Asian Journal of Convergence in Technology **Volume 4 Issue III**
ISSN No.:2350-1146, I.F-5.11

SPATIAL ANALYSIS OF MONSOON RAINFALL OF MAHARASHTRA STATE USING REMOTE SENSING TRMM DATA AND QGIS

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***Abstract*— India is heavily dependent on the monsoon rainfall for agriculture. In India about 46% of net sown area is irrigated land and 54% is dependent on monsoon and rains from clouds. It is therefore necessary to study distribution of rainfall which helps in water management i.e. making availability of water required for the cropping season and dependability on rainfall during season. IMD generates its rainfall data for Maharashtra based on its approximately 878 rain gauging stations spread across the state. But, these rain gauge networks are insufficient to capture high spatial and temporal variability of precipitation system accurately. With the help of IMD data we can only get graphical representation of precipitation data. However, satellite rainfall estimates provide global coverage, provide information on rainfall frequency and intensity in regions that are inaccessible to other observing systems such as rain gauges and radar and also visualize rainfall distribution on any area with the help of map but it needs area-specific calibration and validation due to the indirect nature of the radiation measurements. TRMM Precipitation Radar provides the most accurate high resolution satellite based rainfall estimates to date. The present study is carried out over the Maharashtra state to understand the spatial distribution of rainfall. All methodologies have been run in the QGIS which is open source software. To achieve the objective, it is divided into two sections. First section includes TRMM Data collection and statistical calculation of precipitation data of Maharashtra state. In the second section rainfall distribution over study area through mapping is accomplished. From this study of rainfall distribution from the year 2010 to 2016 it has been interpreted that there is heavy rainfall in Konkan and Vidarbha region and poor rainfall in Marathwada region of Maharashtra.**

Keywords—TRMM data, QGIS, spatial distribution, IMD

I. INTRODUCTION

Rainfall is an important agro-climatological factor. It is important to study and analyze the distribution of rainfall for cropping and agriculture. India is a tropical country so its agricultural planning and water utilization depends on monsoon rainfall. In India monsoon mostly begins in late May/early June and gradually covers the Indian land mass by June-end / July (Mahopatra et al, 2018). Mainly heavy rainfall occurs during the monsoon season but is unequal both in time and space so it is important to analyze the rainfall variation in space and time (Bhargava et al, 2013). The official records indicate that between the year 1995 and 2006, about 166,304 committed suicide and about 18,000 farmers were taking their own lives every year (Merriott et al, 2016). According to the report of the National Crime Records Bureau, Accidental Deaths & Suicides in India – 2010, says 15,964 farmers committed suicide in 2010.The three most affected states are: Maharashtra (3,141), Karnataka (2,585) and Andhra Pradesh (2,525) (https://www.downtoearth.org.in).To reduce this number of suicides it is important to study rainfall variations in country to help farmers and deal with this social problem. However, measurement of rainfall distribution over the globe is a challenging task. The rainfall measurements are limited to land areas where rain-gauges can be deployed. Direct rainfall measurements in most of the oceans can't be done. In that case currently, satellite remote sensing is the only means to overcome these difficulties encountered with conventional ground-based rainfall measurements. Satellite-based precipitation data can give high temporal (3 hourly) and spatial resolutions. Satellites have random errors that are caused by various factors like sampling frequency, nonuniform field-of-view of the sensors and uncertainties in the rainfall retrieval algorithms (NAIR et al, 2009). It is therefore essential to validate the satellite derived data with more conventional rain estimates to quantify the direct usability of the products. However, due to advent of remote sensing data (including TRMM data) and Open source GIS tool, the estimation process becomes easier than conventional methods.

Rainfall analysis and determination of mean monsoon rainfall would improve the management of water resources applications as well as the effective consumption of water. Examination of rainfall data enables us to determine the expected rainfall at various chances. Such information can also be used to prevent floods and droughts and apply to development and designing of water resources associated to engineering such as reservoir design, flood control work and soil and water conservation setting up like dams, farm ponds, bunds etc.

This research has been conducted for Maharashtra state where in 2018 twelve districts have received deficient rainfall this season and are facing drought (https://www.hindustantimes.com). It is important to study rainfall variation over there to combat with the social and agro-economic problems. This study analyzes variation in mean monsoon rainfall of Maharashtra state of six years from 2010 to 2016 and also the variation in rainfall in each monsoon month i.e. June, July, August, and September of years 2010 to 2016.

II. Study Area

Maharashtra state is a part of western, central, southern and south-central India. It is situated at 20˚00" North Latitude and 76˚00" East Longitude. Maharashtra is divided into five geographic regions i.e. Konkan, Khandesh, Western Maharashtra, Vidarbha and Marathwada. Temperature varies between 22 °C and 39 °C during summer season and between 12˚C and 34˚C winter season. Normally rainfall starts in the first week of June. In Maharashtra, July is the wettest month, while August also gets substantial rain.

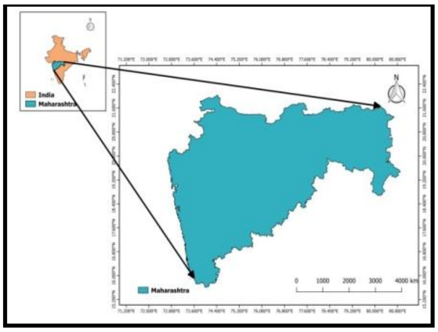

Fig. 1: Location map of study area

III. Materials and Methodology

3.1 Material

3.1.1 QGIS

QGIS also known as Quantum GIS is a free and open source GIS application enabling the user to visualize, manage, edit, analyse data, and compose printable maps. It runs on Linux, UNIX, Mac OSX, Windows and Android and can be downloaded free of charge from qgis.org.

The major features of QGIS include:

- Direct viewing and exploration of spatial data
- Support for numerous vector, raster, and database formats
- Create, edit and export spatial data
- Perform spatial analysis
- Publish your map on the internet
- An extensible plug-in architecture
- Remote control

3.1.2 TRMM DATA

The Tropical Rainfall Monitoring Mission (TRMM), dedicated exclusively to monitor tropical and sub-tropical rainfall was launched in November 1997. TRMM is a joint US-Japanese satellite mission. TRMM at 35 inclination to the equator is a low frequency, low altitude (orbit boosted to 403 km in August 2001) satellite (NAIR et al, 2009). The low altitude of TRMM makes possible the resolution of cloud radiances over small areas, which permits a more accurate estimation of precipitation. With TRMM it is possible to obtain physically direct measurements of rainfall and its vertical structure on different hours of the day, thereby allowing study of rainfall variability at shorter timescales. This makes TRMM one of the best available remotely sensed rainfall estimates for the tropics. There have been numerous attempts to validate TRMM data with ground-based estimates like gauge and radar data in the tropics. Both temporal errors (±8% to±12% per month) and sampling errors (approximately 30%) can be expected in TRMM rainfall estimates (Cheema et al, 2011). Ji and Stocker (2003) and Chokngamwong et al. (2005) observed a correlation of 0.56 and 0.86 between the satellite and rain gauge measurements, respectively (Cheema et al, 2011).

Sensors aboarded by TRMM:

- Precipitation Radar (PR)
- TRMM Microwave Imager (TMI)
- Visible and Infrared Scanner (VIRS
- Clouds and the Earth's Radiant Energy Sensor (CERES)
- Lightning Imaging Sensor (LIS)

3.2 Methodology

For this study TRMM data of 6 years from 2010 to 2016 of four monsoon months i.e. June, July, August and September was downloaded from Mirador via internet. The downloaded data was then converted into raster format from Netcdf format using open source GIS i.e. QGIS. Then shape file of Maharashtra state was downloaded through DIVA-GIS via internet. Study area was then extracted from the TRMM data in QGIS of each month. Then the precipitation data was converted into mm from mm/hr. After that analysis of rainfall in each monsoon month and mean monsoon rainfall of six years was done. The monsoon rainfall calculated was also compared with the rainfall data available on government portals. Then the mapping of mean monsoon rainfall of Maharashtra was done.

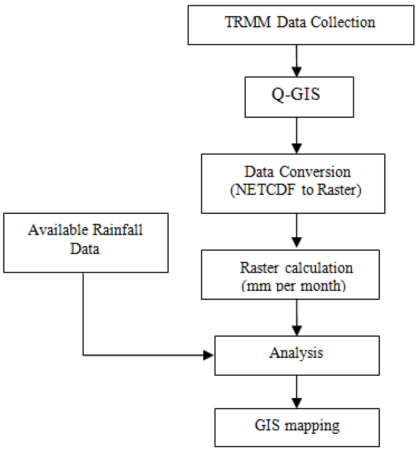

Fig. 2: Flowchart of methodology

IV. Results and Discussion

4.1 Variation in mean monthly monsoon rainfall :

The variation of rainfall over Maharashtra state gradually takes place in every month. There was an increase in rainfall as the monsoon started i.e. from June till July but after the month of July the rainfall decreased upto September. Thus rainfall was highest in the month of July and least in the month of September. This trend of rainfall variation had been followed in each year except 2015.In 2015 rainfall was high in the month of June then there was a sudden fall in the month of July again it raised in August and again dropped down in September. Thus in year 2015 there were more fluctuations in rainfall distribution from June to August over Maharashtra. In the year 2013 there was highest rainfall in the month of July as shown in graph below. All this analysis shows that July is the wet month in monsoon season of Maharashtra state.

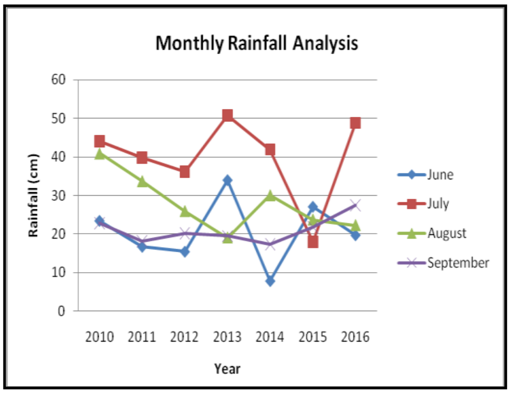

Fig. 3: MonthlyRainfall analysis per year graph

Fig. 4 illustrates the spatial distribution of rainfall in Maharashtra. It shows the trend of rainfall distribution over Maharashtra in July. From the fig. it has been observed that Vidarbha and Konkan region of Maharashtra received more rainfall as compared to other region. As per our observations this trend has been followed for all other months also. In between Vidarbha and Konkan, Konkan is the wettest region of Maharashtra as it received high rainfall in all years as well as all months of monsoon season. Vidarbha region received more rainfall in 2012 and 2013 as compared to other years.

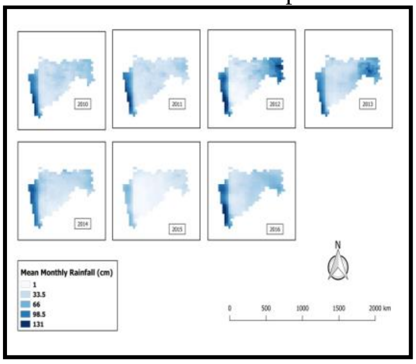

Fig. 4: Spatial rainfall distribution in July

4.2 Mean variation in monsoon rainfall

Variation in mean monsoon rainfall over Maharashtra is varying year to year from 2010 to 2016.Year 2010 was the wettest year among all analyzed years with mean monsoon rainfall of 131.15cm while year 2015 was the dry year with rainfall 90.37cm.July is the wet month in Maharashtra. The rainfall in July was high in 2010, 2011, 2012, 2013, 2014 and 2016 as compared to other months. Rainfall in these six years was 44.02cm, 39.75cm, 36.11cm, 50.69cm, 41.89cm and 48.74 cm respectively. It illustrates that the trend of high rainfall in July is followed in all years except 2015 where rainfall in July has decreased as compared to other months.

The spatial distribution of rainfall in all years can also be seen from the Fig 5. The below maps illustrates that the rainfall distribution over Konkan region and Vidarbh region was high in all years while in central Maharashtra i.e. Paschim Maharashtra and Marathwada there was low rainfall.In the year 2013 and 2010 there was a little more rain than in other years. This spatial distribution of rainfall shows the need of constructing conservation structure Konkan and Vidarbh region of Maharashtra and diversion of water from these regions to Central Maharashtra.

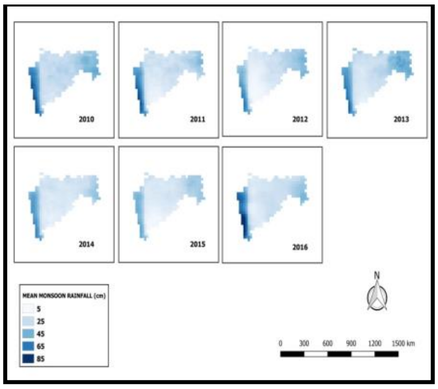

Fig. 5: Spatial rainfall distribution

Table 1: Mean monsoon rainfall distribution in cm for 2010 -2016

Year/ Month	2010	2011	2012	2013	2014	2015	2016
June	23.35	16.65	15.37	33.87	7.78	27	19.63
July	44.02	39.75	36.11	50.69	41.89	17.95	48.74
August	40.93	33.74	25.92	19.04	30.05	23.71	22.28
Sept.	22.85	18.22	20.25	19.49	17.35	21.71	27.4

In the present study the estimated Mean monsoon rainfall has been compared with Normal monsoon rainfall of Maharashtra which has been depicted in Fig. 6. The graph illustrates that the estimated Mean monsoon rainfall through TRMM and GIS of all years except 2010,2013 and 2016 is below the Normal monsoon rainfall maharashtra i.e. 113.13mm.Mean monsoon rainfall of these three years is more than normal monsoon rainfall. It has been analaysed that years with high rainfall shows more errors as compared to rest of other years.

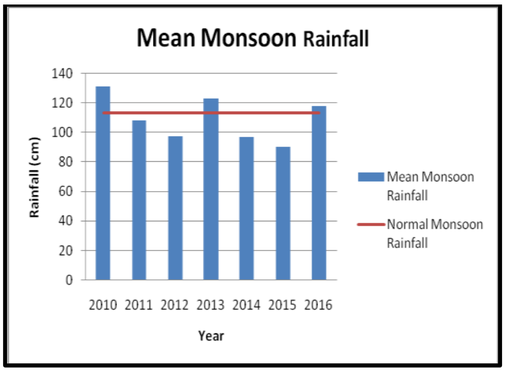

Fig. 6: Mean monsoon rainfall Vs Normal monsoon rainfall

V. CONCLUSIONS

In this study it has been analyzed that rainfall is high in year 2010 while poor in year 2015.It has also been examined that July is the higher rainfall receiving month in monsoon season. In 2015 situation of drought has been observed as the rainfall is less than 50% of the normal mean rainfall. Rainfall distribution over Maharashtra is fluctuating in each year. Only the region of Konkan and Vidarbha receives high rainfall every year. In between Konkan and Vidarbha, Konkan receives high rainfall in Maharashtra. However, Central Maharashtra receives least rainfall throughout the monsoon season of each year. This shows that there is the need of constructing soil and water construction structures like dam, farm ponds etc. in central Maharashtra so as to make water available in summers. There is also the need to harvest and conserve water in Konkan region as it receives high rainfall but because of hilly region water escapes from there meet the coastline. This will help the farmers for irrigation purpose after monsoon season resulting in increase in their crop yield and economic status. In the present study, TRMM data has been used as this data is easy to download and is available free of cost through mirador. While rain-gauge data of all region is not easily available. This data is easy to access and also provide the data of all inaccessible regions where rain-gauges are not available. But this data shows errors upto 30%.It has been observed that when rainfall is high error is more but when it is low error is least. There are many regions in Maharashtra where raingauges are installed very far regions and at some places raingauges are not available. So there is error upto 30% in analysis through TRMM data. This shows that there is the need to calibrate and validate the TRMM data with the ground data.

Acknowledgment

Authors are thankful to friends for their help and advice during research work. The authors also thank the anonymous reviewers for their advices that helped to improve the quality of the manuscript.

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