Agriculture crop condition assessment using satellite based vegetation condition index and rainfall anomaly index over Selected Village in Tehsil Nawagarh and Pamgarh in Chhattisgarh, India

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ABSTRACT

Nawagarh and Pamgarh Tehsil, Janjgir-champa District, Chhattisgarh state located in central India. Agriculture is dependent on the monsoon is critical in ensuring food availability to people of Chhattisgarh in India. Agricultural crop condition is environmental phenomenon which can be depending in meteorological, agricultural and hydrological condition, its stage – rainfall level of impacts on hydrological cycle and agro-ecosystems.

Agricultural crop condition is one of the most affecting economies in Nawagarh and Pamgarh. Agricultural crop condition has been a recurrent phenomenon in many part of India. Remote sensing plays an important role for near-real time monitoring of the crop condition over large area. In the present study LANDSAT-8 data from 2013, 2014, 2017 and 2018 were used for monitoring agricultural crop condition through NDVI based Vegetation condition index. VCI was calculated for whole study area. Rainfall Anomaly Index was computed from CPC NOAA South Asia observed rainfall data from 2013, 2014, 2017 and 2018 for monitoring of meteorological drought condition of study area.

Results revealed that RAI and VCI could capture spatial pattern of vegetation condition and dryness within seasons and across different years, the results show that Nawagarh and Pamgarh Tehsil in selected village was the affected area due to crop condition.

Keyword: - *Agricultural crop condition, LANDSAT-8, NDVI, VCI, RAI.*

1. INTRODUCTION

Chhattisgarh state has a rich natural endowment of land, water forest and annual average rainfall of 1350 mm. Chhattisgarh is primarily a mono crop area. Paddy is the principal crop, generally grown in Kharif season. This season starts from mid-June to mid-October. The Rabi crop is generally not taken due to various reasons. The principle factor influencing the issue is that the Rabi season, very little moisture is left in the root zone, temperature rises rapidly by mid-January and soils are light. The soils are reddish brown and devoid of many key nutrients. Rain fall is adequate for growing paddy. In many areas it is more than required. Excess rainfall leads to removal of top soils and nutrients. Due to excess rainfall, in few areas, the crop fails. This is defined as "Paniya Aakal" - drought due to excess rain. There are dry spells in the Kharif season. Due to these dry spells, the crop fails. This leads to drought. (State IAG Chhattisgarh Joint Need Assessment Report on Drought in Chhattisgarh May 2016).

Meteorological indices estimation in meteorological condition monitoring is based mainly rainfall data. There are many indices which incorporate historic rainfall data for a given time period commonly used indices are, Rainfall Anomaly Index (RAI), (N.R.Patel et. al., 2015), Standardized Precipitation Index SPI,(Nalbantis&Tsakiris,

2009) and Palmer Drought Severity Index (PDSI) (Jie WEI and Ailikun, 2009). Every index has its own advantages and disadvantages. Satellite data are effective in regional estimation and also for early warning of drought. It gives spatial information which is necessary for regular monitoring of drought. Various satellite based indices are developed like Normalized Difference Vegetation Index NDVI, Vegetation Condition Index VCI (Kogan, 1990), Temperature condition index was also suggested by (Konag 1997), (Thenkabail et. al. 2004), Vegetation Temperature condition index (Z. Wang et. al. 2004) and many more are used for crop condition monitoring. With the availability of LANDSAT-8, NDVI data it is easy to monitor short term Agricultural crop condition stress as it provides vegetation data.

2. STUDY AREA

Study area is Janjgir-champa district, Nawagaeh and Pamgarh Tehsil in selected Village (Fig.1). It comprises of study area Nawagarh Tehsil in total 73 villages and Pamgarh Tehsil in total 74 villages in Chhattisgarh, India.

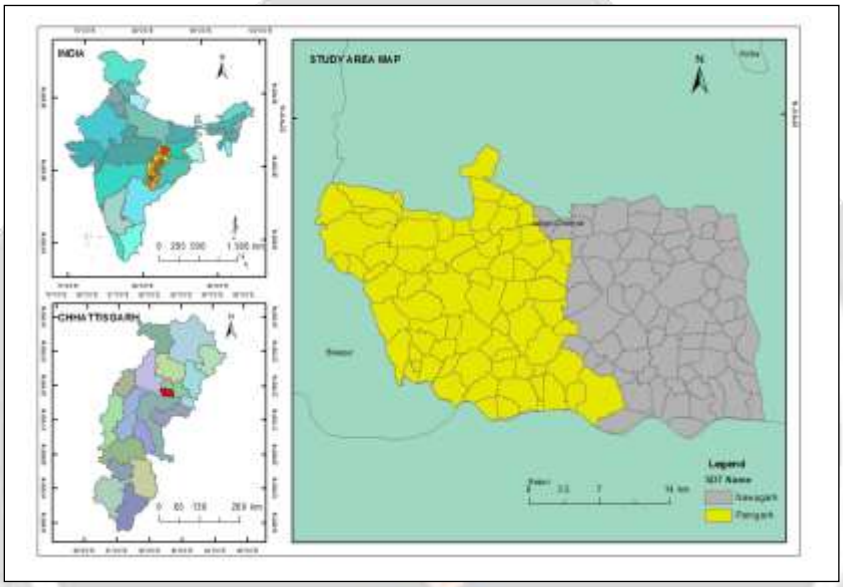

Fig -1: Location of study area

3. MATERIALS AND METHODOLOGY

3.1 Data Actuation

Data has been acquired from two sources: NDVI derived from satellite sources (04 years - monthly composite) and Rainfall Data from meteorological satellite data (NOAA CPC.) sources (04 years data- monthly composite).

Satellite data LANDSAT-8 satellite data was downloaded through distribution server: (USGS) Earth Explorer. The data is kharif season composite NDVI for India from which Chhattisgarh, Janjgir–champa district, Nawagarh and Pamgarh Tehsil was extracted from Jun to Nov for 2013, 2014, 2017, and 2018. This data is used for calculating vegetation condition index for crop condition monitoring. Its image has a constant resolution of 30 meter.

Meteorological data NOAA- CPC satellite data was downloaded freely through server: ftp://ftpprd.ncep.noaa.gov/pub/cpc/fews/S.Asia/data/ . The data is monthly composite climate prediction center in South Asia reason for India from which Chhattisgarh, Janjgir–champa district, Nawagarh and Pamgarh was extracted from Jun to Nov for 2013, 2014, 2017, and 2018. This data is used for calculating Rainfall Anomaly index for meteorological condition monitoring. Its image has a constant resolution of 0.1 degree providing monthly coverage of earth's surface.

3.2 Methodology

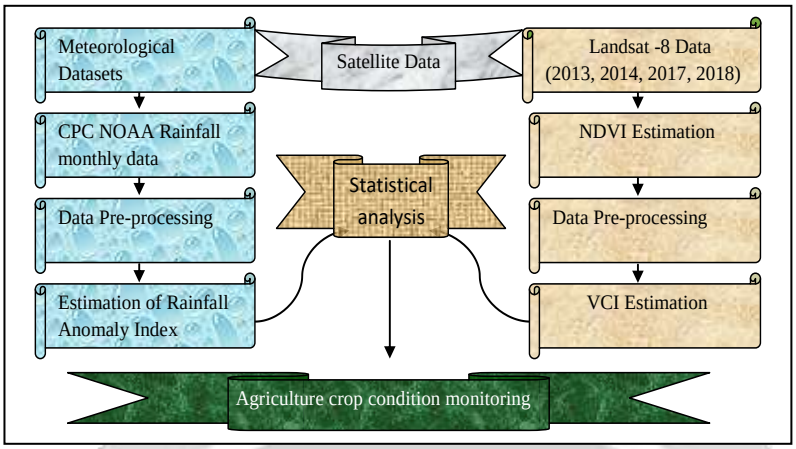

Fig -2: Methodology of study area

Here is an idea of methodology used in study area. Correlation technique is used to show the relationship between RAI, and VCI (kharif) in study area. The flow chart mentioned below (Fig.2) explains about the methodology for this research work. VCI was calculated from NDVI image on basis from 2013, 2014, 2017 and 2018. Rainfall data was also used for the 2013, 2014, 2017 and 2018 year. Rainfall data basis calculated in Rainfall anomaly. These indices were then used for some correlation with RAI & VCI for detecting the impact of agricultural crop condition.

3.2 Index Calculation

Under this part various indices (satellite and meteorological) are explained.

3.2.1 Normalized Differential Vegetation Index (NDVI)

The drought severity analysis was done on temporal basis for *2013,2014,2017,2018* years. The NDVI was used to estimate the vegetation condition on basis as given in this equation.

$$NDVI = (NIR-R) / (NIR+R)$$

Where NIR is reflectance in near infrared band and R is reflectance in red band. Its value ranges between -1 to +1. Negative value indicates weak vegetation and positive indicates healthy vegetation.

3.2.2 Vegetation Condition Index (VCI)

It is a pixel wise normalization of NDVI over some time period, developed by Kogan (1990, 1995) to make a relation statement of changes in the NDVI signal by filtering out the contribution of local geographic resources to the spatial variability of NDVI. The VCI is computed as.

$$VCI = (NDVIi – NDVImin) / (NDVImax- NDVImin)$$

Where, NDVIi is the smoothed weekly NDVI, NDVImax, and NDVImin are maximum and minimum NDVI, respectively, for that pixel and monthly period from multiyear smoothed NDVI data and i define the monthly interval. Its value ranges from 0 to 100.It is measured as percent. VCI with 50% value reflects fair vegetation condition, 50-100% indicates above normal. When VCI is 100%it suggests that NDVI value of that month is equal to NDVImax which indicates the optimum condition for vegetation.

3.2.3 Rainfall Anomaly index (RAI)

To indicate the meteorological drought for the growing season of kharif crop rainfall anomaly index is computed. Rainfall anomaly index give the drought years, the year with highest and lowest as well as the impact of drought and its severity in the study area. In this technique, the rainfall values for the period of study were ranked in the descending order of the magnitude with the highest rainfall being ranked first and lowest rainfall being ranked last. This technique developed by Van Rooy (1965).

$$RAI = \{(RFi - RF\ mean) / RF\ mean\} * 100$$

Where, RFi – is rainfall during month, RF mean - average rainfall at the same time during many years. Unit in mm the value ranges from -100 to ∞.

4. RESULTS AND DISCUSSION

This chapter discusses about the total study that evaluate the agricultural crop condition in study area using Satellite derived index (VCI), meteorological based index (RAI) and the comparison between VCI and RAI for getting the idea that which approach is best for monitoring crop condition using LANDSAT-8-NDVI data. The data of 2013, 2014, 2017 and 2018 is considered as the time period for monitoring crop condition.

4.1 Analysis of satellite based Meteorological and Agricultural condition monitoring

Rainfall and Normalized Differential Vegetation index has been computed for study area. RF and NDVI have been computed for the Jun to Nov, kharif season for the year 2013, 2014, 2017 and 2018.

Satellite based meteorological rainfall data in study area. The results during kharif season between Jun to Nov during 2013, 2014, 2017 and 2018 show the meteorological rainfall, which are a series of maps indicating the stress condition in each monthly period. The Figure -3 depict that the low values of rainfall shows meteorological condition and high value of rainfall shows the normal condition.

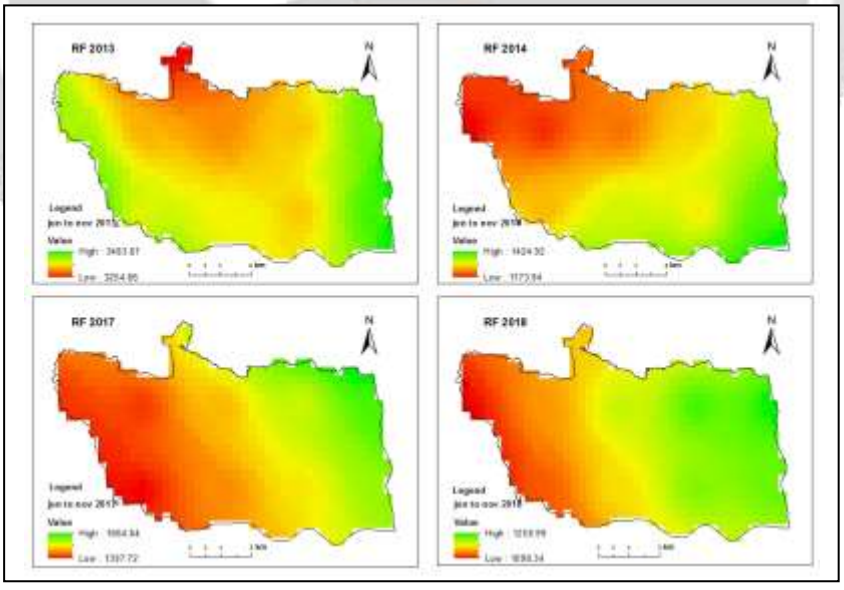

Fig -3: Rainfall 2013, 2014, 2017 and 2018

Satellite based NDVI monitoring in study area was. The results of monitoring NDVI during kharif season between Jun to Nov during 2013, 2014, 2017 and 2018 show the NDVI, which are a series of maps indicating the stress condition in each monthly period. The Figures -4 depict that the low values of NDVI shows severe crop condition and high value of NDVI shows the healthy crop condition.

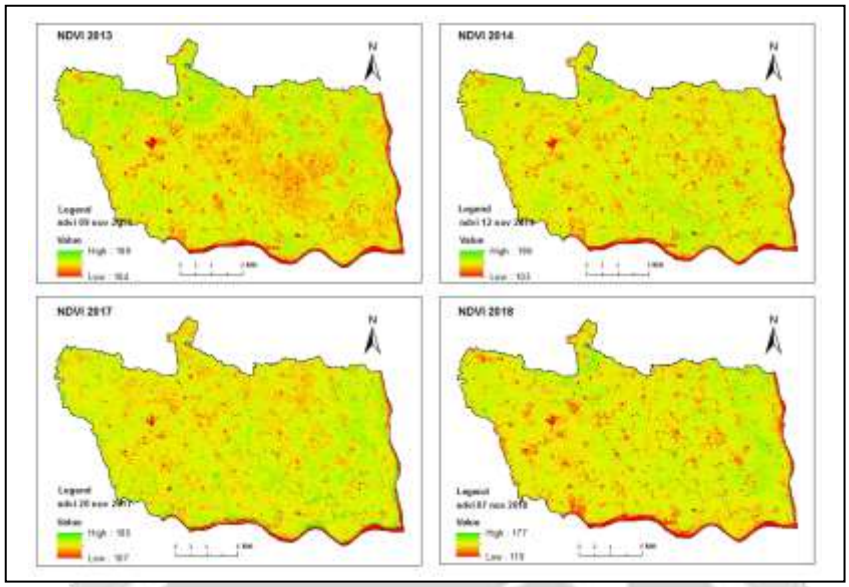

Fig -4: NDVI 2013, 2014, 2017 and 2018

4.1.1 Satellite based RAI Meteorological drought condition monitoring

Satellite based meteorological drought condition monitoring in study area was carried out using RAI. The results show the meteorological drought condition during kharif season between Jun to Nov during 2013, 2014, 2017 and 2018 which are a series of maps indicating the drought' condition in each monthly period. Figures -5 Show the drought condition.

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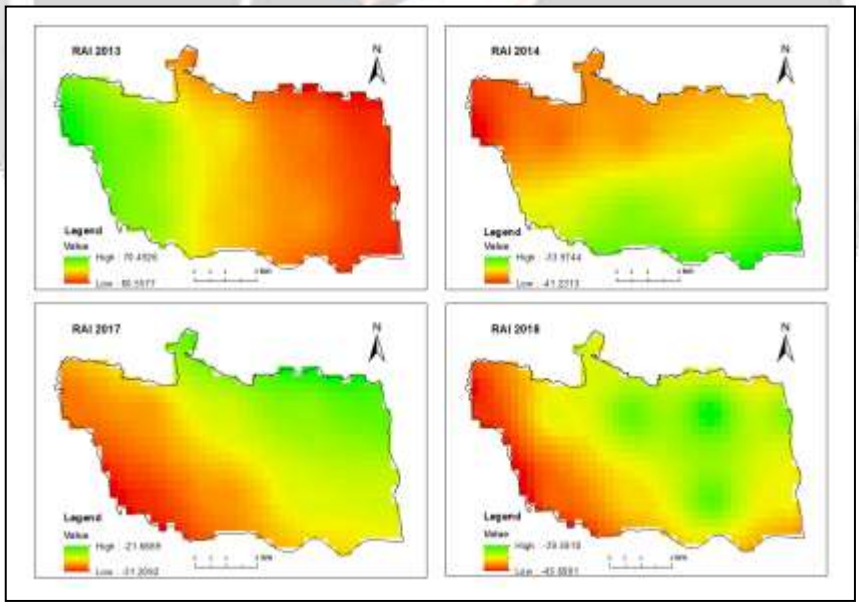


Fig -5: RAI meteorological drought condition 2013, 2014, 2017 and 2018

4.1.2 Satellite based VCI Agricultural crop condition monitoring

Satellite based agricultural crop condition monitoring in study area was carried out using VCI. The results show the agricultural crop condition during kharif season between Jun to Nov during 2013, 2014, 2017 and 2018 which are a series of maps indicating the crop' condition in each monthly period. Figures -6 Show the agricultural crop condition.

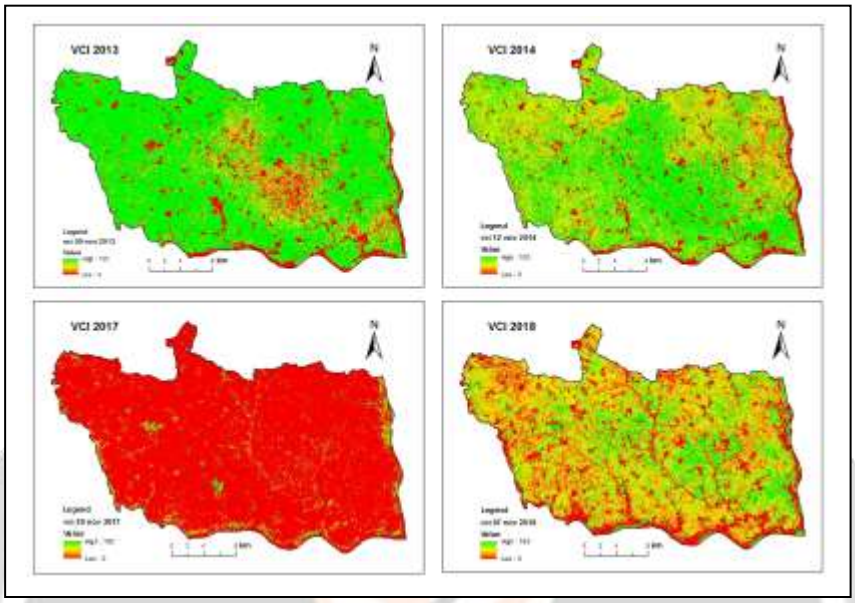
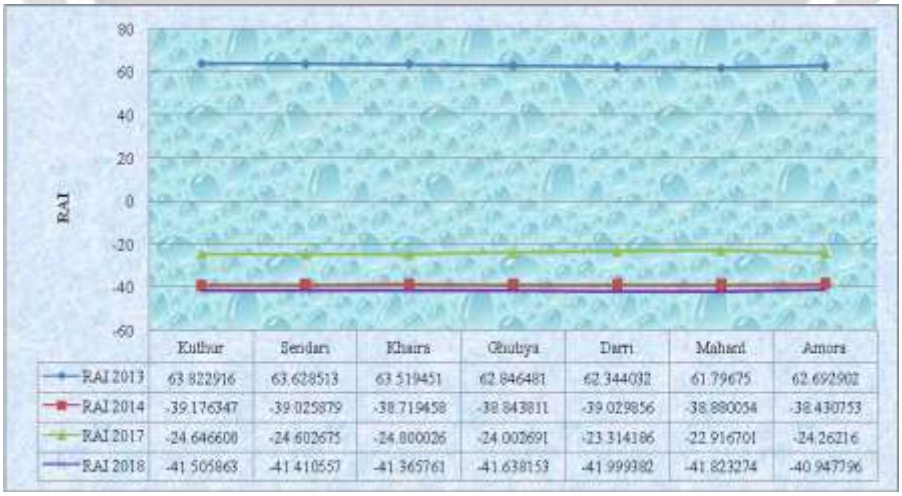


Fig -6: VCI agricultural crop condition 2013, 2014, 2017 and 2018

4.2 Comparison between RAI selected Tehsil Nawagarh and Pamgarh in village wise

Nawagarh and Pamgarh village for temporal pattern of RAI during 2013, 2014, 2017 and 2018.

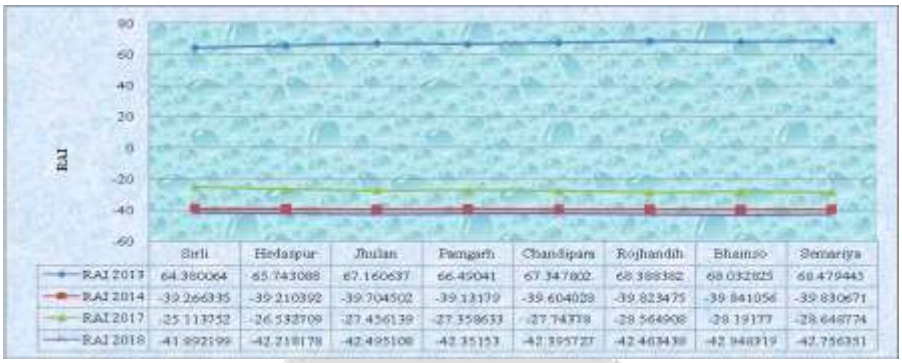
4.2.1 Nawagarh RAI 2013, 2014, 2017, 2018



	Kuthur	Sendari	Khaira	Ghutiya	Darri	Mahard	Amora
RAI 2013	63.822916	63.628513	63.519451	62.846481	62.344032	61.79675	62.692902
RAI 2014	-39.176347	-39.025879	-38.719458	-38.843811	-39.029856	-38.880054	-38.430753
RAI 2017	-24.646608	-24.602675	-24.800026	-24.002691	-23.314186	-22.916701	-24.26216
RAI 2018	-41.505863	-41.410557	-41.365761	-41.638153	-41.999382	-41.823274	-40.947796

Fig -7: Nawagarh RAI 2013, 2014, 2017 and 2018 study area

4.2.2 Pamgarh RAI 2013, 2014, 2017, 2018



	Sirli	Hedaipur	Jhulan	Pamgarh	Chandipara	Rojhandih	Bhainso	Semariya
RAI 2013	64.380064	65.743088	67.160637	66.45041	67.347802	68.388382	68.032825	68.479443
RAI 2014	-39.266335	-39.210392	-39.704502	-39.13179	-39.604028	-39.823475	-39.841056	-39.830671
RAI 2017	-25.113752	-26.532709	-27.456139	-27.358633	-27.74378	-28.564908	-28.19177	-28.648774
RAI 2018	-41.892199	-42.218178	-42.495108	-42.35153	-42.395727	-42.463438	-42.948319	-42.756351

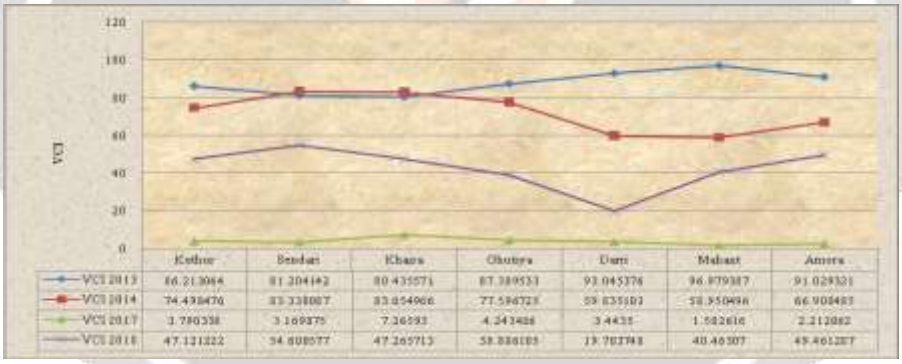
Fig -8: Pamgarh RAI 2013, 2014, 2017 and 2018 study area

The Figure -7 shows the Nawagarh had maximum RAI Kuthur village in the year of 2013 and minimum RAI Darri village in the year of 2018. In case of RAI the Figure -8 shows the Pamgarh had maximum RAI Semariya village in the year of 2013 and minimum RAI Bhainso village in the year of 2018.

4.3 Comparison between VCI selected Tehsil Nawagarh and Pamgarh in village wise

Nawagarh and Pamgarh village for temporal pattern of VCI during 2013, 2014, 2017 and 2018.

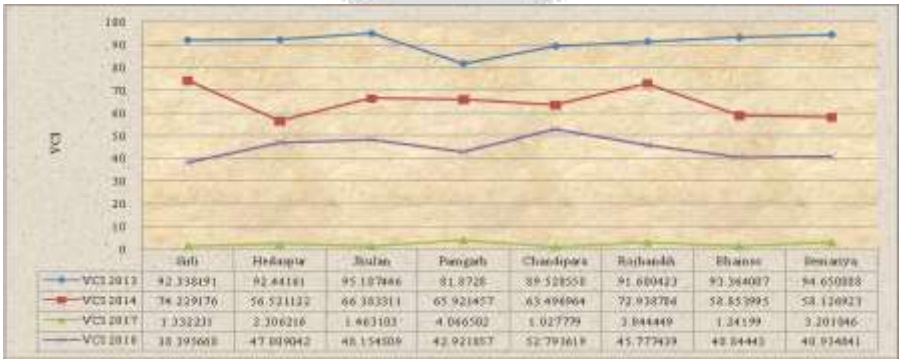
4.3.1 Nawagarh VCI 2013, 2014, 2017, 2018



	Kuthur	Bandari	Khaira	Ghuiya	Dari	Mahasi	Amora
VCI 2013	86.213084	81.204492	80.435571	87.389533	93.045376	96.879387	91.029321
VCI 2014	74.438476	83.338087	83.054966	77.594723	59.835102	58.950996	66.908483
VCI 2017	3.790338	3.169375	7.26293	4.243486	3.4435	1.582616	2.212082
VCI 2018	47.121222	54.808577	47.265715	58.886183	19.703798	40.46307	49.461287

Fig -9: Nawagarh RAI 2013, 2014, 2017 and 2018 study area

4.3.1 Pamgarh VCI 2013, 2014, 2017, 2018



	Sirli	Hedaipur	Jhulan	Pamgarh	Chandipara	Rojhandih	Bhainso	Semariya
VCI 2013	92.338191	92.44181	95.187446	81.8728	89.528558	91.680423	93.364087	94.650888
VCI 2014	74.229176	56.521122	66.383311	65.921457	65.496964	72.938784	58.853995	58.126923
VCI 2017	1.332231	2.306216	1.463103	4.046502	1.027779	3.844449	1.24199	3.201046
VCI 2018	38.395668	47.809042	48.154509	42.921857	52.793619	45.777439	48.84443	48.934841

Fig -10: Pamgarh RAI 2013, 2014, 2017 and 2018 study area

The Figure -9 shows the Nawagarh had maximum VCI Mahant village in the year of 2013 and minimum VCI Mahant village in the year of 2017. In case of VCI the Figure -10 shows the Pamgarh had maximum VCI Jhulan village in the year of 2013 and minimum VCI Chandipara village in the year of 2017.

5. CONCLUSIONS

This section discusses about the results of the various different method used in this study for satellite based Agricultural crop condition monitoring in study area.

A practical approach was developed in the study for crop condition monitoring in study area. The approach was based on Vegetation Condition index from LANDSAT-8 satellite data and Rainfall Anomaly Index computed from CPC NOAA South Asia observed rainfall data. Assessment of crop condition monitoring then establishes from the correlation RAI and VCI.

The first conclusion from this research is that method for crop condition monitoring as they account for both satellite as well as meteorological data. They give better results in real time crop condition monitoring. VCI provides good information spatially for crop condition monitoring.

The correlation between meteorological indices and satellite indices suggest that VCI gives better information about vegetation because it does not only describe the land use but also depicts the impact of weather on crop condition. VCI is a good indicator for detecting crop on seasonal basis.

The main study area in this research deals with RAI and VCI. The overall outcome of the work is that for monitoring crop condition spatially RAI and VCI give better results.

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