Symbiosis Institute of Geoinformatics (SIG)

SYMBIOSIS
INTERNATIONAL UNIVERSITY

Drought Monitoring System

Prof. (Dr.). T.P. Singh

Symbiosis Institute of Geo-informatics (SIG), Symbiosis International University, Pune, India

Sentinel Asia

Symbiosis International (Deemed University)

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- **NAAC A++, Category I , QS Ranking(India) 23,**

Vision

Promoting international understanding through quality education

Symbiosis International (Deemed University)

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Students	Ph.D.	Programme Offered	Faculties	Constituents
20000+	800+	84+	8	43

Symbiosis International (Deemed University)

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Major Research Projects 90+

Minor Research Project 100 +

MoU with International University 66+

Research Collaborations 54

Constituents 43

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Disaster Management Cell (Sentinel Asia)

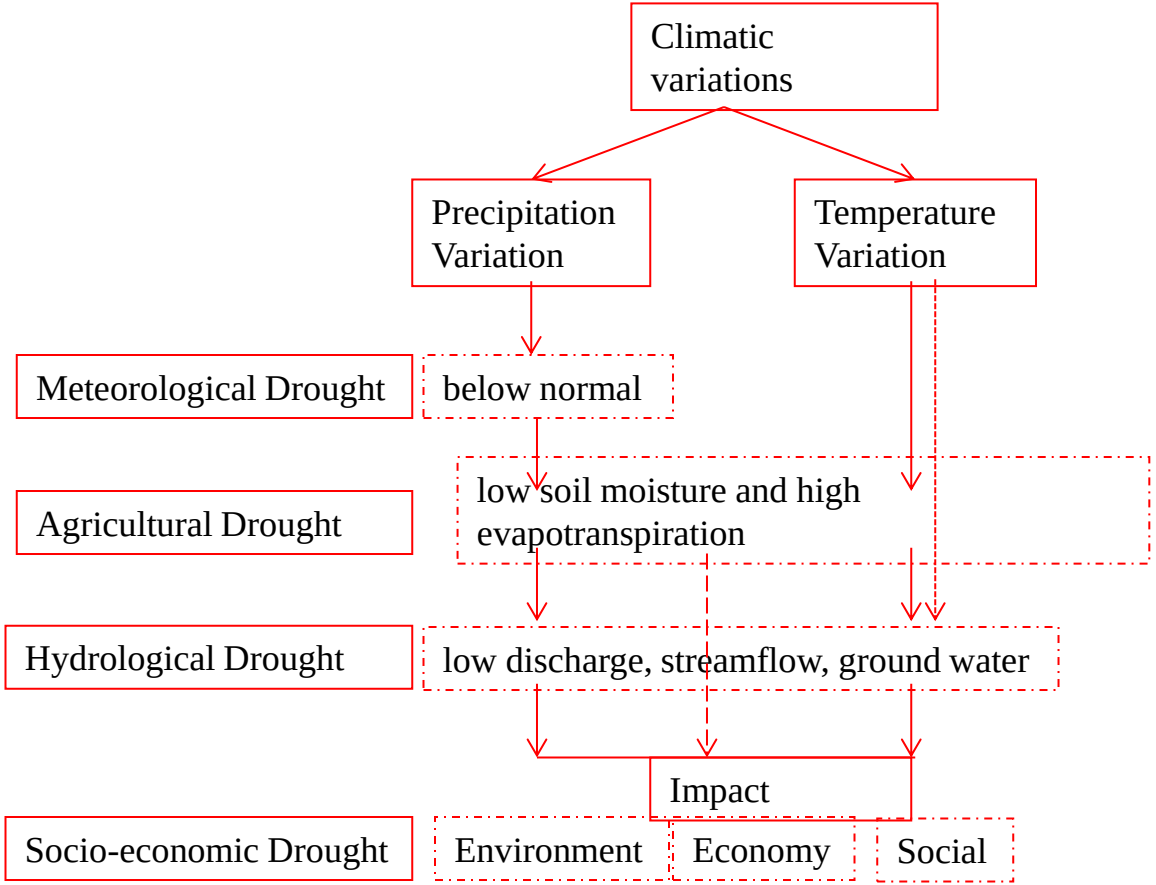
Drought Monitoring

- Drought is most damaging natural calamity in the world with damages accounting to US$6-8 billion.
- Ambiguity in the definition of drought makes it difficult to measure and quantify.
- Drought at an unprecedented scale is caused by 2 major factors – increasing human population and uneven precipitation distribution.
- Unlike other natural disasters, drought functions over time – onset and offset difficulty to assess due to spatiotemporal nature making quantification difficult.

https://drive.google.com/drive/folders/1cRtto_7RPJwPLTTMmTaUBajMPe5sywO3?usp=sharing
Data Set

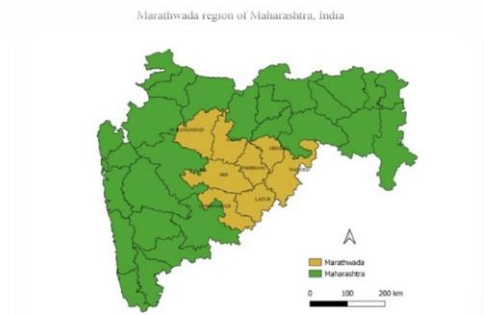
https://drive.google.com/file/d/1AAFqs3ZU--W7AYYlDTxiS5YIUmBu9cRn/view?usp=sharing
Python Library

DROUGHT PROPAGATION



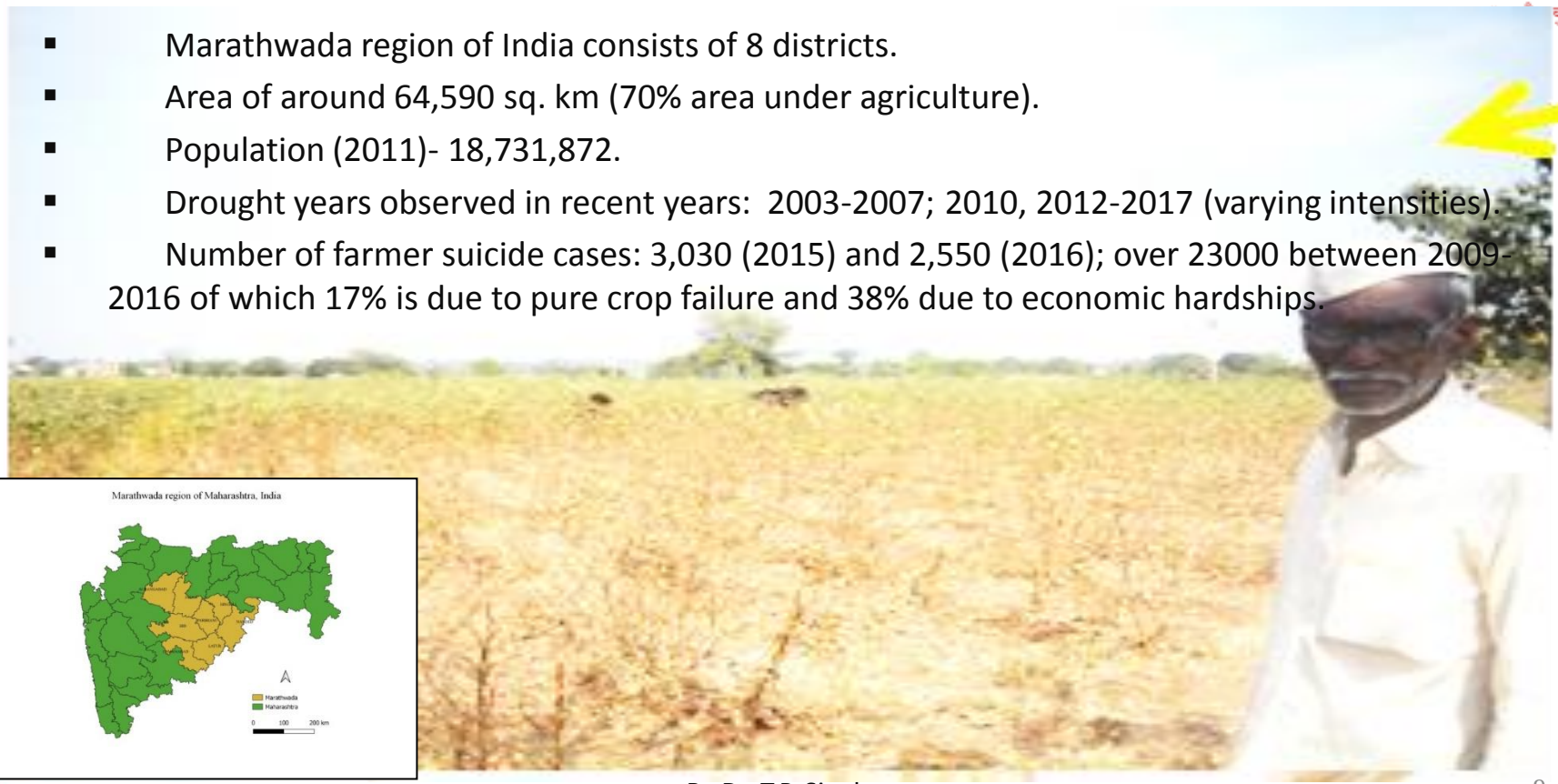
DROUGHT IN INDIA

- Around 44% of India's landmass (1.4462 million sq. km.) was under drought in 2018.
- Over 500 million people directly affected by prolonged water deficit and heat waves.
- Farmer suicides in India grew 41.7% from 5,650 in 2014 to 8,007 in 2015
- As of 2018, Maharashtra witnessed farmer suicides mostly because of crop loss and debt towards agricultural expenses in the last 3 decades.



DROUGHT IN MARATHWADA

- Marathwada region of India consists of 8 districts.
- Area of around 64,590 sq. km (70% area under agriculture).
- Population (2011)- 18,731,872.
- Drought years observed in recent years: 2003-2007; 2010, 2012-2017 (varying intensities).
- Number of farmer suicide cases: 3,030 (2015) and 2,550 (2016); over 23000 between 2009-2016 of which 17% is due to pure crop failure and 38% due to economic hardships.



CONSEQUENCES OF DROUGHT

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Environmental

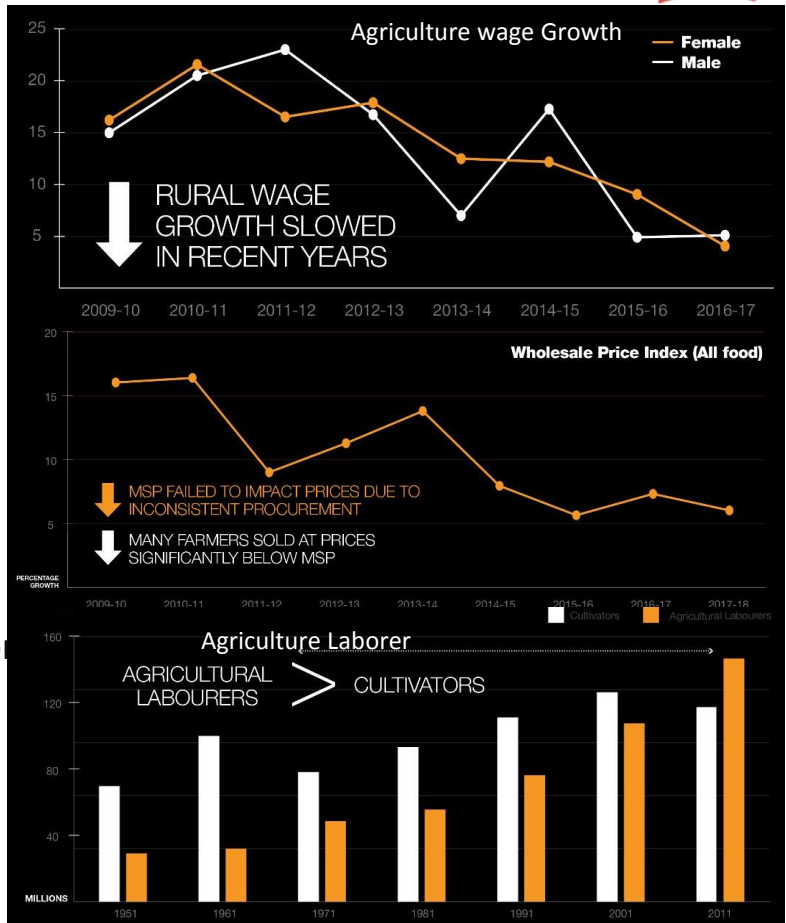
- Prolonged drought reduces soil quality.
- Affects water cycle and food chain in the ecosystem.
- Increase in incidents of wildfires.
- Stress on vegetation.

Social

- Migration of animals and relocation of humans.
- Increase in victims of hunger and malnutrition.
- Spread of diseases due to lack of clean drinking water.
- Reduced income causes rise in poverty and crime.

Economic

- Crop failure and economic instability in agriculture sector
- Losses in hydroelectric power generation.
- Affects timber industry



By Dr. T.P. Singh

LIVESTOCK CONDITION

- Over the last decade Marathwada has consistently seen decline of 20%-30% in average annual rainfall.
- Over 900 small, medium and large reservoirs with less 10% water capacity are present in Marathwada as of December 2018.
- With 5.6 million livestock in Marathwada and no water and fodder available, fodder camps are seen across the region.
- The quality of water and fodder received as relief in these camps is below par in most camps.




WORK AND MIGRATION

- The Government of India run Rural Employment Guarantee scheme (MGNREGA) has 21.5 million registered workers in Maharashtra of which only 26% are active.
- There are around 1.5 million seasonal workers in Marathwada who work in farms on daily wages.
- In recent years migration of these seasonal workers have increased by around 40-50 percent as per farmer unions and local governing body data.
- Empty roads and abandoned homes is common in villages and hamlets affected by ever increasing drought.

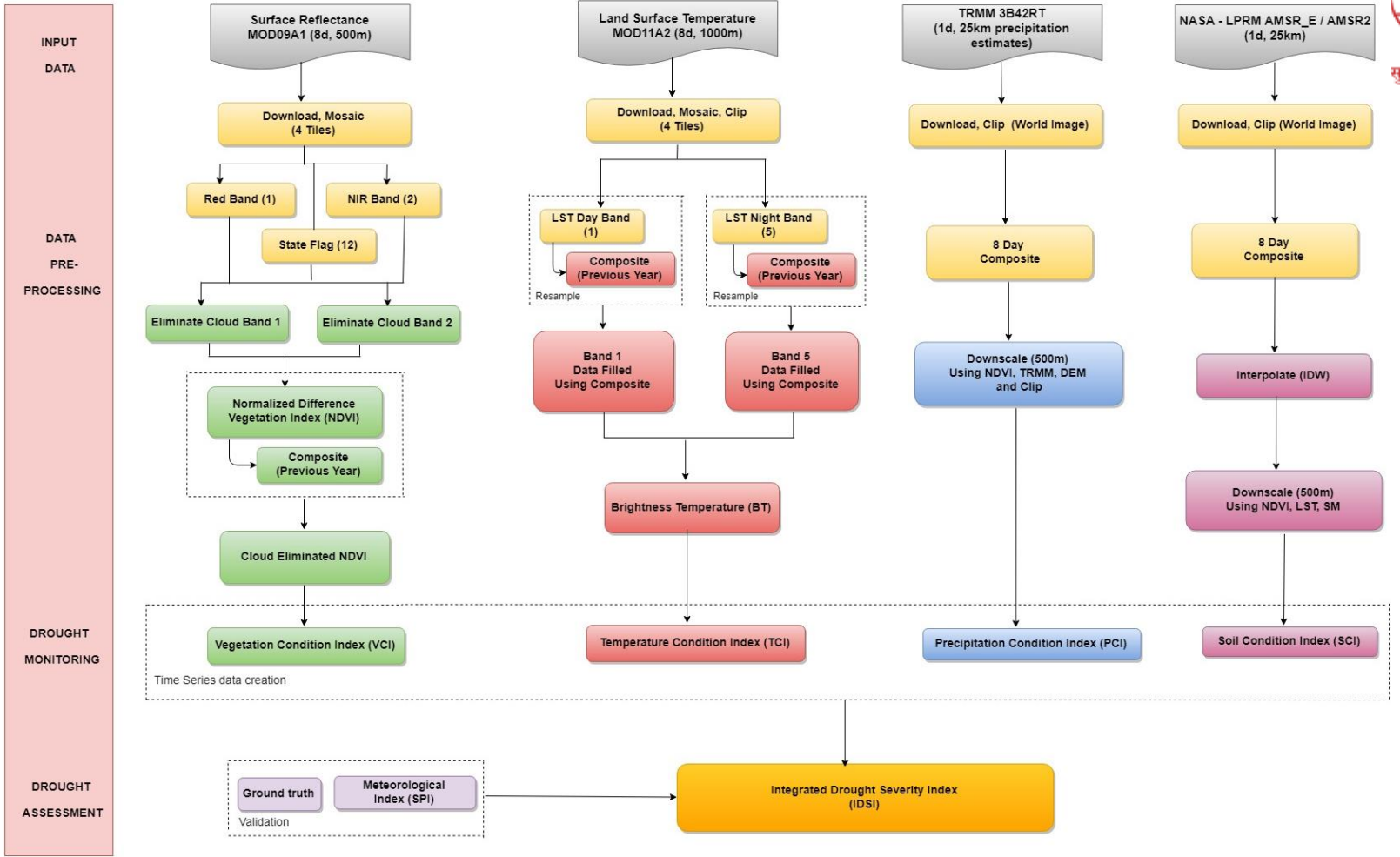
NEED FOR DROUGHT MONITORING

- Due to creeping nature of drought, it is difficult to assess onset and offset of drought.
- With change in geographical regions the definition of drought changes drastically.
- The relief given by the government and policy makers often doesn't negate the root of agricultural drought.
- The objective is to develop a near-real-time drought monitoring system at the scale of a state, district or pixel with an 8-day time interval.
- The prototype drought system will serve as an interface between climate service providers and various stakeholders' partners by communicating information concerned with drought and its impacts.

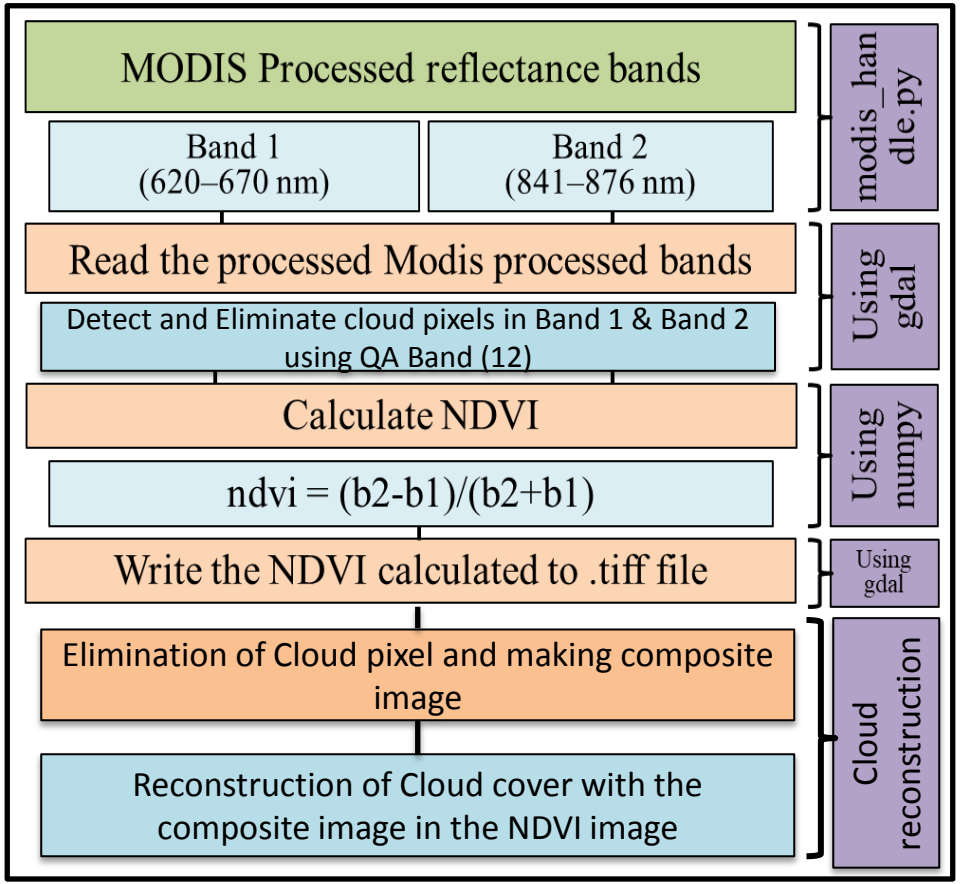
DATA ACQUISITION

Remote Sensing Data	
	Moderate-resolution Imaging Spectroradiometer (MODIS)
	Tropical Rainfall Measuring Mission (TRMM)
	Advanced Microwave Scanning Radiometer for EOS (AMSR-E), AMSR 2
Ancillary data	Station wise - Daily Soil Moisture, Daily Evapotranspiration Grid wise - Daily Minimum and Maximum Temperature, Daily Rainfall
Administrative boundaries	Country, state, districts, taluka boundary shape files

METHODOLOGY



MODIS PRODUCTS DATA PROCESSING METHODOLOGY : PRODUCT MOD09A1



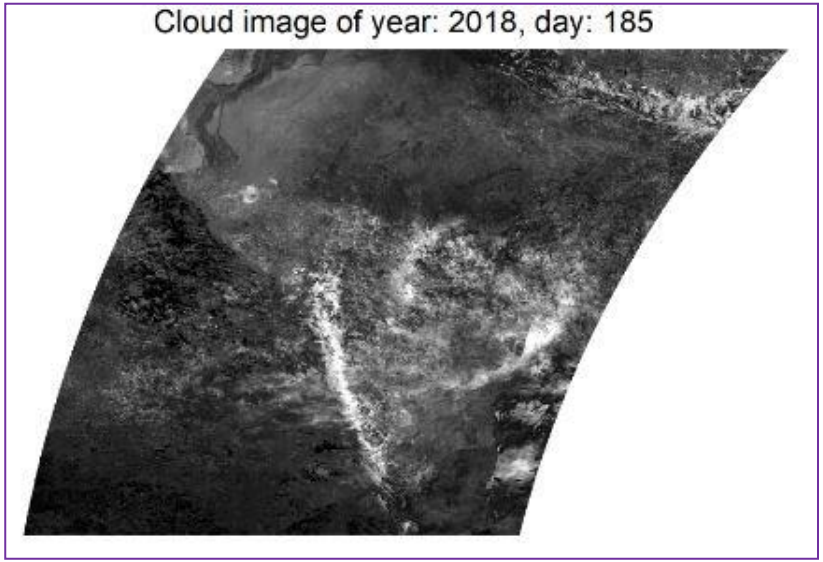
CLOUD ELIMINATION METHODOLOGY : PRODUCT MOD09A1

- From MODIS Reflectance (MOD09A1) product extract QC_500m Reflectance band quality (band 8) and 500m State Flag band (band 12).
- These are bit field bands with data types as 32 bit unsigned integer and 16 bit unsigned integer.
- These integer value per pixel are converted into binary to find out the cloud state in each band.
- The position (row and column) of pixels where cloud is present is determined by the position of binary encoded values as mentioned in the MODIS user manual.
- The pixels which are not present due to the cloud flag are then replaced by a 5 year composite image for the specific bands. For example: To replace the DN values of cloud pixels for 2018, a composite image is created using data from 2013-2017 (46 image per year- total of 230 images).
- The bands worked for cloud removal at the initial stages is MOD09A1 band 1 and 2 which are further used to calculate NDVI and EVI images without cloud data present.

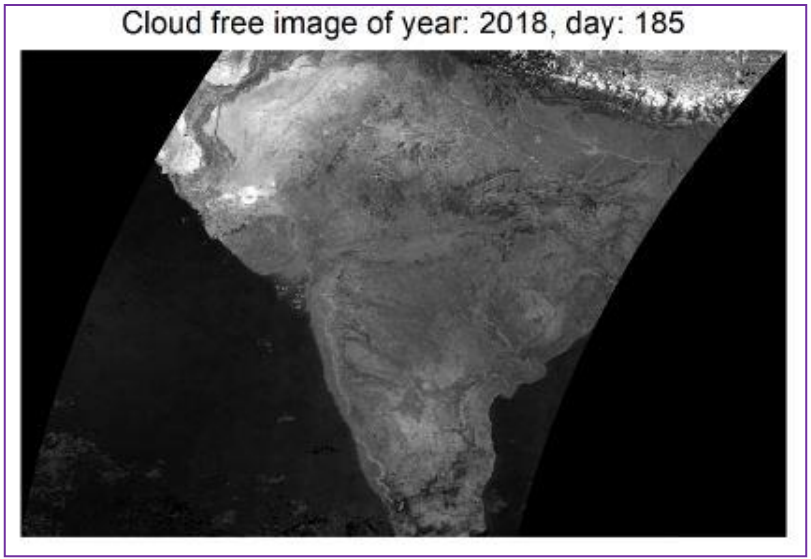
CLOUD ELIMINATION

Cloud Removed from image of year: 2018 and day: 185 using 5 year average composite images from year 2003-2007

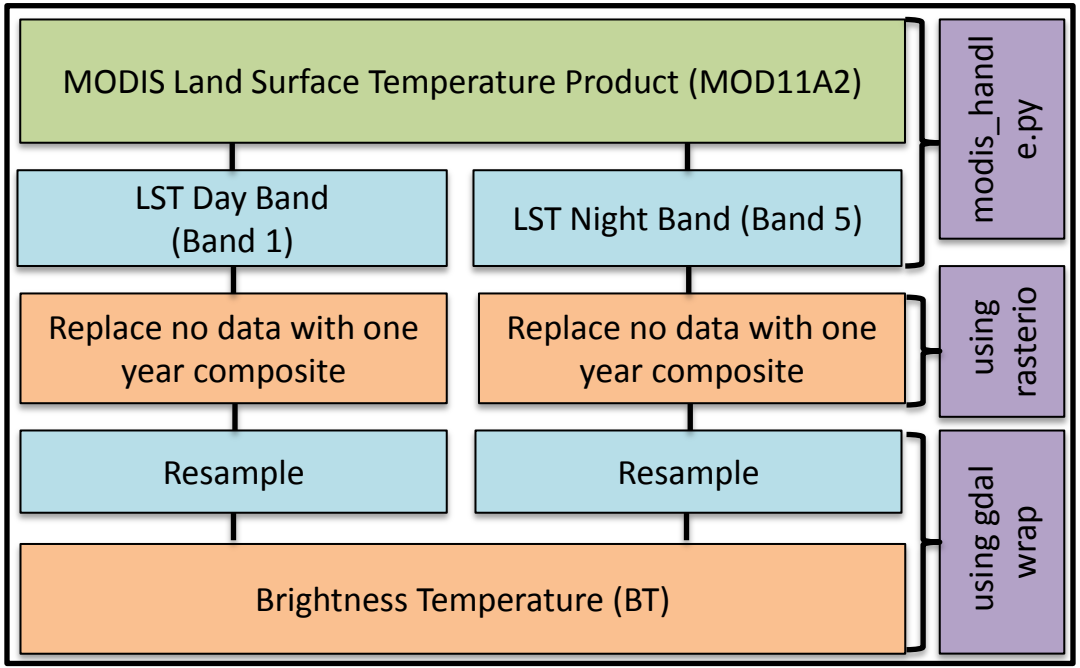
Before



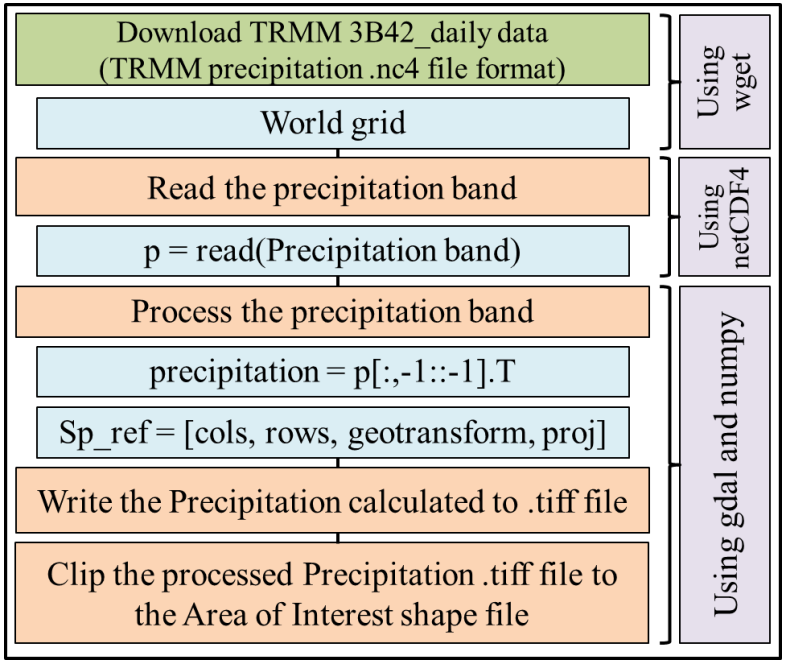
After

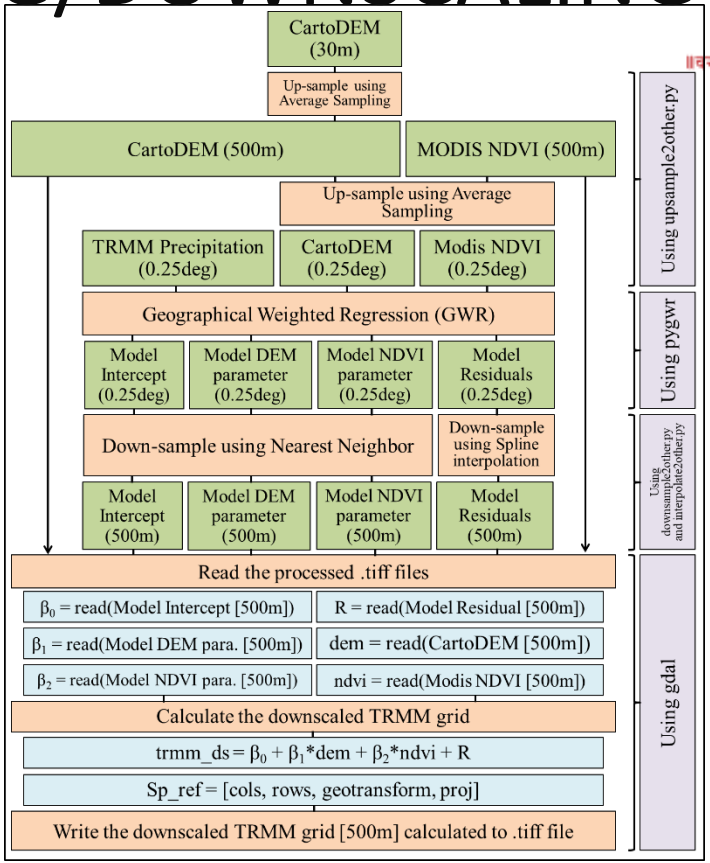


MODIS PRODUCTS DATA PROCESSING



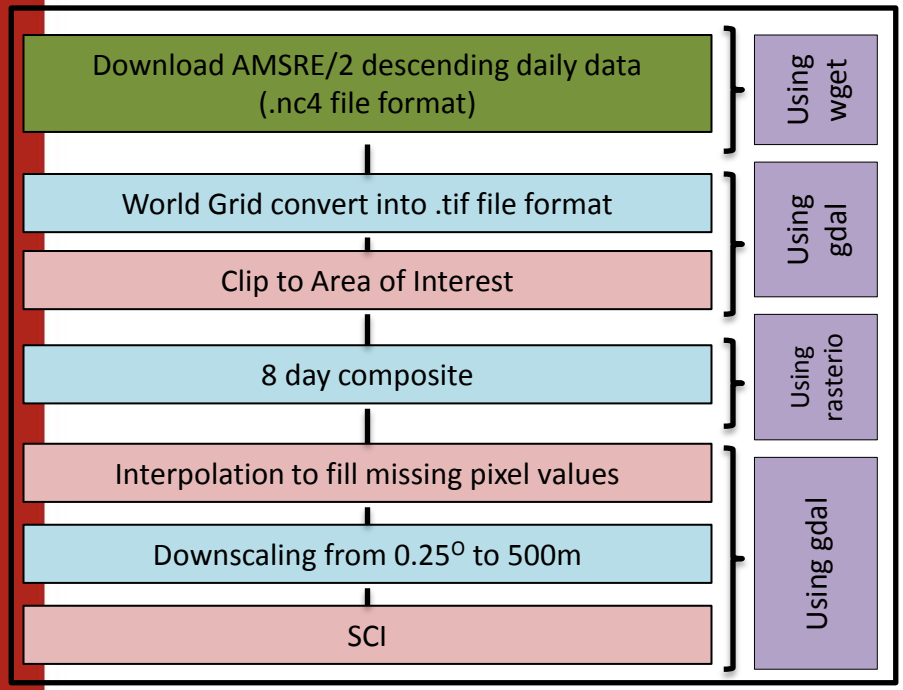
TRMM DATA PROCESSING/DOWNSCALING

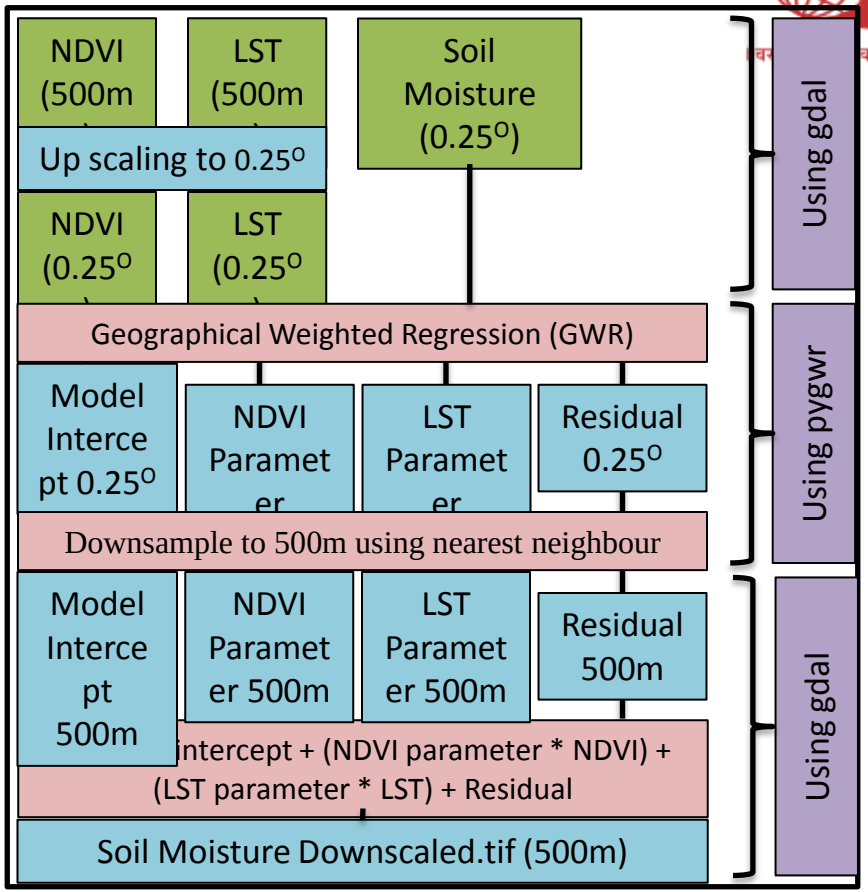




- Reference: Chen, F., Liu, Y., Liu, Q., & Li, X. (2014). Spatial downscaling of TRMM 3B43 precipitation considering spatial heterogeneity. International journal of remote sensing, 35(9), 3074-3093.

AMSRE/2 DATA PROCESSING/DOWNSCALE





INDICES – NDVI, VCI

Normalized Difference Vegetation Index (NDVI)

Formula : $NDVI = (R_{857} - R_{645}) / (R_{857} + R_{645})$, (Kriegler et al. 1969)

where R645 is the TOA red light reflectance and R857 is the TOA near-infrared (NIR) reflectance.

Vegetation Condition Index (VCI)

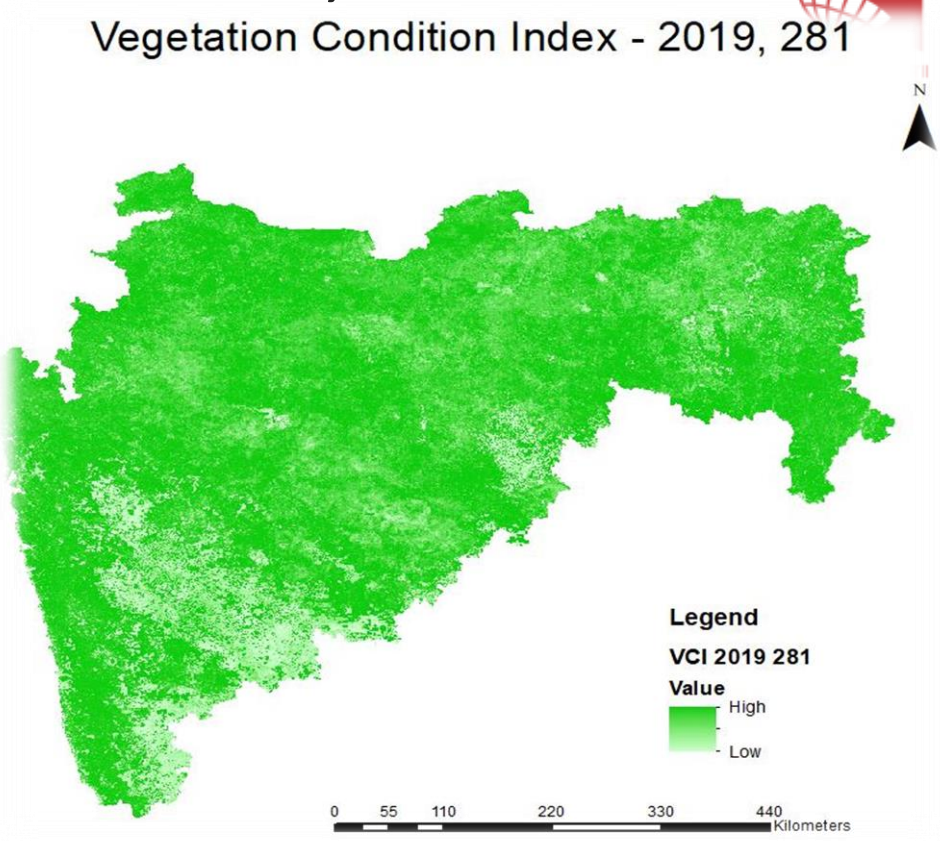
VCI is normalization of NDVI to reflect reflective changes in vegetation condition from extremely poor (0) to excellent (100)

Formula :

$VCI = 100 * (NDVI - NDVI_{min}) / (NDVI_{max} + NDVI_{min})$, (Kogan, 1990)

NDVI max and NDVI min are multiple year maximum NDVI and minimum NDVI for a pixel with reference to a specific climatology.

The VCI values between 50% to 100 % denote optimal or above normal conditions.



INDICES – TCI

Temperature Condition Index (TCI)

TCI was developed based on LST observation from TIR remote sensing.

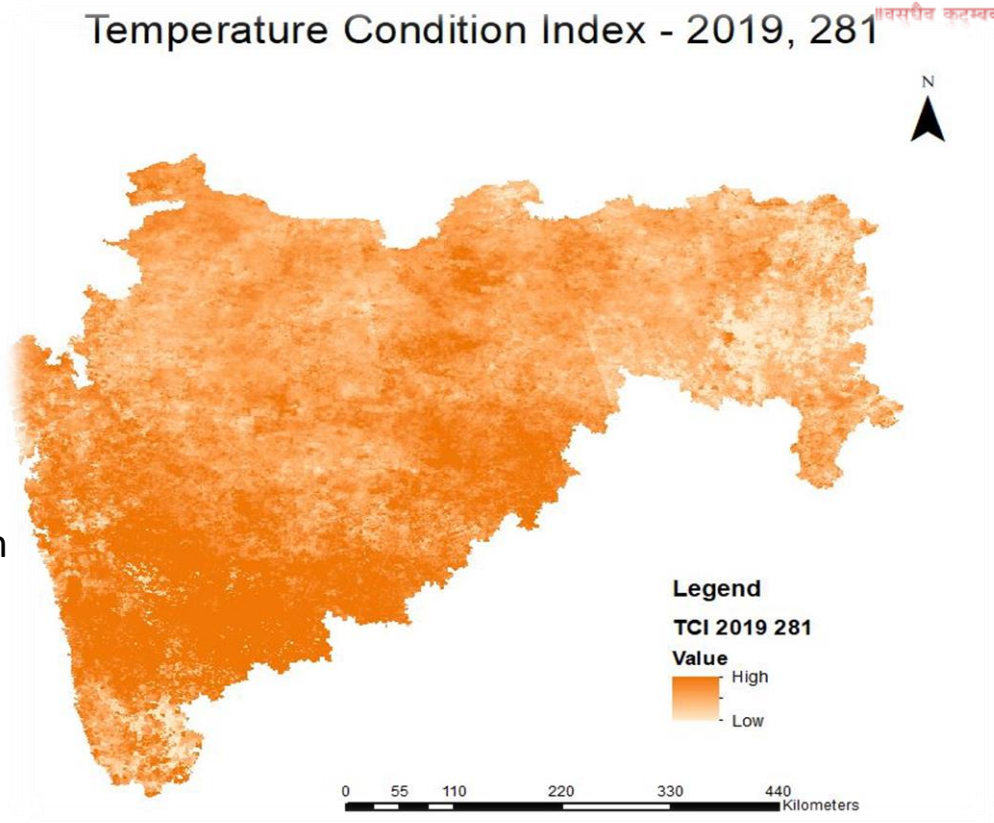
Formula :

TCI = 100 * (BT_{max} - BT) / (BT_{max} – BT_{min}), (Kogan, 1995**)**

The weekly thermal brightness temperature is termed as BT

BT is calculated from every week's satellite data of around 17 years i.e. from 2002 to current.

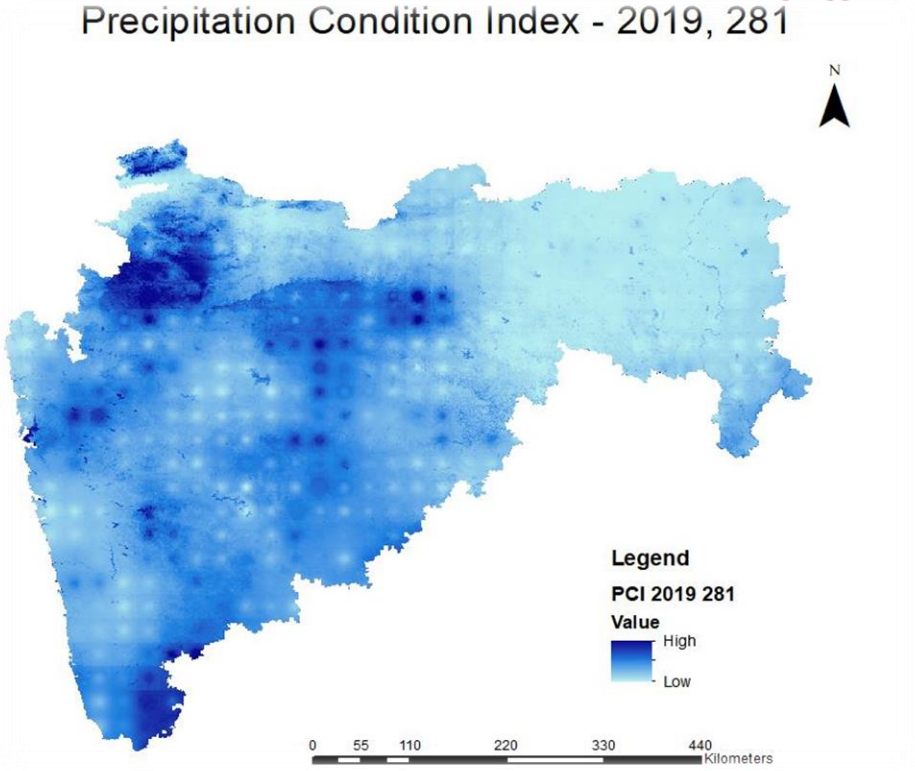
BT max and BT min are termed as multiple year maximum and minimum, pixel specific thermal brightness temperature.



INDICES – PCI

The Precipitation condition index is made with the downscaled TRMM data and the historic data. The Precipitation Condition Index is calculated using the formula

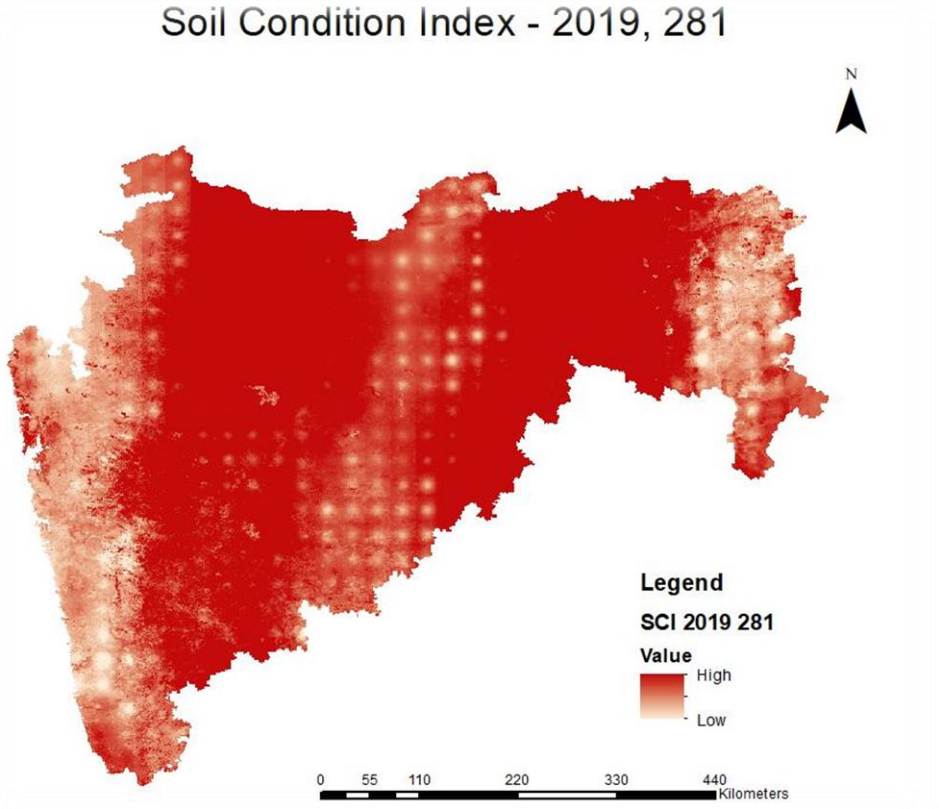
PCI = 100 * (TRMM - $TRMM_{min}$) / ($TRMM_{max}$ - $TRMM_{min}$)



INDICES – SCI

The Soil condition Index (SCI) makes use of the current soil moisture and the historic data. The Soil Condition Index is calculated using the formula

SCI =100*(SM -SMmin) / (SMmax - SM min)



Advance Drought Response Index (ADRI)-281days 2019

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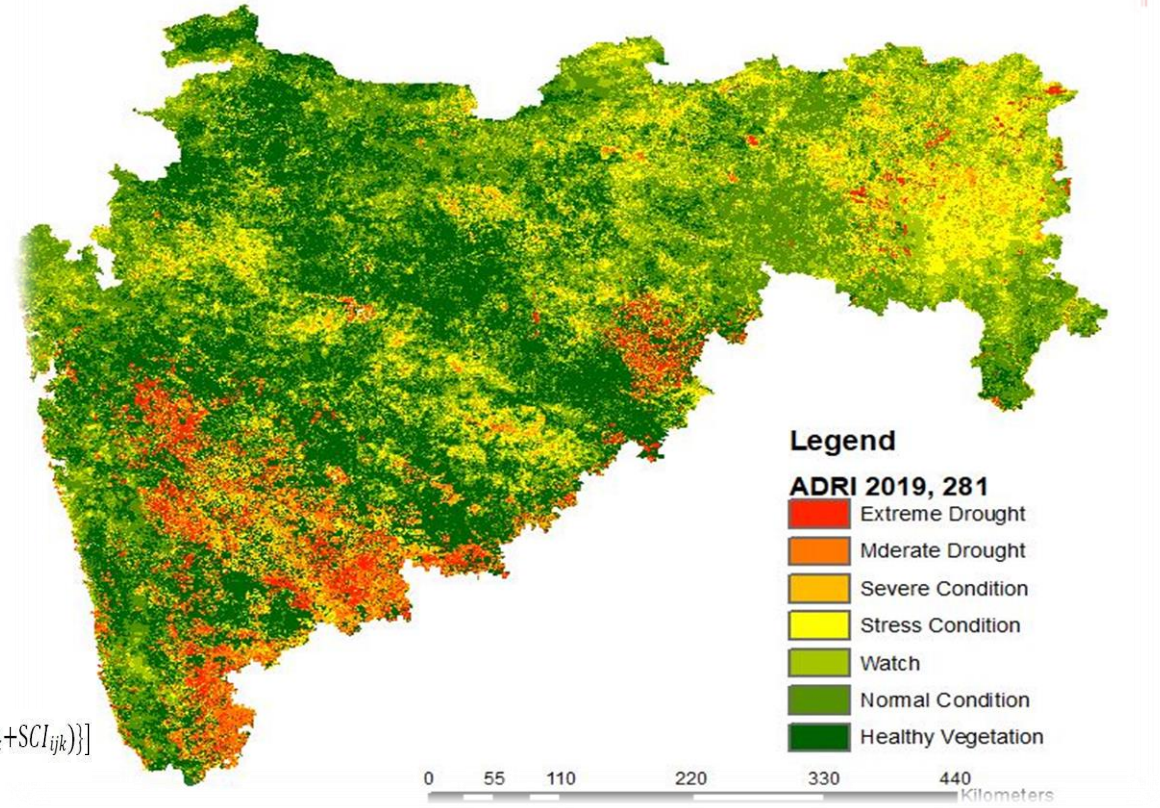
ADRI is an modified version of IDSI which allows better understanding on drought incidence, duration over the two decade ADRI is useful tool in drought mitigation studies and in decision-making process.

Where, $ADRI_{ijk}$, VCI_{ijk}, TCI_{ijk}, PCI_{ijk} and SCI_{ijk} are IDSI, VCI, TCI, PCI and SCI value for pixel i in composite j of year k. The ADRI value ranges between 0 to 100; L is the normalization factor to keep the output value in expected range and c is a constant to avoid null in denominator. The values close to 0 reveals extreme drought situation as vegetation is under stress, precipitation is very low and temperature is very high. Likewise, the values closer to 100 reveals normal situation as vegetation growth is good, precipitation is high and temperature

$$ADRI = [L * VCI_{ijk} * \{c + \frac{1}{L*(VCI_{ijk}+TCI_{ijk}+PCI_{ijk}+SCI_{ijk}+c)} * (TCI_{ijk} + PCI_{ijk} + SCI_{ijk})\}]$$



DERIVED ADRI IMAGES : YEAR 2019

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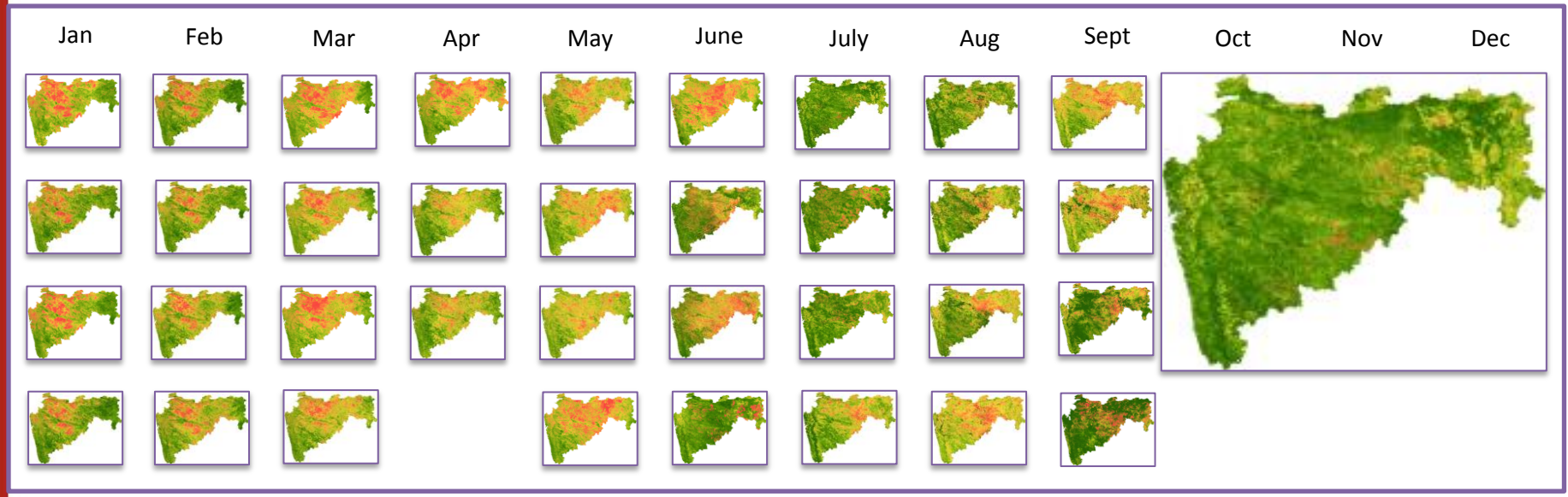
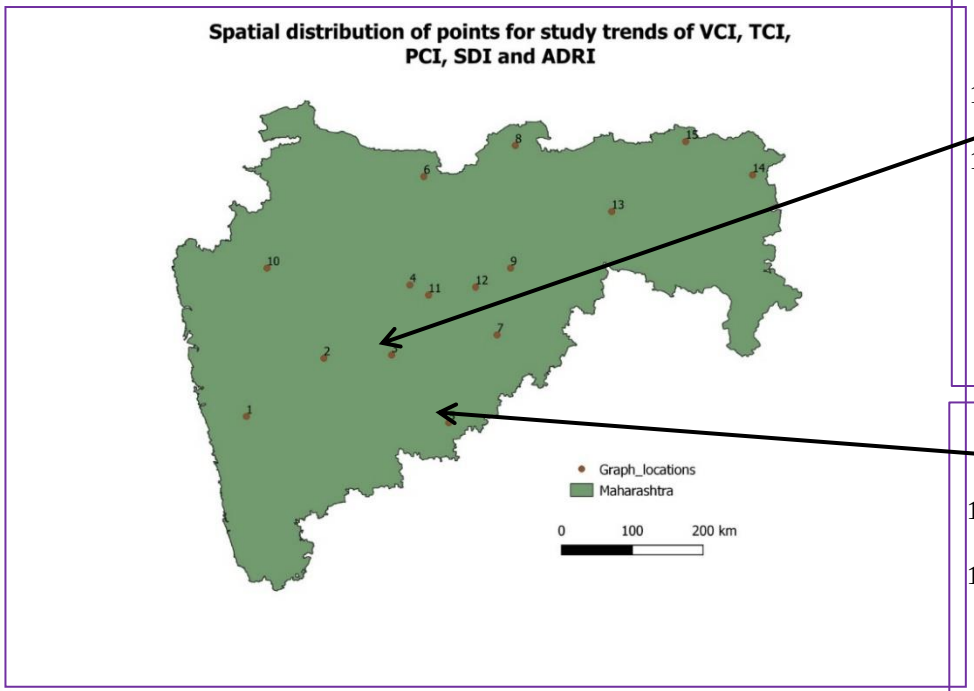
DETAILS

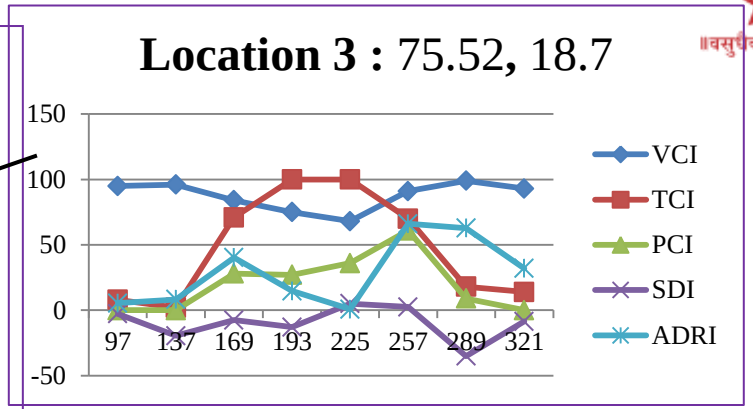
Data processed from : **Year 2004 - 2019**

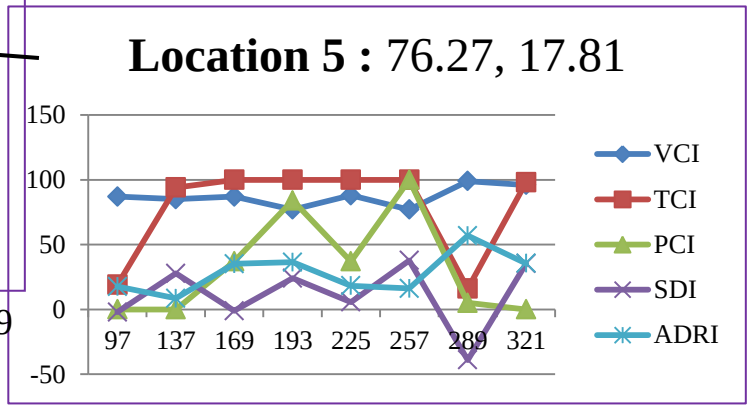
Total images derived : **689**



PCA BASED SDI vs ADRI







Trend for drought year 2013- days 97, 137, 169,193,225,257,289 and 321.

X axis: days; Y axis: values associated with condition indices, SDI and ADRI









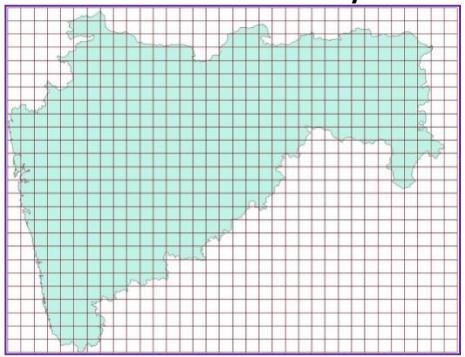

PRODUCT VALIDATION

- Standardized Precipitation Index (SPI) is a meteorological drought index which works on long term averages of 3, 6, 9, 12 or 24 months over a period of at least 30 years.
- SPI is trusted index around the world for calculating drought severity based on precipitation records collected from ground stations.
- Indian Meteorological Department's daily precipitation records is used to calculate SPI.
- The results achieved from Advance Drought Response Index (ADRI) are being compared to SPI calculated using IMD's data.

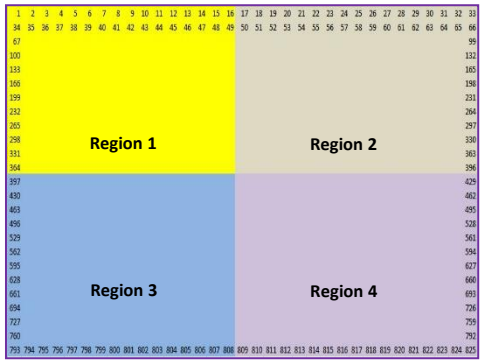
TREND ANALYSIS FOR TRMM AND IMD DATA

- 1st June to 31st October for the years 2004 to 2013
- Weekly data i.e. the eight day composite data
- The precipitation records of 25 rows and 33 columns are divided into 4 segments.
- All 825 grid values are segregated as section matrices with dimensions

Grid wise division of study area



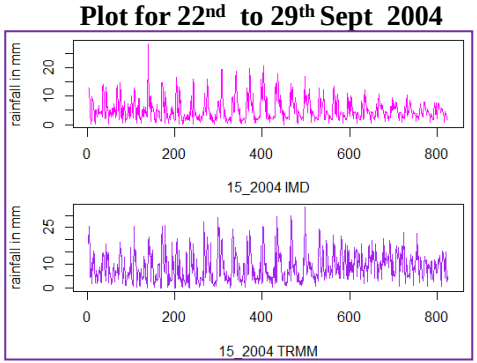
Matrix/Region division

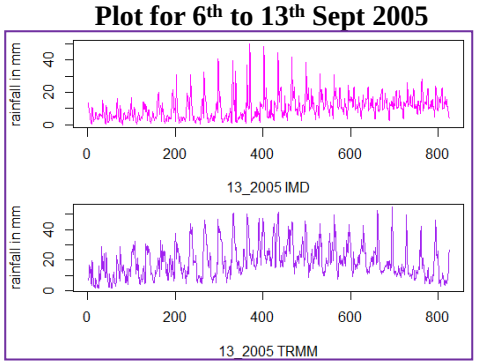


TREND ANALYSIS FOR TRMM AND IMD DATA

- The graphs clearly shows that the regions 1 and 3 show excellent correlation values.
- However, it is interesting to see that some of the values show undesirable correlation in region 4.
- This region 4 has recorded drought over the years and could say it as drought prone area of Maharashtra.
- With the findings documented, it clearly shows that TRMM and IMD data are very well correlated.

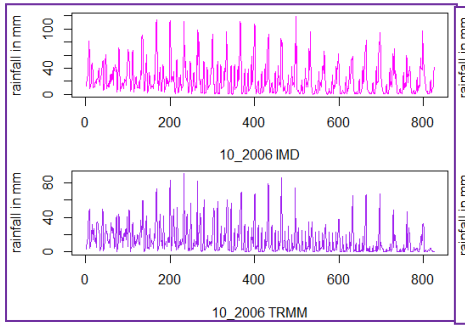
Following are the Trend Analysis Plot for TRMM and IMD data :



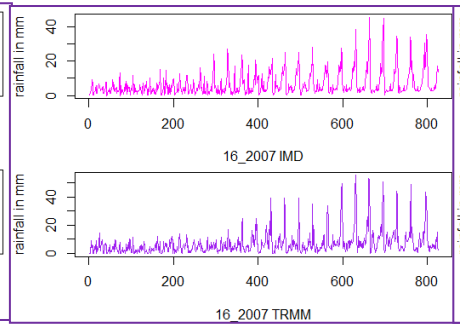


TREND ANALYSIS FOR TRMM AND IMD DATA

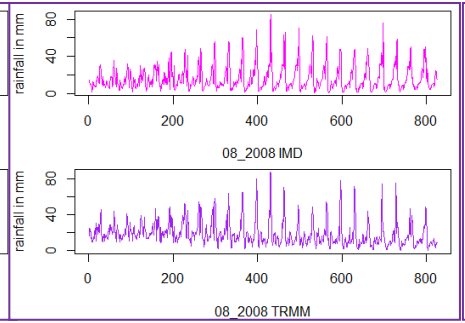
Plot for 13th to 20th Aug 2006



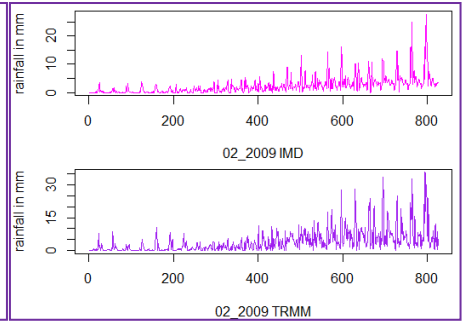
Plot for 30th Sept to 7th Oct 2007



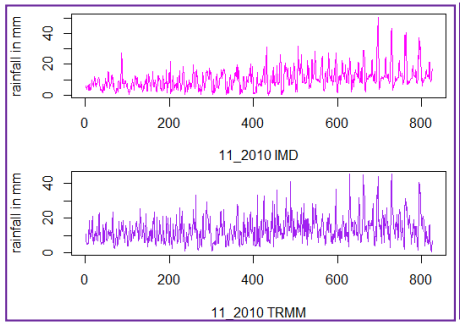
Plot for 28th Jul to 04th Aug 2008



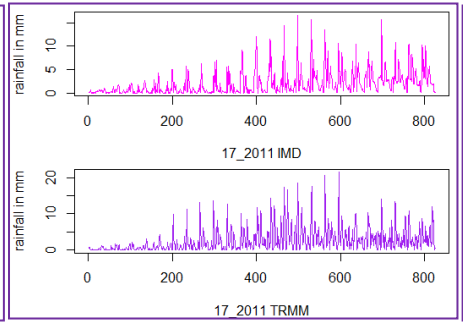
Plot for 09th to 16th June 2009



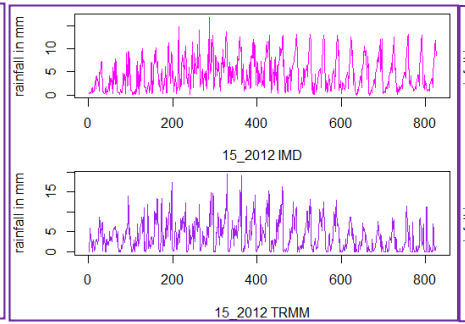
Plot for 21st to 28th Aug 2010



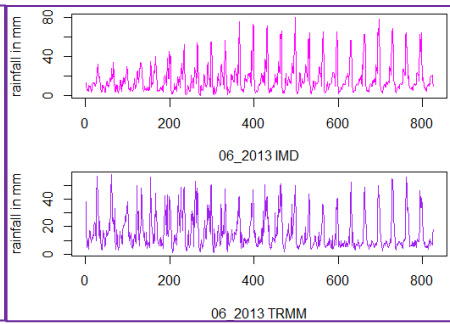
Plot for 08th to 15th Oct 2011



Plot for 22nd to 29th Sept 2012



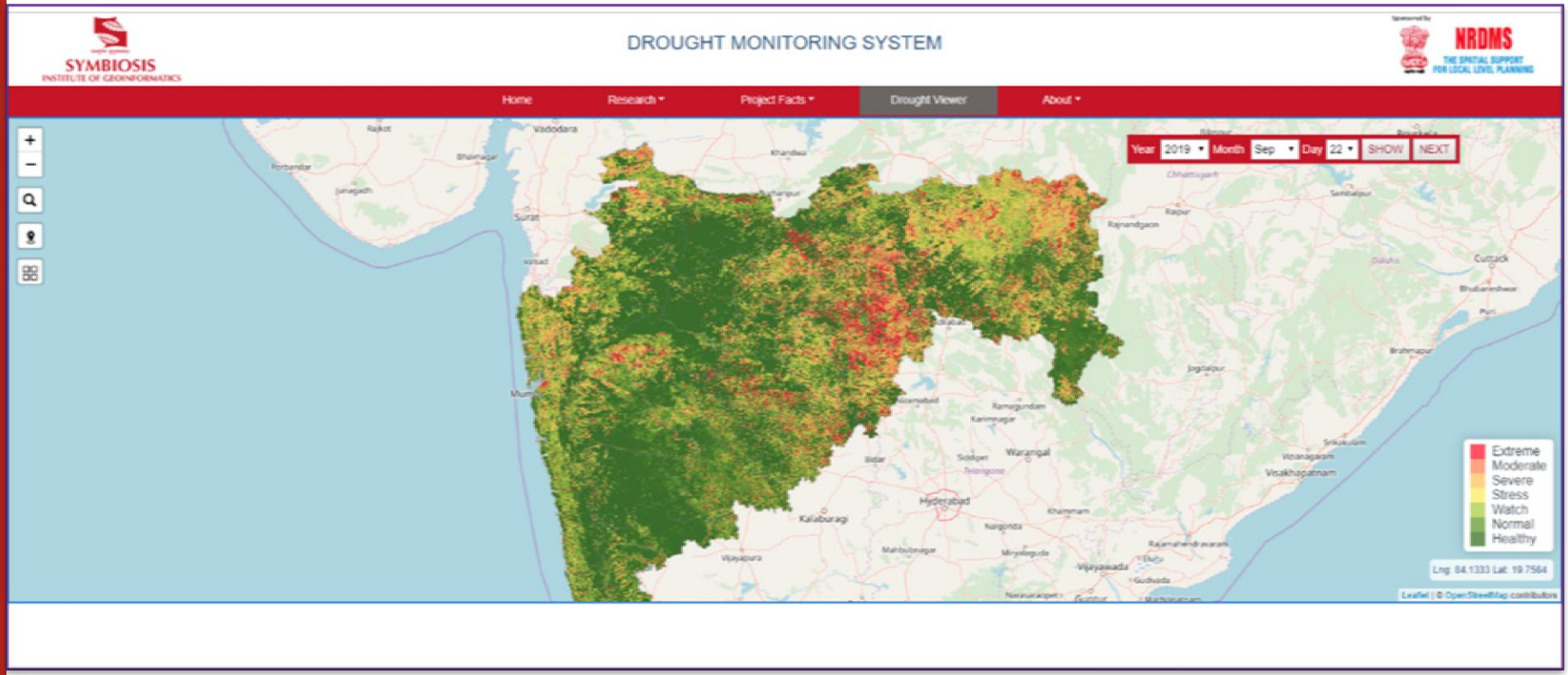
Plot for 12th to 19th Jul 2013



Link to website
Drought Monitoring System

Monitoring Drought– Drought Viewer

http://113.193.17.140/dms/



Thank You !