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NOTABLE NOVEMBER- GEOGRAPHICAL BEHAVIOUR OF 2015 AND 2021 FLOODING IN TAMIL NADU (INDIA)

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ABSTRACT

The unprecedented monsoonal rainfall of 2021 and subsequent flooding in Tamil Nadu has initiated a reminiscence of a similar abnormal event of 2015. The month of November observed the maximum input of rainfall during both years. The unprecedented rainfall and flooding have sparked debates ranging from climate change to urbanization. The current study is a spatial examination of rainfall in the state for November of 2015 and 2021. It also tends to observe this rainfall behavior in the backdrop of existing and altering land uses. It has been observed that this unprecedented rainfall exhibited a correlation with urbanization with a geographical concentration of the phenomena in the coastal, northeastern part of the statein both years. Such a regional level analysis can help identify vulnerability in the light of climate change and extreme event concerns.

KEYWORDS: *Tamil Nadu, Monsoon, Rainfall, Land Use, CHIRPS, Urban.*

INTRODUCTION

The Indian rainfall season is majorly the monsoon season and is a major rainfall system in itself (Krishnamurti, 2015). It can be further divided into the South West Monsoon (SWM) from June to September (Centre, 2021) and North East Monsoon (NEM) from October to December (Centre, 2021). India receives maximum (Krishnamurti, 2015), around an average of 75% of its rainfall during the southwest monsoon season which ranges from June to September (Desk, 2021b.). During this period, the central and western parts of the country receive more than 90% of their annual rainfall (Halpert & Bell, 1996). The NEM is the main cyclone season for the North Indian Ocean basin and the primary rainfall season for the Tamil Nadu subdivision (Centre, 2021). India's southwestern tip intercepts the first monsoonal rains in May (Centre, 2021). NEM is mainly confined to the meteorological sub-divisions of Tamil Nadu, Puducherry, and Karaikal (TN); Coastal Andhra Pradesh and Yanam, Rayalseema, Kerala and Mahe, and South Interior Karnataka during October and December on the windward side (Centre, 2021). Tamil Nadu state is located on the leeward side of the Western Ghats (Centre, 2021).

The current study focusses on the exceptionally high rainfall and flooding experienced by the state of Tamil Nadu in the years of 2015 (DHNS, 2015; NDMA; Desk, 2017) and recent, 2021 (Kuchi, 2021; Nath, 2021); and for both the years the month of November has been exceptionally notable, recording this excessive rainfall (PTI, 2015 a.; Lakshmi, 2015; NDMA;

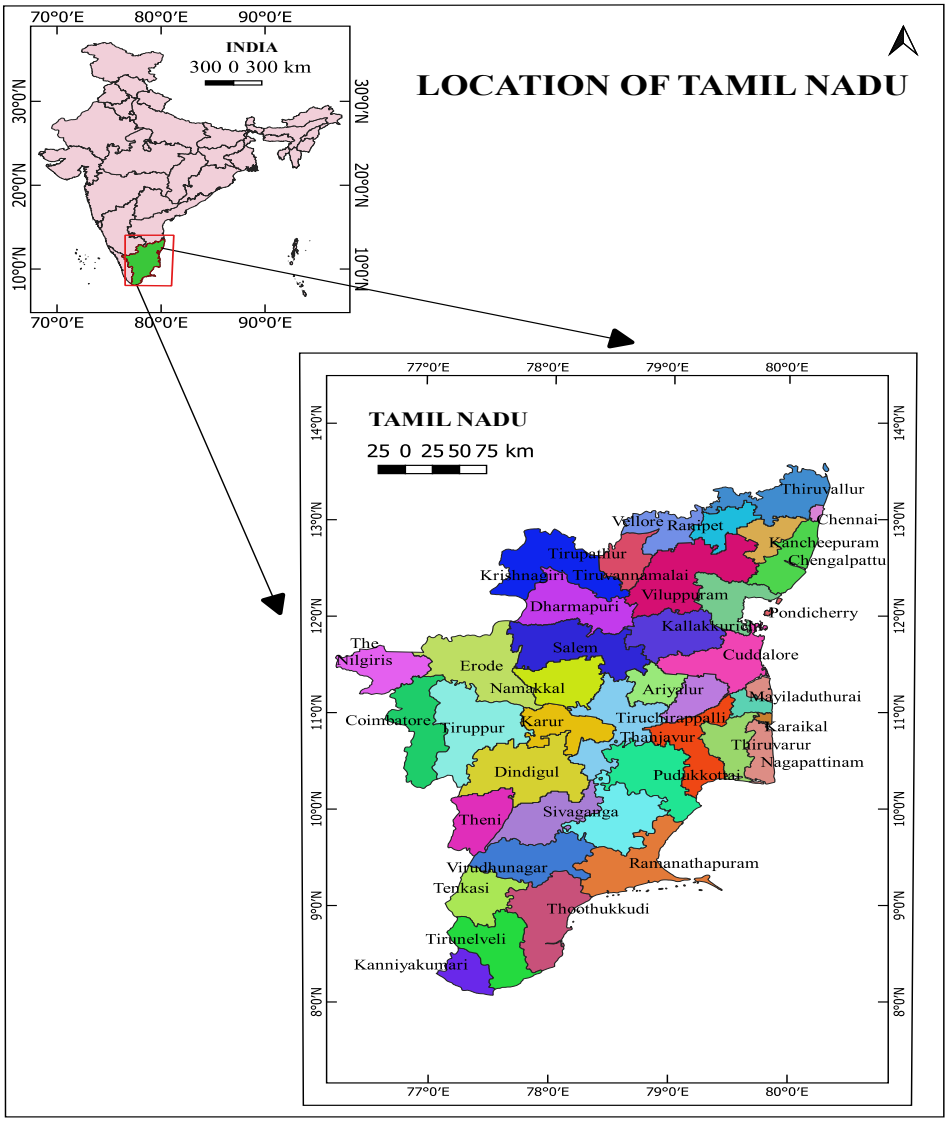
Desk, 2021a. ; Nath, 2021). In both the years, there was a loss of life and property as well (NDMA, n.d.; PTI, 2018; Krishna, 2021; Koushik and Sriram, 2021; Nath, 2021) causing massive large scale destruction (Bureau, 2015; Janardhaan, 2015; Janardhan, 2016; PTI, 2015 b.; Sathyanarayana, 2015; Vishu & Sridharan, 2016). The Chennai flash floods were ranked amongst the topmost disasters of the year for Asia with one-day rainfall nearing a month's average (Express, 2015).

In 2021, NEM was very excessive with 68% more rain than normally received from 1st October to 11th December (Team, 2021). The intensification of low-pressure systems during NEM was attributed to this immense rainfall (Centre, 2021; Desk, 2021b.; Network, 2021; Now, 2021). The reasons for the devastating impact of this rainfall have been attributed to numerous human activities in the state (Cann,2021; Davies, 2021; Gautham, 2021; Pielke, et al., 2007; Sahu, 2021). Chennai recorded the wettest November with incessant rains paralyzing the city (Chandrababu, 2021).

While statistical analysis is available in detail (Centre, 2021), an analysis that involves observing this data spatially stands significant. The current study first examines the land use and observes land-use changes in the State of Tamil Nadu in 2015 and 2020 through remote sensing data. It then diversifies further to examine how and where the daily rates of rainfall have varied daily and weekly through remote sensing data for the notable months of November of 2015 and 2021 for the State to draw a geographical patterning of this rainfall.Further, its correlation with land use is also examined. South Indian states of Tamil Nadu, Kerala, Telangana all have observed increased rates of precipitation owing to altering land use, more urbanization, and specific climatological factors that have played an important role in causing these changes in rainfall intensity (Boyaj, *et al*., 2020). As of 2021, the State has 38 districts (Government, 2021).

Study Area- The state of Tamil Nadu covers an area of 130,058 sq. km. One of the southernmost two states of India, Tamil Nadu faces the Bay of Bengal to the east, the Western Ghats and the state of Kerala in the west, Nellore and Chittoor districts of Andhra Pradesh, in north and Kolar, Bangalore and Mysore districts of Karnataka on its northwest; and the Indian Ocean in its south (Pune, 2020). The average height of Western Ghats is 1200 m and that of Eastern Ghats is 600m; these two ranges meet further southward in the state and rise remarkably in the form of Nilgiri hills (Pune, 2020). The Eastern Ghats also have peaks that are lower in height in the outlying hills. The major rivers are—the Kaveri, the Ponnaiyar, the Palar, the Vaigai, and the Tambraparni flowing eastward. The enclaves of Puducherry and Karaikal are located on the north-central coast of the State and are a part of the Puducherry Union territory(Aiyappan, 2021). The maximum range of temperature during the hottest months can be between 20 degrees Celsius to about 38 degrees Celsius while during the coolest months it can range from 21 degrees to 30 degrees Celsius (Aiyappan, 2021). The capital of Tamil Nadu in Chennai is located on the north-easternmost side of the State (Aiyappan, 2021). The State is largely agricultural with an industrial core in Chennai (Aiyappan, 2021).

Fig.1. India- Location and Administrative Divisions of Tamil Nadu State (2021)



Source-Author, 2021

Methods- The following methodology was attempted:

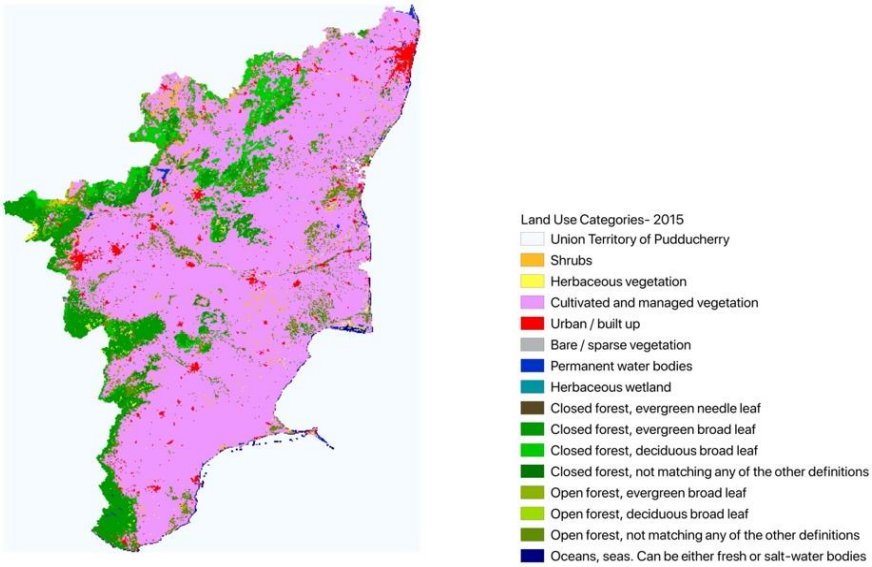
For land use information for the years 2015 and 2020 has been derived from satellite imageries. Google Earth Engine has been accessed for it. The map for 2015 has been extracted from a database- Copernicus Global Land Cover Layers: CGLS-LC100 Collection 3. It is described as a World Cover product comes whch shows 11 land cover classes which have been generated within the framework of the European Space Agency (ESA) World Cover project. It is a part of the 5th Earth Observation Envelope Programme (EOEP-5) of ESA(Engine, n.d.). For the spatial analysis of rainfall for the selected month of November for 2015 and 2021, the data source is CHIRPS Daily: Climate Hazards Group InfraRed Precipitation With Station Data (Version

2.0 Final). The Climate Hazards Group InfraRed Precipitation with Station Largely, satellite data, useful for weather and climate analysis gridded in nature (Gandhi, 2020). These are, further, examined to observe the spatial variation and regions where this variation is taking place and to observe its relationship with land use if any. The methodology of examination followed here is that of 'Visual Interpretation Method' of Change Detection'. To further observe the differentiation in rainfall trend for November, Sen's slope analysis has also been spatially depicted for the period from all November months from 2015 to 2021. All processing of extracted satellite data has been done in QGIS 3.16. software.

Results - Following observations were recorded:

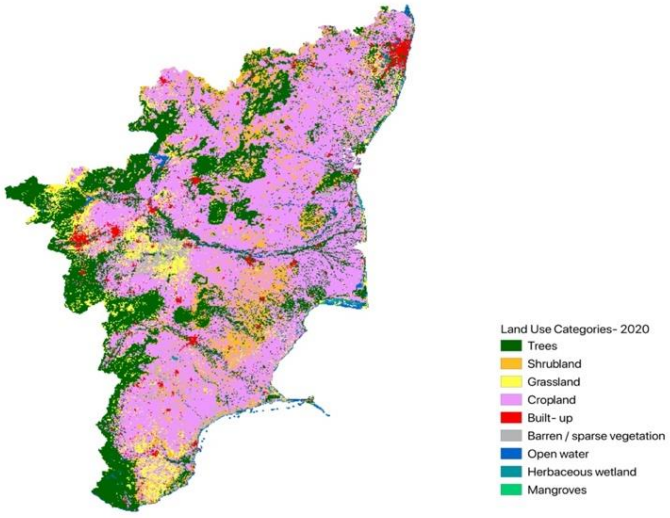
Observations on Land Use – As mentioned earlier, the land use of the state is predominantly agricultural and this can be observed for both the years of examination. The urban built-up area predominated in the northeast as the Chennai Metropolitan region with the capital city of Chennai. Other centers of the urban built-up area were also observed across the state. The southwestern part is composed of forested land in a narrow zone and some patches in the north-central part. In 2020 as well, no significant change can be observed in the agricultural zone, while the shrub and grassland have exhibited a marked increase for the state. Open water has also shown an increased proportion in 2020 as can be observed from Fig.3. A slight increase in a forested area is also observed. A major increase is reported in herbaceous vegetation in 2020 as compared to 2015 as per Fig.2. and 3. An increase in grassland can be attributed to a decline in agricultural land in that portion of the state.

Fig.2. Tamil Nadu- Land Use- 2015



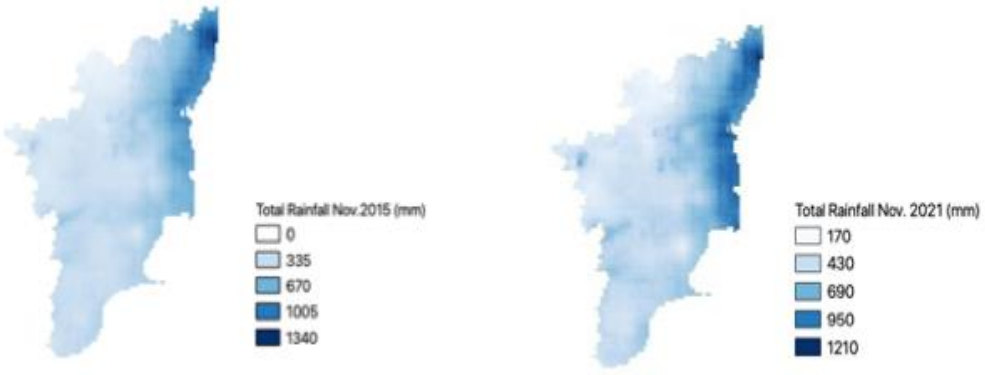
Source- Author, 2021; derived from Copernicus Global Land Cover Layers: CGLS-LC100 Collection 3, Google Earth Engine Code Editor

Fig. 3. Tamil Nadu- Land Use- 2020



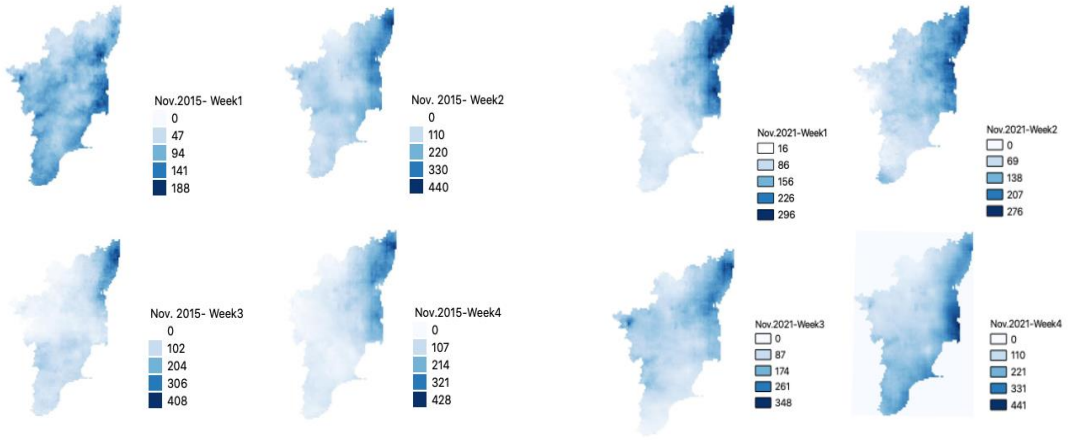
Source- Author, 2021; derived from ESA World Cover 10m v100, Google Earth Engine Code Editor

Fig. 4. Tamil Nadu An Overview of Total Rainfall for November- 2015 and 2021



Source- Author, 2021; derived from CHIRPS Daily Rainfall Data, Google Earth Engine Code Editor.

Fig.5. Tamil Nadu- Rainfall for November- 2015 and 2021



***All data is in mm**

Source- Author, 2021; derived from CHIRPS Daily Rainfall Data, Google Earth Engine Code Editor

Analysis of Rainfall-This examination has been attempted in two parts to observe the geographical distribution of rainfall in the state in the two notable episodes of 2015 and 2021.

As can be observed very clearly, maximum rainfall in both years was concentrated in the northeastern part of the state, with the urban conurbation of the Chennai Metropolitan area as the core of this high rainfall. Further, in the west, around Coimbatore, another center of high rainfall can be observed. Extending this analysis to the weekly trends of rainfall in November of 2015 and 2021, observed in Fig. 5, indicates a pattern too.

DISCUSSIONS

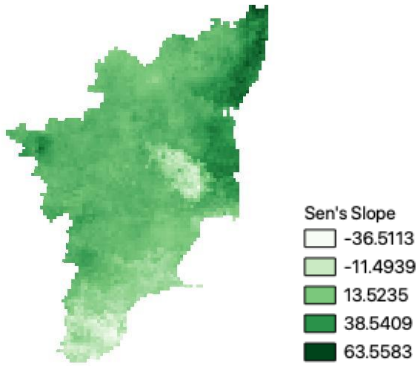
A weekly analysis as a detailed one for November has been attempted through remote sensing for both the years and it brings out a direct correlation of intense rainfall episodes with urbanization in particular. In both 2015 and 2021, it can be observed that the Chennai Metropolitan region experienced the highest concentration of rainfall along with the Coimbatore city region in the west in all weeks of November. On the whole, rainfall decreased towards the interiors, also indicating the possible meteorological factors and topography. Thus, it is convenient to mention that urbanization has a significant role to play in the disastrous rainfall episodes of 2015 and 2021 November and human activities around this region need to be monitored. The district of Kanyakumari also depicts heavy rainfall during these periods, probably due to its location in the extreme south.

In 2015, three synoptic low-pressure systems were formed over the Bay of Bengal in November which caused floods in Tamil Nadu (NDMA, n.d.). In 2021, low-pressure systems and cyclonic circulations were responsible for this flooding (Centre, 2021). As of 2021, the trend of rainfall recorded for November, by the Meteorological Centre at Chennai also indicate similarity of observations. For week 1, the Chennai station recorded the maximum departure from normal at 212% (Centre, 2021). For week 2 of November, Kanyakumari emerged as the district with the

maximum deviation from normal rainfall at a departure of 560% (Centre, 2021). In terms of land use, this is largely a forested district (Centre, 2021). For week 3 of November 2021, large excesses of rainfall were observed in the state and the district of Tirupathur showed a maximum deviation of 1349% (Regional Meteorological Centre, 2021). The last week of November was highly significant in records as large excesses were recorded across the state for all districts (Centre, 2021) and Madurai district in the eastern part of the state recording the maximum departure of 699% (Centre, 2021).

The analysis has been extended further to observe the spatial trend through the Man-Kendall and Sen Slope trends. Mann-Kendall's test is a non-parametric test used frequently in meteorological and hydrological examinations. In the current study, the parameters have been extracted for spatial analysis from Climate Engine at 1.0 value showing all trends (Roy & Chakravarty, 2021). Sen's slope is observed as the median of all slopes (Gocic & Trajkovic, 2013).

Fig. 6. Sen's Slope and Mann- Kendall p-Value for rainfall of November months from 2015-2021



Source- Author, 2021; derived from Climate Engine

CONCLUSIONS

It can be observed that negative values, which indicate a declining trend of rainfall, are concentrated geographically in the central and southernmost part of the state while an increasing trend of rainfall in November is largely observed from 2015-to 2021. Further, the two clusters where the concentration of excessive rainfall was observed in 2015 and 2021 November are the urban centers which can help lead to the conclusion that urban areas indicate an increasing spatial concentration of rainfall. It can be forwarded that while maximum amounts of rainfall are observed in the northeastern parts of the state, the recent trend of 2021 also indicates that in terms of departure from normal, there is no specific land use that is contributing to it. Land use, therefore, does indicate a certain correlation with changing and evolving trends of rainfall in the state.

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