IMPACTS OF EL NINO ON SEA SURFACE TEMPERATURE AND INDIA'S RAINFALL VARIABILITY BY USING RS AND GIS

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Abstract : Determining the climate variability in India is very difficult. However the analyse is essential in order to determine the factors that affecting the monsoon of India. Finding the factors affecting the NEM and SWM would create a great impact and it will surely benefit to Indian agriculture and Indian economy. The variation on SST of Pacific Ocean is EL NINO and in Indian Ocean termed as Indian Ocean Dipole. The main aim of this project is to determine the climate variability which is based on variation of Sea Surface Temperature, and also to determine the impact of EL NINO and IOD in Indian Monsoon (Both NEM, SWM).Monthly mean SST anomaly data is used for analysing the SST variation in CWDA tool of a remote sensing software. Rainfall data from IMD also used for analysing the rainfall variability and for creating monsoon variability map. The drought years after 2000 is 2002 and 2009. Both are an EL NINO years. We have found the influence of monsoon variability by EL NINO (2002, 2004, 2009, and 2014) and IOD (2003, 2006). The strong EL NINO decrease the SWM about 30% than the average and increase the NEM about 20% than the average. The moderate EL NINO decrease both the SWM, NEM about 15-20% than the normal. The high vulnerable zones of PEN strong are UP, central and Western. The moderate zones are Southern, Tamilnadu and Bengal. The low vulnerable zones are Himalayan and Eastern states.

***IndexTerms* – EL Nino, sea surface temperature, rainfall variability, RS, GIS.**

I. INTRODUCTION

India is the agricultural country. Rainfall is the main source of agriculture in India. Rainfall occurring in June-Sept south-west monsoon account for nearly 76 per cent of the annual precipitation received by the country. More than half of the total cultivated area is dependent on these rains. The inter-annual variability of Indian Monsoon rainfall (both SWM and NEM) has been linked to variations of sea surface temperatures, surface pressure, atmospheric pressure etc. over the Equatorial, Pacific and Indian Ocean. But the SST variation in the Pacific Ocean (EL NINO) and Indian Ocean Dipole (IOD) can affect the monsoon rainfall of India typically .There is strong relation between the El Nino & Indian droughts since 1960, as the country had faced 13 droughts & 10 of these were in the El Nino years.

It may be worth noting that since 1980, all the six droughts faced by India were in the El Nino years, but still not all El Nino years led to drought in the country. Since 1999, there were 4 El Nino years (2002, 2004, 2006 & 2009), & three of these (except 2006) resulted into the drought years.

EL NINO The year 2006, which was an El Nino year, however, received normal monsoon rainfall. This situation has been explained by the phenomenon of Equatorial Indian Ocean Oscillation (EQUINOO) or Indian Ocean Dipole (IOD). In the six El Nino years, IOD was unfavorable and thus leading to droughts. It is necessary to analyse the available data on temperature changes in the Pacific Ocean as well as Indian Ocean to see if it is possible to understand better the relation of these changes with Indian Rainfall. This study will give an awareness regarding the changes in rainfall with the impact of and IOD. The Study was done from 2000 to 2014.

II. STUDY AREA

India i.e. Bharat, officially the Republic of India is a country in south Asia. It is the seventh-largest country by area, the second-most populous country with over 1.2 billion people, and the most populous democracy in the world. Bounded by the Arabian Sea on the south-west, the Indian Ocean on the south and the Bay of Bengal on the south-east. It shares the land borders with Pakistan to the west; China, Nepal, & Bhutan to the north-east, & Myanmar & Bangladesh to the east. In the Indian Ocean, India is in the vicinity of Sri Lanka and the Maldives; in addition, India's Andaman and Nicobar Islands share a maritime border with Thailand and Indonesia.

2.1 Location of the Study Area

India lies in the north of equator between 6° 44' & 35° 30' north latitude, 68° 7' & 97° 25' east longitude. India's coastline measures 7,517 kms (4,700 mi) in length; of this distance, 5,423 kms (3,400 mi) belong to peninsular India & 2,094 kms (1,300 mi) to the Andaman, Lakshadweep & Nicobar island chains. The mainland coastline according to Indian naval hydrographic charts consists of the following:

43% of sandy beaches; 11% of rocky shores, including cliffs; & 46% mudflats/marshy shores. Major Himalayan-origin rivers that substantially flow through India include the Ganges and the Brahmaputra, both of which drain into the Bay of Bengal. The Ganges (important tributaries) include the Yamuna & the Kosi; where the latter's extremely low gradient is often leads to severe floods & course changes. Major peninsular rivers, where steeper gradients prevent their water from flooding, include the Mahanadi, the Godavari, the Krishna and the Kaveri which also drain into the Narmada, the Bay of Bengal & the Tapti, which drain into the Arabian Sea.

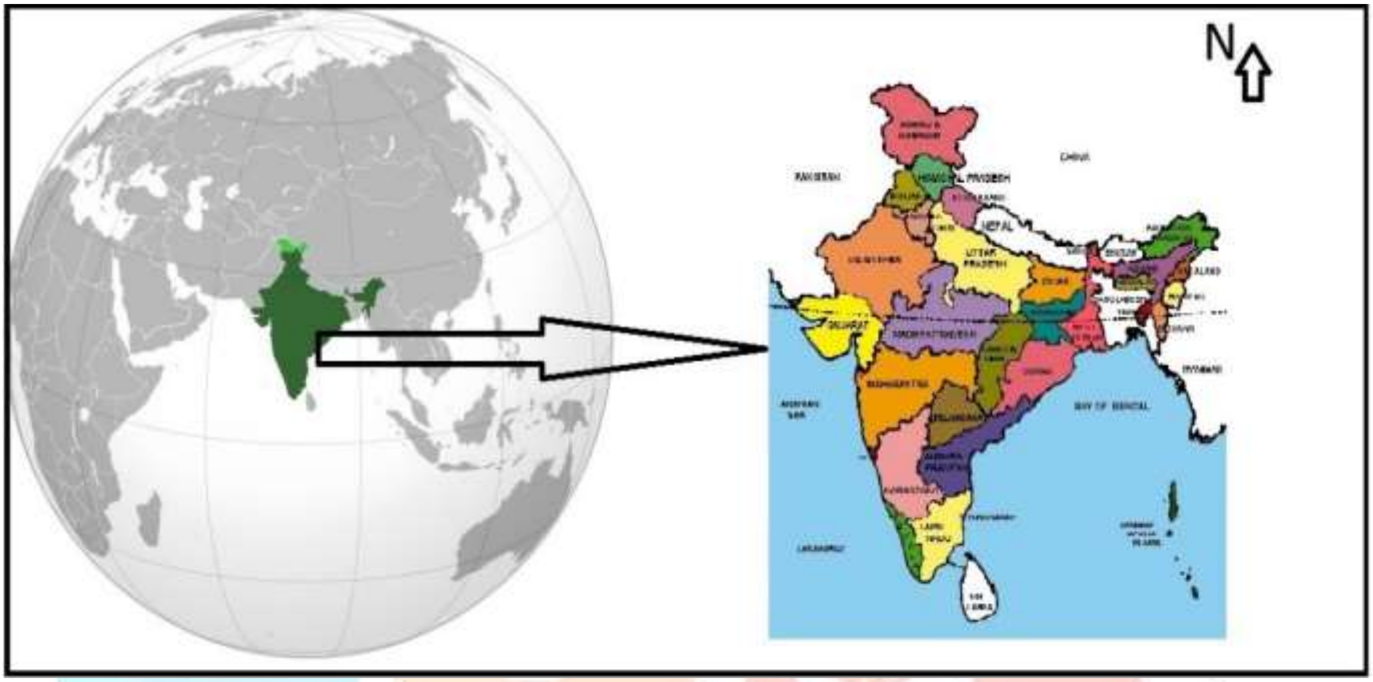


Figure.1 Location of the Study area

III. Objectives

1. To create the meteorological sub division map of India.
2. To create the rainfall map of India.
3. To create the NINO index map by analysing the SST data and to create the IOD index map of Indian Ocean by analysing the SST data.
4. To create the Rainfall variability map of NINO years and to create the Rainfall variability map of IOD years.
5. To quantify the variation of rainfall during NINO and IOD years.
6. To prepare the rainfall vulnerability map of India.

IV. Methods and Methodology

4.1 Data Description

Remote sensing techniques offer a wide range of possibilities in the study of various ocean related parameters. The unique capabilities of satellite based sensors in providing a wide spectrum of information available through the electromagnetic spectrum in repetitive and synoptic coverage over in accessible and larger areas in frequent intervals made the remote sensing technology an effective tool.

The satellite data used in this study is monthly SST anomaly data- NOAA series satellite-AVHRR sensor in HDF file format. The spatial resolution is 50 km with two day repeat cycle. Night time data is used for data processing to get more accurate results. Because of the 50 km resolution the coverage of the data is wider.

4.1.1 SST Anomaly Data

The term temperature anomaly means a departure from a reference value or long-term average. A positive anomaly indicates that the observed temperature was warmer than the reference value, while a negative anomaly indicates that the observed temperature was cooler than the reference value. The data used in this study is SST monthly anomaly data in HDF format. From 2000 January to December 2015, totally 180 monthly anomaly data used for the study.

Hierarchical Data Format (HDF) is a set of file formats (HDF4, HDF5) designed to store and organize large amounts of data. The HDF Group (THG), originally part of the National Centre for Supercomputing Applications (NCSA), is the main source of information on the HDF format specification and software libraries. This format is especially used for many satellites data equations.

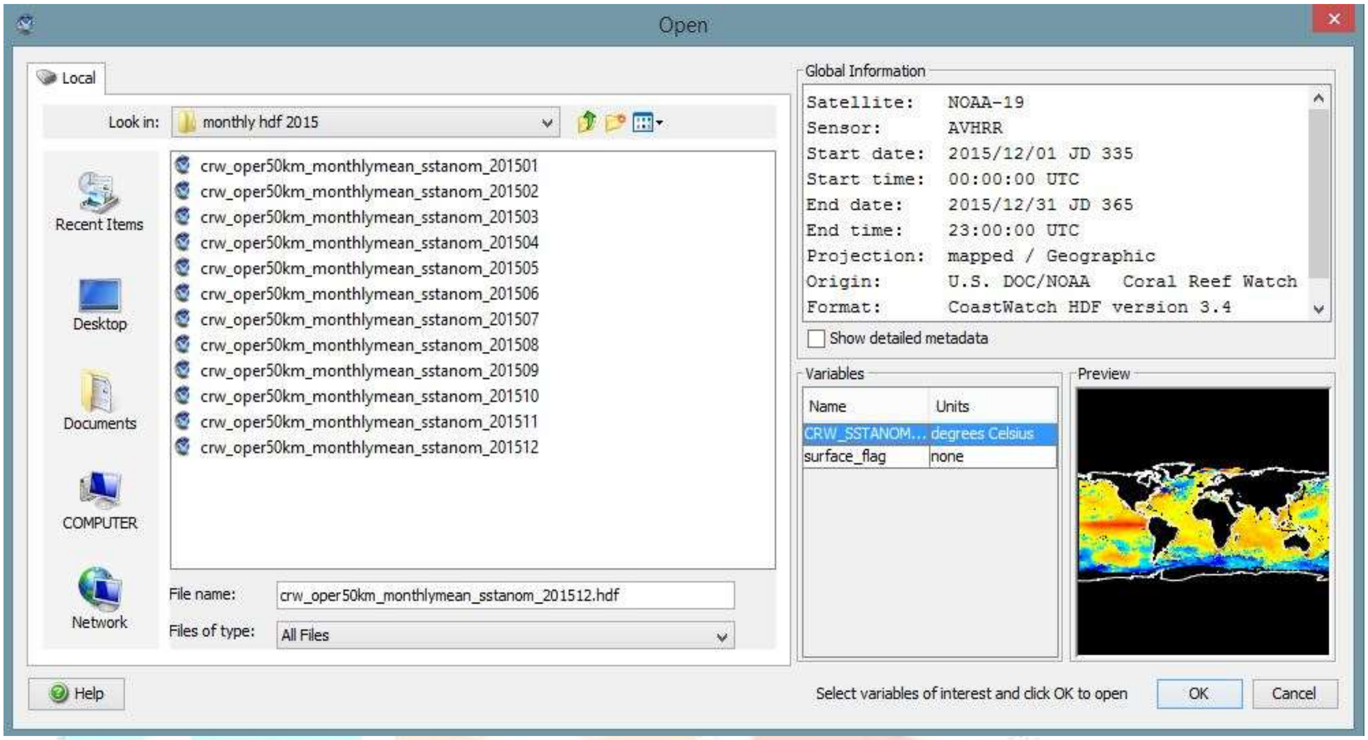
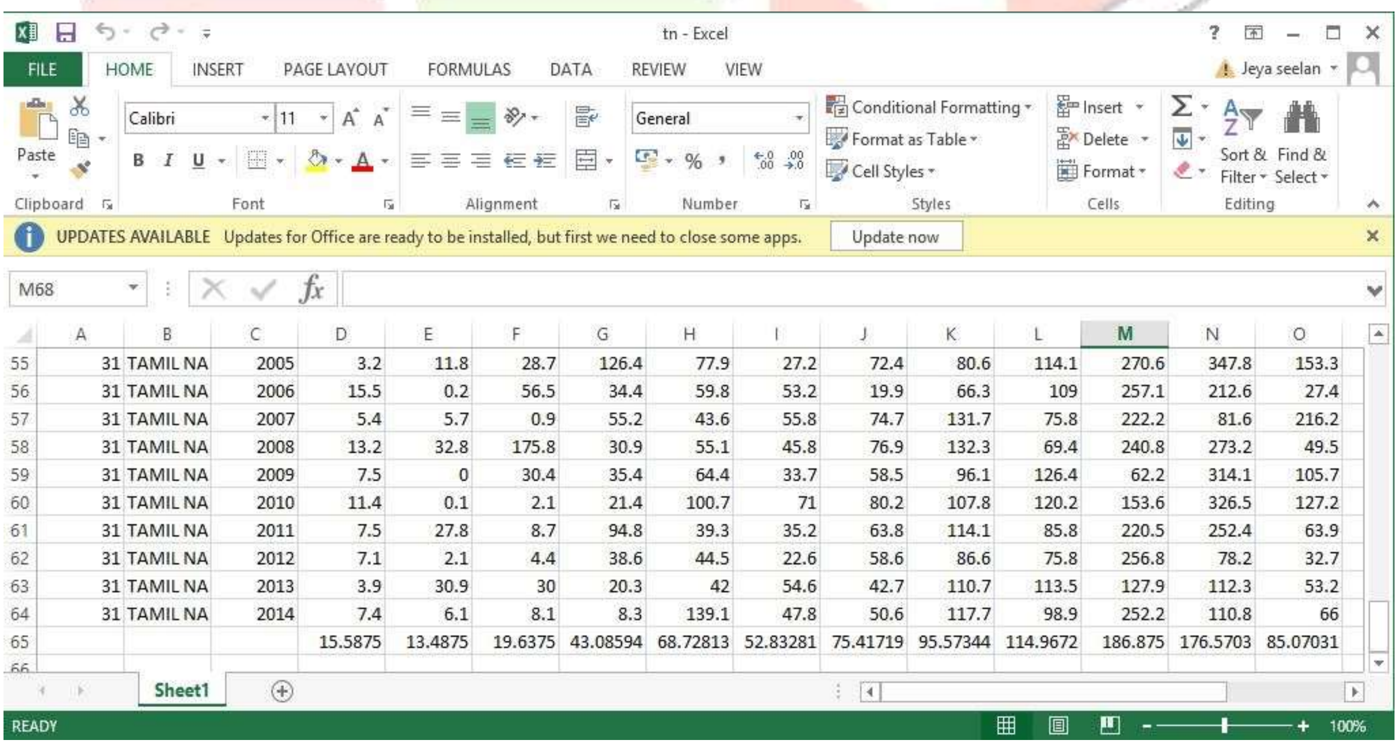


Figure.2 Opening HDF data

4.1.2 Rainfall Data

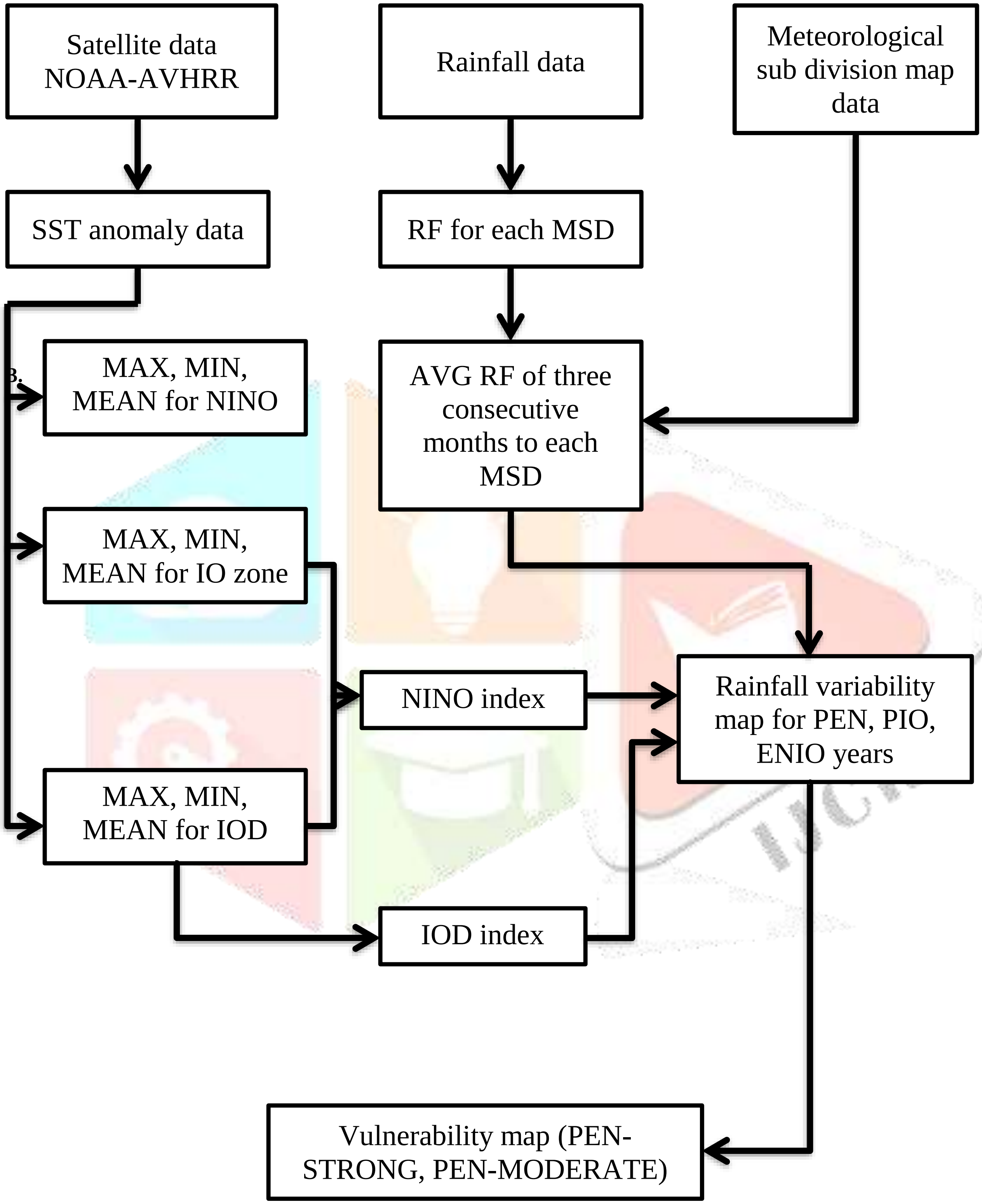
The rainfall data of India from the Indian Meteorological Department is used for the study in .excel format. The data is available for all the meteorological sub divisions of India. Month and season wise data are available also for all the sub divisions.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
55	31	TAMIL NA	2005	3.2	11.8	28.7	126.4	77.9	27.2	72.4	80.6	114.1	270.6	347.8	153.3
56	31	TAMIL NA	2006	15.5	0.2	56.5	34.4	59.8	53.2	19.9	66.3	109	257.1	212.6	27.4
57	31	TAMIL NA	2007	5.4	5.7	0.9	55.2	43.6	55.8	74.7	131.7	75.8	222.2	81.6	216.2
58	31	TAMIL NA	2008	13.2	32.8	175.8	30.9	55.1	45.8	76.9	132.3	69.4	240.8	273.2	49.5
59	31	TAMIL NA	2009	7.5	0	30.4	35.4	64.4	33.7	58.5	96.1	126.4	62.2	314.1	105.7
60	31	TAMIL NA	2010	11.4	0.1	2.1	21.4	100.7	71	80.2	107.8	120.2	153.6	326.5	127.2
61	31	TAMIL NA	2011	7.5	27.8	8.7	94.8	39.3	35.2	63.8	114.1	85.8	220.5	252.4	63.9
62	31	TAMIL NA	2012	7.1	2.1	4.4	38.6	44.5	22.6	58.6	86.6	75.8	256.8	78.2	32.7
63	31	TAMIL NA	2013	3.9	30.9	30	20.3	42	54.6	42.7	110.7	113.5	127.9	112.3	53.2
64	31	TAMIL NA	2014	7.4	6.1	8.1	8.3	139.1	47.8	50.6	117.7	98.9	252.2	110.8	66
65				15.5875	13.4875	19.6375	43.08594	68.72813	52.83281	75.41719	95.57344	114.9672	186.875	176.5703	85.07031

Figure.3 Rainfall Data

4.2 Methodology



V. Results and Discussions

The overall results of EL NINO years and rainfall variability are compared to get the vulnerable zones for EL NINO. The influence of EL NINO on the SWM and NEM are compared. The variation of rainfall with respect to the SST of Pacific Ocean also analysed.

Table.1 SWM MONSOON VARIATION 2002

SL NO	ZONE	AVG SWM in mm	ACT SWM in mm	VARIATION
1	Himalayan	778	715	-9%
2	UP	625	481	-24%
3	Western	586	568	-4%
4	Eastern	1631	1515	-3%
5	Central	866	787	-10%
6	Bengal	1298	1182	-19%
7	Southern	1150	951	-18%
8	TN	338	315	-7%

Table.2 SWM Variation 2004

SLNO	ZONE	AVG SWM in mm	ACT SWM in mm	VARIATION
1	Himalayan	778	715	-9%
2	UP	625	481	-24%
3	Western	586	568	-4%
4	Eastern	1631	1515	-3%
5	Central	866	787	-10%
6	Bengal	1298	1182	-19%
7	Southern	1150	951	-18%
8	TN	338	315	-7%

Table.3 SWM Variation 2014

SL NO	ZONE	AVG SWM in mm	ACT SWM in mm	VARIATION
1	Himalayan	778	684	-13%
2	UP	625	325	-48%
3	Western	586	552	-6%
4	Eastern	1631	1556	-5%
5	Central	866	751	-14%
6	Bengal	1298	1223	-18%
7	Southern	1150	1116	-6%
8	TN	338	315	-8%

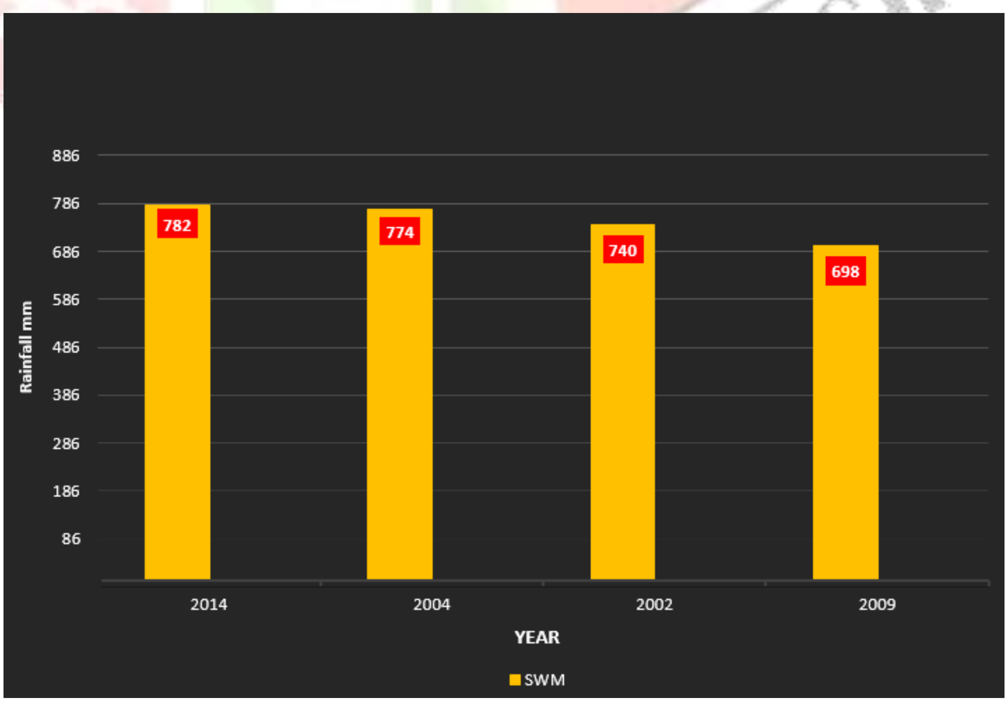


Figure.4 SWM Variability of Pen Years

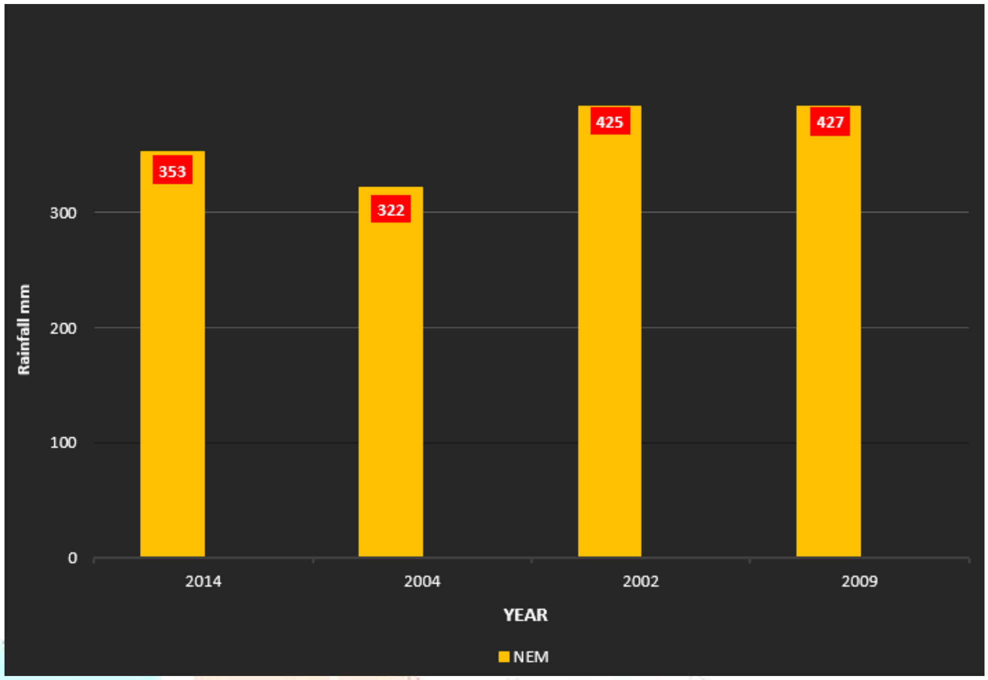


Figure.5 NEM Variability of Pen Years

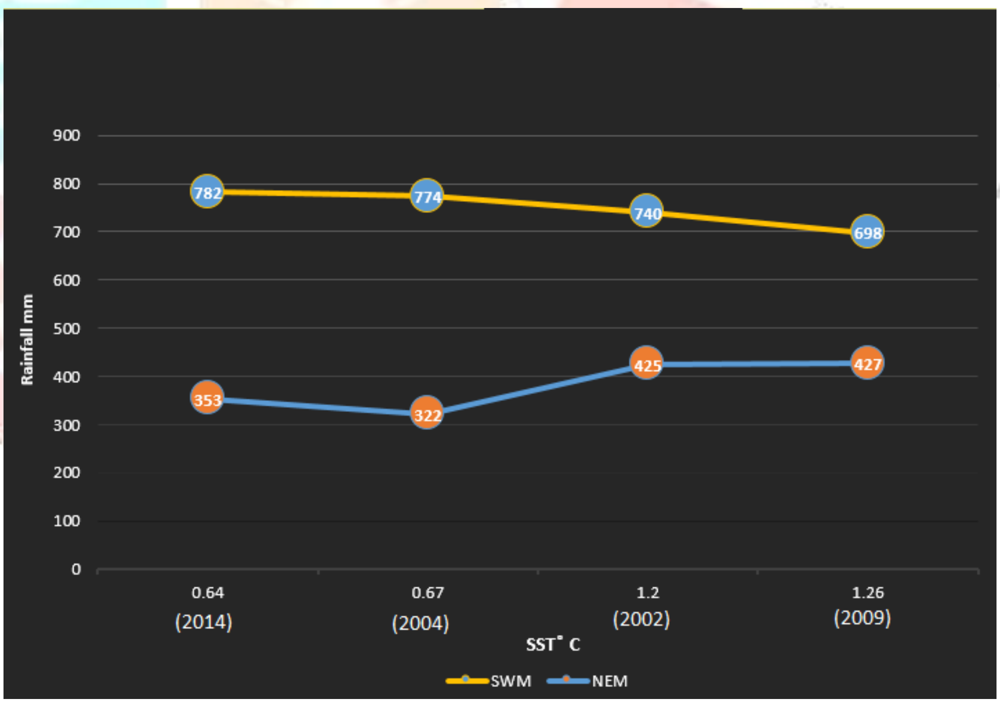


Figure.6 Rainfall Variability With Respect To the SST

5.1 Vulnerability Map of India for PEN

5.1.1 Vulnerability Zones to PEN - Strong

According to the combined results comparison (From 2000 to 2014), the vulnerable zones for Pure EL NINO year with strong influence on Pacific Ocean (more than 1.2 C) and on Indian Ocean (more than 0.6 C) are identified. A strong Pure EL NINO can decrease the India's South West Monsoon rainfall up to 30%. But on the other hand a Strong PEN increase the North East Monsoon of India up to 15-20%. The rainfall increase and decrease will be based on the influence of SST on Pacific Ocean and Indian Ocean. The direct influence of rainfall of SWM will be more in UP zone, Central zone and western zone when PEN-Strong occurs. Bengal zone, Sothern zone, Tamilnadu have up to 20 % effect of their average rainfall. Himalayan zone and Eastern zone have only less effect of the Strong PEN. The NEM will be increase in the Southern states like Tamilnadu, Kerala, Karnataka and Andhra Pradesh up to 20 %. So the Strong Pure EL NINO can increase the NEM monsoon and decrease the SWM.

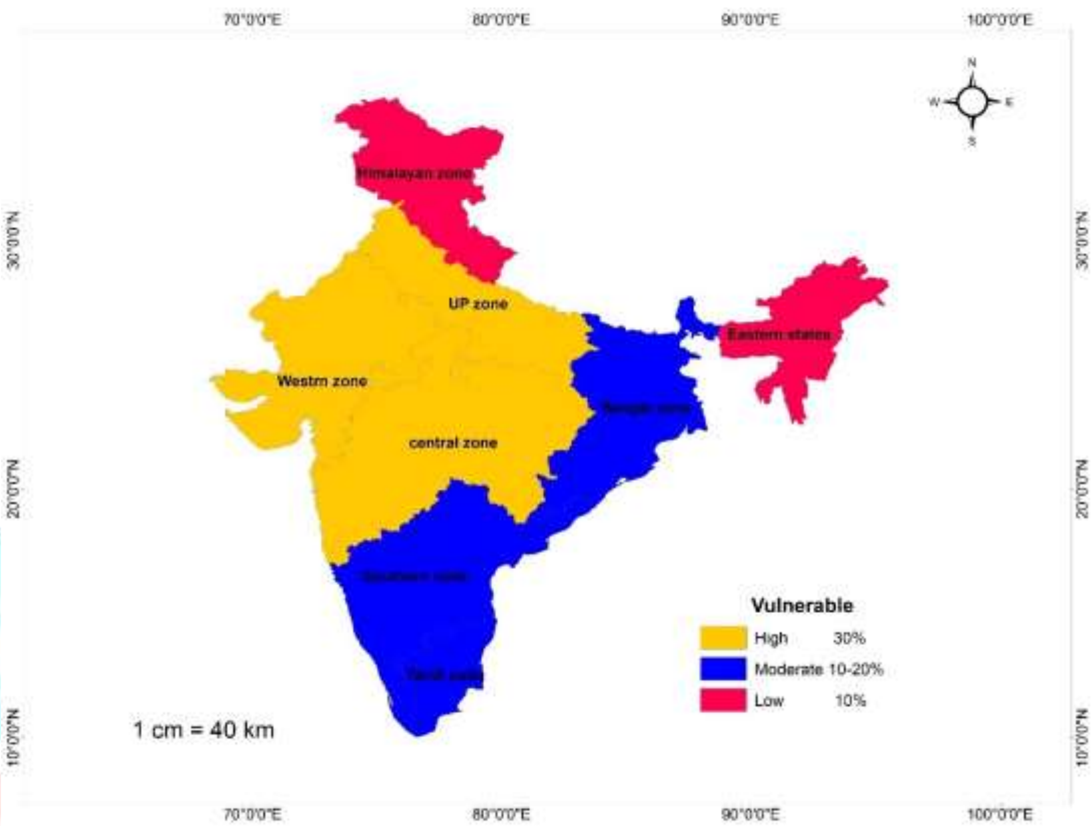


Figure.7 Vulnerability Zones of SWM for PEN-Strong

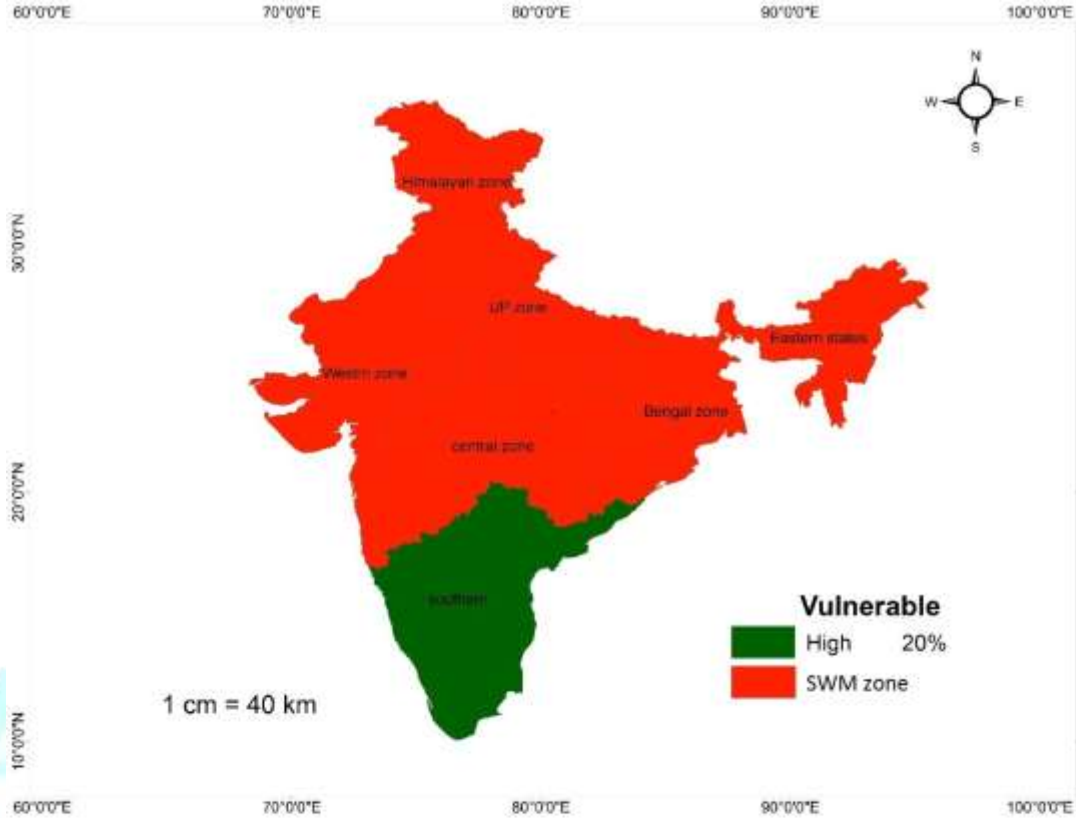


Figure.8 Vulnerability map for PEN-STRONG to NEM

5.1.2 Vulnerability Zones to PEN-Moderate

A Pure EL NINO year with moderate influence on Pacific Ocean (more than 0.8 C) and on Indian Ocean (more than 0.35 C) can affect the rainfall of India. A Moderate Pure EL NINO can decrease the India's South West Monsoon rainfall up to 20% and the North East Monsoon of India up to 15-20 %.

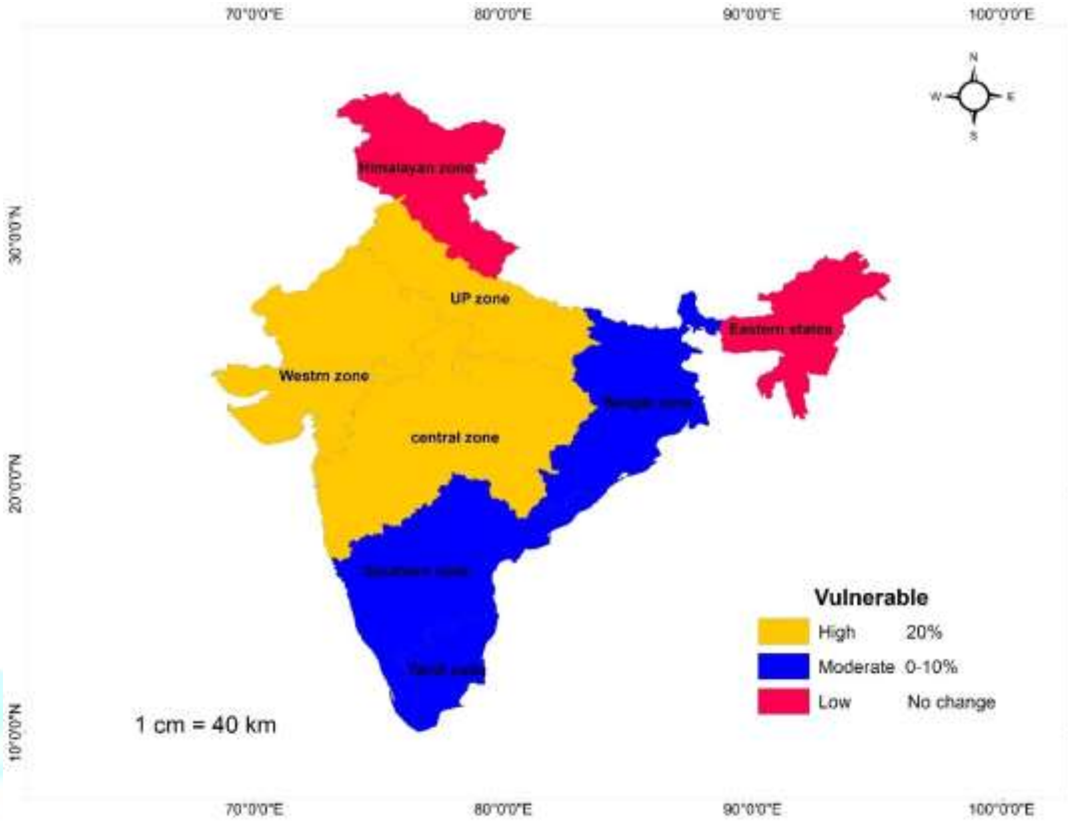


Figure.9 Vulnerability map for PEN-STRONG to NEM

The high affect zones of Moderate EL NINO years are UP, Central, Western. During the Moderate-PEN years the zones under high may receive 20% lesser than their average rainfall. The Moderate zones will receive 0-10% lesser than average. The other zones will not affected by moderate –PEN years.

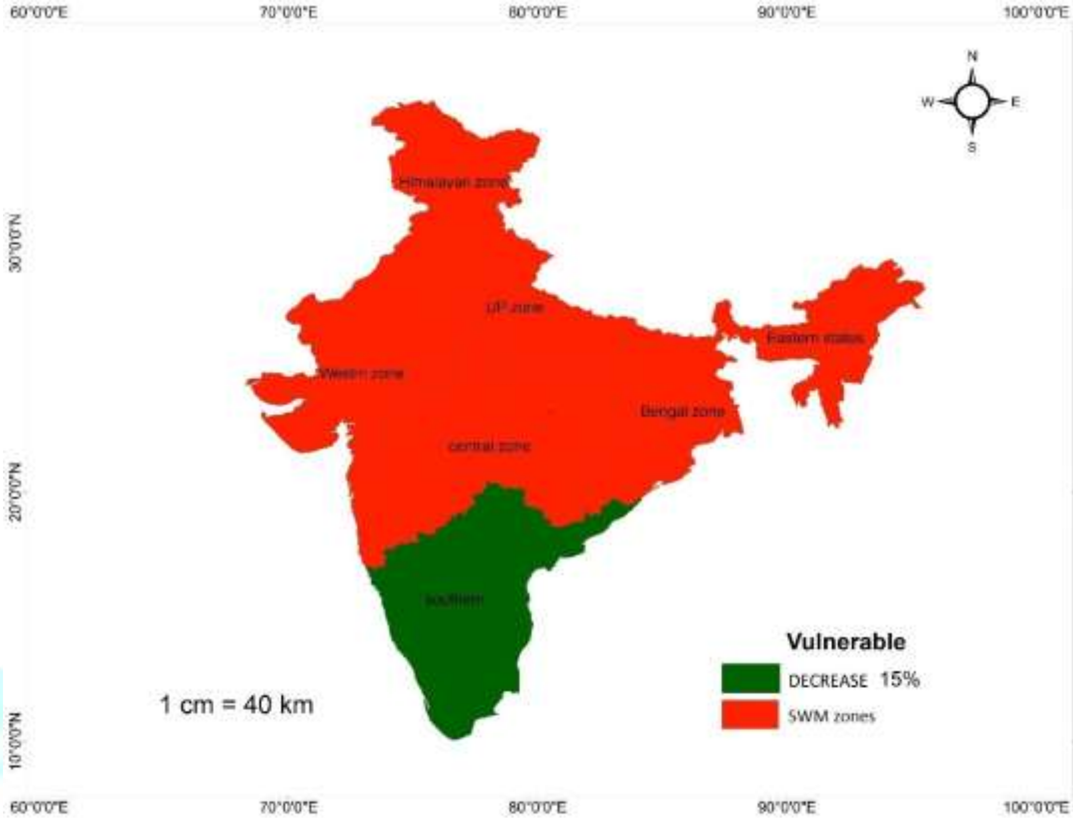


Figure.10 Vulnerability Zones of NEM for PEN-Moderate

VI. Conclusion

Remote sensing data have been found to be extremely useful for provide spatial and non-spatial information. With the help of satellite based map and digital information all the required information are integrated in the GIS based mapping system which is finally concluded as follows,

1. Generally EL NINO starts from June and extended up to 7-12 months.
2. An EL NINO can affect the SWM rainfall and NEM rainfall of India.
3. A moderate EL NINO can decrease the NEM rainfall.
4. A strong EL NINO can decreases the SWM rainfall and cause the drought like conditions. On the other hand a strong EL NINO increases the NEM rainfall.
5. When there is increase of SST in Indian Ocean SWM rainfall will decreases and NEM rainfall will increases.
6. When there is increase in SST of Eastern Equatorial Indian Ocean SWM rainfall maximally get decreased. (Cause Drought like conditions)
7. When both EL NINO and IOD occurs, the influence of EL NINO on rainfall of India will decreased by the IOD. IOD negated the effect of EL NINO and give the average rainfall to SWM and higher rainfall to NEM.
8. When IOD only occurs the SWM rainfall increases and NEM have no change.
9. Vulnerable zones of India to EL NINO are,
10. High Vulnerable regions are UP, Central and western.
11. Moderate Vulnerable regions are Southern, Bengal Zone, Tamil Nadu.
12. Low Vulnerable regions are Eastern and Himalayan regions.

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