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A Study on Temporal and Spatial Variation of Soil Moisture

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Abstract:

Weather and climate, runoff potential and flood control, soil erosion and slope failure, reservoir management, geotechnical engineering, and water quality are all areas where soil moisture information is useful to government organizations and private organizations. Soil moisture is a key variable in controlling the exchange of water and heat energy between the land surface and the atmosphere through evaporation and plant transpiration.

The goal of the research is to identify serially independent series, all time series should be subjected to a serial correlation test. To identify the trend change points in the time series, distribution free cumulative sum test and sequential Mann-Kendall tests are to be applied. The study results benefits water resource management, drought mitigation, socio-economic development, and sustainable agricultural planning in the region.

Keywords —Soil moisture, ecosystem, irrigation.

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1. INTRODUCTION

The amount of water in the soil is defined as its moisture content. Water content is expressed as a ratio that can range from 0 (completely dry) to the value of the material's porosity at saturation. Soil moisture status is critical for climate change research and conducting soil water balances.

This soil moisture may be present as adsorbed moisture at internal surfaces and as capillary condensed water in small pores. At low relative humidity's, moisture consists mainly of adsorbed water. At higher relative humidity's, liquid water becomes more and more important, depending on the pore size

1.1 General

In soil science, hydrology and agricultural sciences, water content has an important role for groundwater recharge, agriculture and soil chemistry. Plants can readily absorb soil water. Not all the water, held in soil, is available to plants. Much of water remains in the soil as a thin film. On the otherhand soil water dissolves salts and makes up the soil solution, which is important as medium for supply of nutrients to growing plants.Soil moisture data is required for parameterizing numerical models that are used to calculate evapo-transpiration and deep percolation for groundwater impact studies. Variations in soil texture, topography, crop cover, irrigation techniques, and groundwater level depth cause spatial and temporal variability in soil moisture.

1.2 The importance of soil moisture:

- Soil water acts as a nutrient itself.
- Soil water regulates soil temperature.
- Soil forming processes and weathering depend on water.
- Microorganisms require water for their metabolic activities.

• Soil water helps in chemical and biological activities of soil.
• It is a principal constituent of the growing plant.
• Water is essential for photosynthesis.

The characterisation of the temporal and geographical variability of soil moisture is critical for understanding the hydrological process. Solute transport in water and chemical leaching into ground water The spatial variability of soil moisture aids in the mapping of soil parameters throughout the field as well as the variety of irrigation requirements**.** While temporal variability of water content and infiltration aids in irrigation management, temporal correlation structure aids in anticipating future irrigation. The goal of this study was to look at the spatiotemporal variability of surface soil water content (10-40cm).
We evaluated pre-monsoon, monsoon and post-monsoon. soil moisture variability from 2001-2020 year. The goal of the study was to map layer-wise soil moisture up to 40 cm depth which is useful for irrigation planning. The results indicated that soil moisture content changed temporally and spatially with soil texture and profile depth significantly.

H.SHAHANDEH ET AL (2005) The spatial variability of soil properties that affect the soil nitrogen budget and com grain yield was studied for 2 years in south-central texas to better access the potential for variable-rate nitrogen fertilization. **PRIGENT ET AL (2005):** A systematic and integrated analysis of the sensitivity of the available satellite observations to in situ soil moisture measurements. First, this analysis helps identify and separate the physical mechanisms that affect the satellite observations. Second, this analysis enables an objective comparison of the relative potential of the various satellite observations for soil moisture retrieval when other conditions are held constant. **KRISTINE M. LARSON ET AL (2008) :** They studied about how a GPS receiver collocated with in situ soil moisture sensors shows excellent agreement in measuring near-surface volumetric water content variations.**C.J.WILLIAMS ET AL (2009):** In this study assess the controls on spatial and temporal near surface soil moisture variability in a small ($0.02cm^2$) Semi -arid mountanious catchment by evoluting the spatial correlations between soil moisture and numerous site characteristics throughout the water year. **VENKATESH B ET AL (2011):** An experimental study was carried out to understand spatiotemporal variability of soil moisture under different land covers (acacia ,degraded forest, forest) in watersheds located in the Western Ghats mountain ranges of Karnataka State, India**.** The results showed that the seasonal and annual drought are frequent in the study area. There are spatial and temporal variations in the drought years and their severity.**VENKAT LAKSHMI (2013):** Study on active and passive microwave remote sensing provides a unique capability to obtain observations of soil moisture at global and regional scales. This paper presents a comprehensive review of the progress in remote sensing of soil moisture, with focus on technique approaches for soil moisture estimation from optical, thermal, passive microwave, and active microwave measurements**. VIMAL MISHRA AND REEPAL SHAH (2014) :** This paper studied the changes in precipitation, air temperature, and model-simulated soil moisture were examined for the observed (1950–2008) and projected (2010–99) climate for the sowing period of Kharif and Rabi [KHARIF_SOW (May–July) and RABI_SOW (October–December)] and the entire Kharif and Rabi [KHARIF (May–October) and RABI (October–April)] crop-growing periods in India. **STEPHANIE N KIVLIN ET AL (2016)** This journal mainly focused on a randomized block design captured spatial variation and sampled at four dates across 2 years to assess temporal variation will facilitate prediction of how tropical soil microbes will respond to future environment change.**PRABHAVATI K ET AL (2017):** A study was carried out to determine the extent of different land degradation types in Belgaum district on 1: 50,000 scale using remote sensing and GIS techniques. Out of 13,44,084.60 ha of total geographical area of Belgaum district, 3,96,059.5 ha land is degraded accounting for 29.47 per cent. Three micro-watersheds were selected one each from Northern dry zone (Yadawad), Northern transitional zone (Hukkeri) and Hilly zone (Khanapur) for

characterization, soil fertility mapping and soil loss risk assessment. **ASWATHI P. V ET AL (2018):** This paper mainly studied on agricultural and meteorological drought in Maharashtra state using traditional as well as remote sensing methods . The meteorological drought assessment and characterization is done using two standardmeteorological drought indices viz. standard precipitation index (SPI) and effective drought index (EDI).**KENDRA E.KAISER ET AL (2018) :** This journal is mainly based on topographic redistribution of water has been representation various terrain metrics.**ANURADHA HADGILA ET AL (2019) :** The paper describes the detailed analysis of a volume-based soil moisture sensor. The probes used for sensing are made of iron with an alloy coating which is an anti-corrosive and robust material for sensing the moisture content in the field.**HONGBIN LIU AND SHUNTING LI AND YUEPENG ZHOU (2019) :** This journal is based on the study of North east China region, this mainly focus on the discussion on soil physical properties and the spatial variation of soil salinity**. KISHORE PANGALURU ET AL (2019):** This study explored the spatial distribution, characteristics, and temporal variability of soil moisture on monthly, seasonal, and annual temporal scales using AMSR and SMAP satellite observations.**SREEKESH S ET AL (2019) :** The study assessed the severity of meteorological droughts and their manifestation on the agriculture and soil moisture in a semi-arid area. The study has been carried out for the Malaprabha sub-basin which partly covers three districts of North Interior Karnataka, India.The objective of the present study is to Investigate the long-term temporal variation of soil moisture and to evaluate change point in soil moisture time series.

2. STUDY AREA

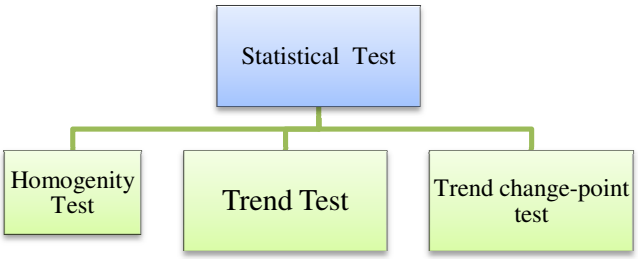
Soil moisture levels differ dramatically from one place to the next. As a result, presenting soil moisture variance per area or district is impracticable. Therefore the analysis was made easy by classifying and selecting the districts which is considered as a representative of the particular geographical region in Karnataka, based on the similarities in the soil moisture pattern, soil moisture fluctuations by considering for a long term (more than 10 years).

Our study is mainly focused to three districts in Karnataka i.e

1. Kalburgi district
2. Chikmagaluru district
3. Mysore district

Fig -1 : Study area

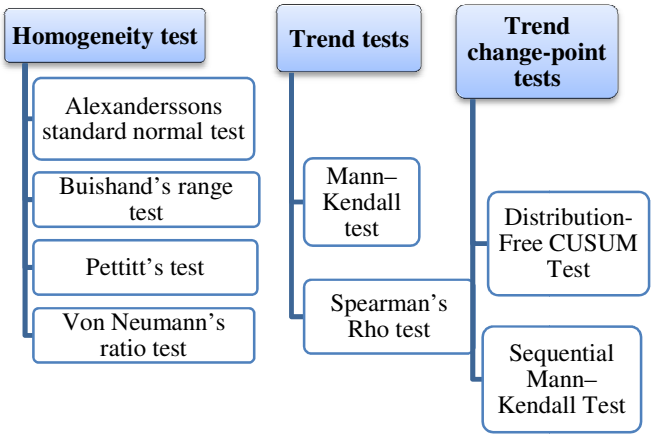
3. METHADOLOGY :



Following careful quality checks and preparation, several statistical tests were run to examine the homogeneity, trends, and trend change points in the time series data.

The following are the steps of data analysis in order:

- Homogeneity test.
- Trend test.
- Trend change-point test.



3.1.Homogeneity test

Homogeneity testing is essential in climatological research to accurately depict weather and climate fluctuations. Inhomogeneity arises in climate data for a variety of causes, including equipment error, changes in nearby sections of the sensor, and human error. To test for homogeneity, the data was subjected to four commonly used statistical tests, which are listed below.

All of the following four tests use in this study assume the null hypothesis of data being homogenious.

- Alexanderssons's standard test
- Buishand's range test
- Pettitt's test
- Von Neumann's ratio test

3.2. Trend Tests Trends tests are used to find significant positive or negative trends in time series data. The null hypothesis is that there is no trend, and the alternative hypothesis is that there is a monotonic growing or declining trend. The Mann-Kendall test and the spearman's Rho test were used to look for patterns when the time series were serially independent. These two tests are commonly used in the literature and are quite effective in finding trends.

3.3. Trend change point Test

Identifying trends and determining the timing of trend change are important aspects of hydroclimatic trend analysis. Without providing the time of trend shift, any trend detection research is incomplete. Unfortunately, no previous research in the area have shown the onset of substantial rainfall patterns.

4. RESULITS & DISCUSSIONS

Continuous data records of soil moisture for pre-monsoon, monsoon and post-monsoon are very important for land surface processes and their management. The difference in soil moisture values during Pre-monsoon and Post-monsoon will represent the effects of precipitation, temperature, and other soil moisture variables. Prior to MK test, serial correlation of soil moisture levels was calculated for Mysore district. The results obtained from the Mann-Kendall test was used to establish the trends in time series of pre-monsoon(March-may),Monsoon(June-September) and Post-monsoon (October-december) . The obtained from analysis of time series data using both GLADS and Copernicus were used to know the spatial and temporal variation in soil moisture records.

The rainfall patterns during the pre-monsoon and post-monsoon seasons show similar spatial distribution with different magnitudes. Therefore, understanding the soil moisture in the spatial and temporal scales with respect to rainfall in the study area will also influence the analysis in this study.
During the summer monsoon season, the maximum soil moisture is found in the western coastal regions and central parts of the Indian subcontinent. Over these regions, the soil moisture is more than 0.4 m3 m-3. The northwest regions show minimum amount of soil moisture (\0.1 m3 m-3).

During the post-monsoon season, soil moisture maximum is in the southeast and northeast regions and it is coherent with the areas of increased rainfall, except in north/northwest India.

The soil moisture is more prominent during the southwest monsoon season and less during the pre - monsoon season showing similar seasonal pattern of the rainfall.

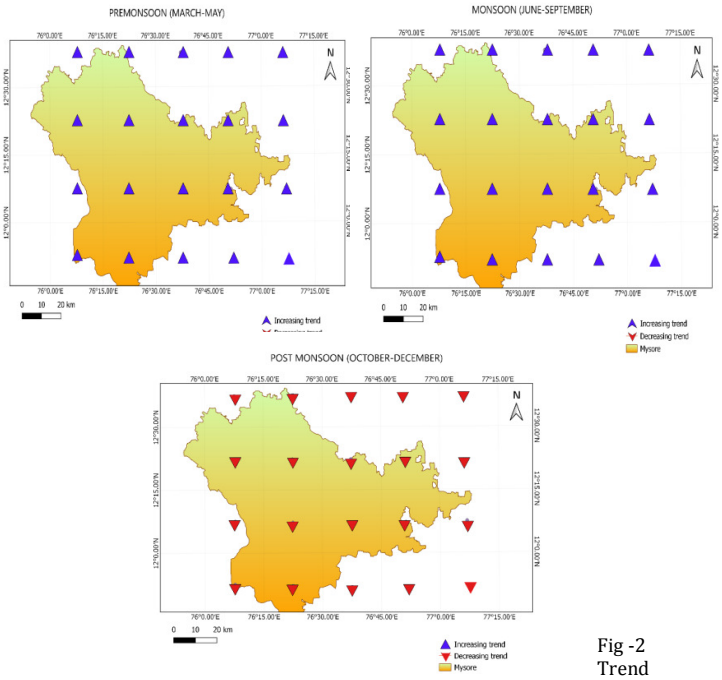


Fig -2 Trend pattern for Mysore

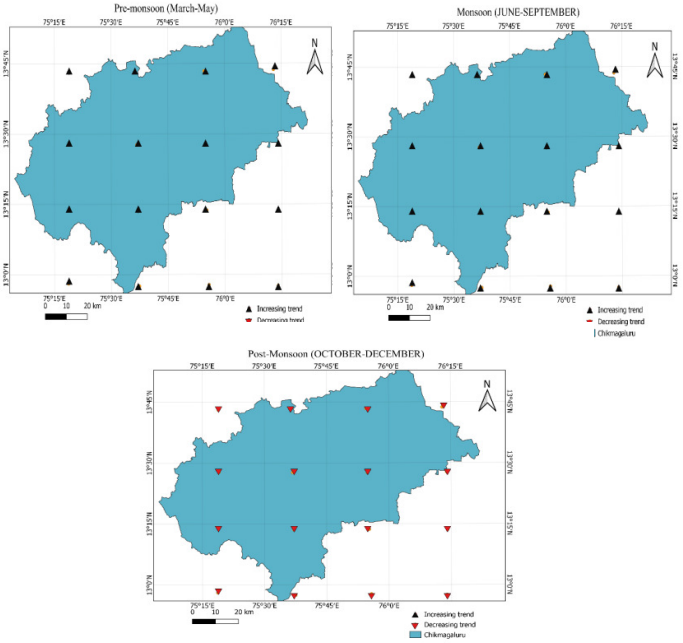


Fig -3 Trend pattern for Chikmagaluru

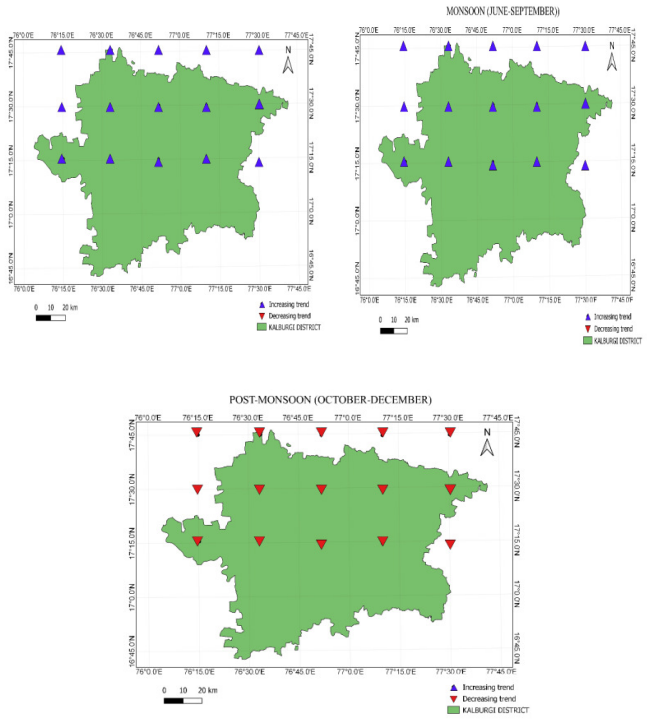


Fig -4 Trend pattern for Kalburgi

Trend analysis and change point detection in a time series are frequent analysis tools. Change point detection is the identification of abrupt variation in the process behavior due to distributional or structural changes, whereas trend can be defined as estimation of gradual departure from past norms. We found that different methods often give different numbers and locations of change points. A change point can be defined as unexpected, structural, changes in time series data properties such as the mean or variance. Many change point detection algorithms have been proposed for single and multiple changes.

5. CONCLUSIONS :

This study explored about the spatial distribution, characteristics , spatial and temporal variability of soil moisture on monthly, seasonal temporal scales using GLADs and Copernicus satellite observations.

In addition, the trend of the soil moisture data were estimated by using Mann-Kendal trend test with 95% confidence level for seasonal (pre-monsoon, Monsoon, post-monsoon) time frames and significance was tested using a p-value of 0.05 . All the analyses are done with R (R core Team 2020).

In this study the trends indicate the increase or decrease of soil moisture in districts belong to three different geographical region of Karnataka, which are very much essential for a better understanding the agricultural yields. The seasonal trends were computed for a grid cell (0.25□ x 0.25□) for period May 2000-November2020. it is important to mention here that the positive trends are obtained for most of the region on seasonal scale (pre-monsoon and monsoon). On the other hand the regions exhibit negative trends during post monsoon. The outcomes acquired in this analysis proved evidence of significant or all increase in soil moisture content throughout the study area. Positive trend in soil moisture indicate the favorability for irrigation. However, some regions show soil trend, which are likely more useful for single cropping. Understanding the variability and changes in the soil moisture under retrospective and projected climate in the key crop-growing seasons is of utmost importance.

These soil moisture satellite measurements provide valuable insights into the spatial and temporal characteristics of soil moisture. High-resolution datasets of soil moisture are crucial for a better understanding of the future across various regions of Karnataka. Long-term observations of regional characteristics are beneficial for a better understanding of crop cultivation and agricultural yield, and ultimately boosting the economy of the country.

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