation was calculated from NDVI, using the following formula:

$$PV = \left(\frac{(NDVI\ - NDVImin)}{(NDVImax\ - NDVImin)}\right)2$$

- Estimation of land surface emissivity. To calculate Land Surface Emissivity (LSE) using the proportion of vegetation, you can employ the following general approach based on the NDVI method. Here’s a step-by-step outline and an example equation you might use in a raster calculator: Calculate LSE: Use the modified NDVI method (NDVITHM) to estimate Land Surface Emissivity based on the proportion of vegetation.

$$\boldsymbol{E} = (\mathbf{0.004} * \boldsymbol{PV}) + 0.\mathbf{98}6$$

- Land Surface Temperature: It is indeed a critical parameter in understanding the interactions between the surface of Earth and the atmosphere, as well as the broader implications for climate and ecosystems. Here’s a more detailed exploration of its significance Energy Partitioning: LST plays a vital role in energy partitioning at the land surface-atmosphere interface. Surface Energy and Water Balances: LST is integral to understanding surface energy and water balances. It provides insights into hydrological cycles, including precipitation, evaporation, and runoff, which are crucial for managing water resources.

LST is derived under:

$$LST = \frac{BT}{\left\{1 + \left[\frac{\lambda * BT}{C2} * \ln(E)\right]\right\}}$$

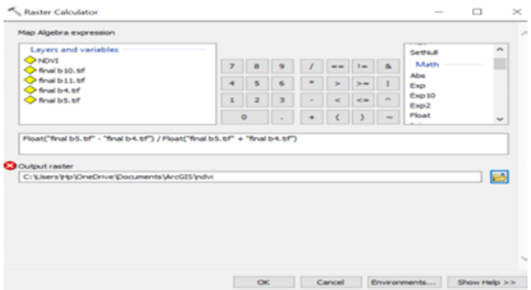
- Soil Moisture Index: It seems like you're discussing the Soil Moisture Index (SMI) and its calculation based on NDVI and LST. To continue from where you left off, the equation for calculating the SMI is typically presented in a form that relates these two indices. While you didn't provide the specific equation (Eq. 1), a common form might look something like this:

SMI = f(NDVI, LST)

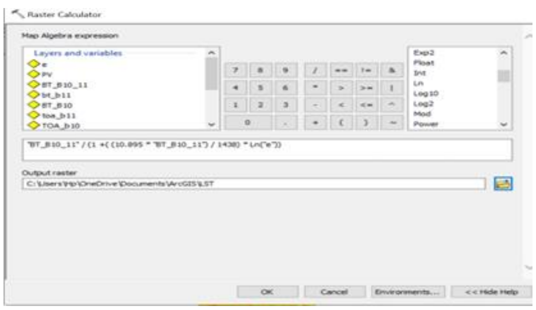
The relationship between LST and NDVI is often modeled empirically, as they both provide insights into vegetation health and soil moisture conditions. The SMI can be calculated using various empirical formulas or regression models that have been developed based on observed data. In your case, since you mentioned the MTRI (Michigan Tech Research Institute) method for presenting SMI values ranging from 0 to 1, you could summarize that the SMI is derived from the interaction of NDVI and LST, with higher values indicating better soil moisture conditions.

$$SMI = \frac{(LSTmax\ - LST)}{(LSTmax\ - LSTmin)}$$

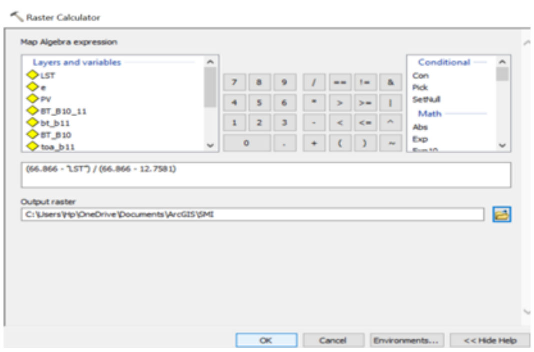
- Calculations of NDVI, LST & SMI in QGIS software as shown in below:



NDVI Calculation



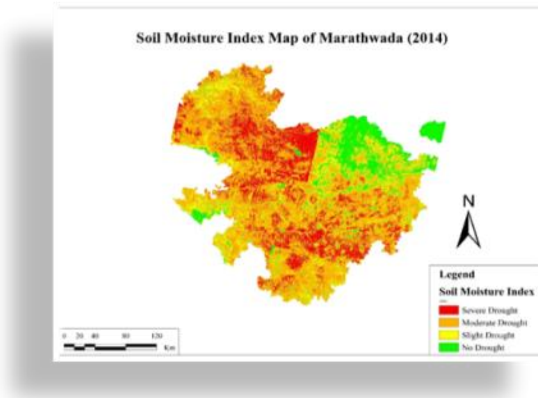
LST Calculation



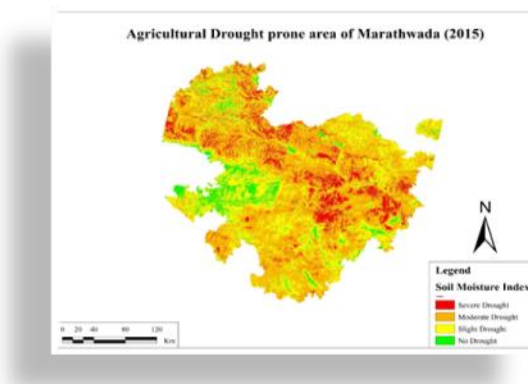
SMI Calculation

IV. RESULTS

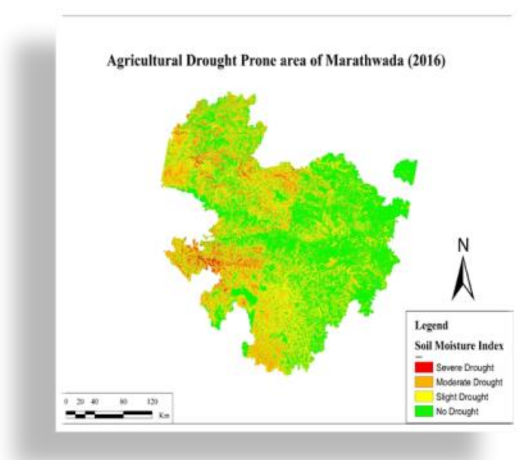
From the research it is clear that drought is like a creeping phenomenon that varies from place to place and also by amount of precipitation. A single value of precipitation cannot be used to predict the severity at different place within the regionit can be seen that if the rainfall is 850 mm in Aurangabad region, then kannad, khultabad and phulambri taluka's will be most affected by drought, while aurangabad, sillod and soegaon will have severe dryness in their place, ganagapur taluka will have moderate dryness and there will be normal conditions for paithan and vaijapur taluka'sHence there is a limit for severity of drought that will characterise it into various levels of dryness. So one should only depend on the amount of precipitation that falls into their area or place, not on the amount of precipitation of the entire region. Soil moisture index of Marathwada for the period of 2014 to 2016 is shown below with the help of map.



SMI map of Marathwada (2014)



SMI map of Marathwada (2015)



SMI map of Marathwada (2016)

CONCLUSION

In this project, NDVI, LST and SMI was calculated using optical and thermal remote sensing from Landsat 8 satellite images. By using SMI agricultural drought prone area is classified over the Marathwada region The execution of the software QGIS - Raster Calculator is also studied and used to full extent.

By this study, we can say that in year 2014 and 2015 almost 90% area of Marathwada region was under drought condition.

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Further These results will be used for drought forecasting or prediction.

We also estimate the accuracy of this method by estimating from other field methods.

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It can be assumed that some major problems with drought can occur in the future, that can cause major effects on human environments and at the ecosystems, which will result to severe water scarcity problems.

Hence development of strategic water management and preparedness plans is a need in regions like marathwada in order to overcome the increased shortage risk.

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