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Earth Observation Techniques for Assessing the Vegetation Health Conditions of Major Cropping Seasons in Kalaburagi District, Karnataka, India

Chippy Pushpangathan [1*], Prof. Ali Raza Moosvi.[1]

[1] Department of Geography, Central University of Karnataka, Kalaburagi, Karnataka, India

Abstract In recent times, earth observation plays a pivotal role in the monitoring and management of resources. Integration of earth observation and sustainable agriculture practices can be used as an effective tool with minimum depreciation cost with optimum output generation. Digital images derived from Satellite-based earth observation helps to generate various indices such as NDVI (Normalized Difference Vegetation Index), EVI (Enhanced Vegetation Index), NDWI (Normalized Difference Water Index) enhances the scope of earth observation in this field. These indices can be applied to monitor VCI (Vegetation Condition Index) and Land Surface Temperature (LST) of a study area in a global as well as regional level. Facilitates assessing crop monitoring, crop health status, water stress, yield prediction can be derived from Satellite-based information in a cost-effective manner. This study examines the capabilities of variables derived from the earth observation can be utilized as a useful tool for vegetation Condition Index in Kalaburagi District, Karnataka India. Normalized Difference Vegetation Index derived from MODIS-Terra (2006-07 to 2017-18) for a decade is used for the present study. Vegetation Condition Index generated from for Kalburagi district as well as its Talukas gives a detailed picture of vegetation stress in the study area in both Kharif and Rabi season. This information can be effectively employed for resource management and sustainable agriculture practice in the study area in different cropping cycle.

Keywords: Earth Observation, NDVI, VCI, Kharif, Rabi

[1] **Corresponding Author:** Chippy Pushpangathan.; **Email:** chippyp@cuk.ac.in

1. Introduction

Agriculture is one of the significant economic activity in the world. It has a vital role in primary livelihood and food for human beings. Integration of sustainable development in

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agrarian activities can open a new vista in agriculture production. Among the seventeen sustainable Development Goals, SDG-2 "Zero hunger"; SDG-6 "Clean water and sanitation"; SDG-12 "Responsible consumption and production"; SDG-13 "Climate action"; and SDG-15 "Life on land "share the area of agriculture. (Holloway & Mengersen, 2018). In a recent trend in agriculture-related to precision, practices employ the concept of sustainability. It can accelerate the economic development by improving productivity, crop quality, food security, and environmental protection and through which will ultimately lead to sustainability (Liaghat & Balasundram, 2010). Effective conservation of natural resources also goes hand in hand with sustainable agriculture practices. In sustainable agriculture considerably demands scientific knowledge about an area of development. Integration of various domains and scientific understanding can improve sustainable agriculture practices. Cropping pattern in of a specific region is influenced by the season. In India, Monsoon season is the major cropping season directly depend on the Monsoon rainfall. It extends from June to November. This season is followed by winter and known as Rabi cropping season. It starts from December to February. The summer season extends from March to May the cropping season is known as Zaid.(DES,2017).

Earth Observation (EO) is a vital component accelerates the discipline of earth science. The word remote sensing stands as a synonym for Earth Observation. It Observes Earth Surface without any direct physical contact. Sensors mounted on the satellites provide near real-time monitoring of earth surface in a birds-eye view level. Information derived from Earth Observation(EO). Various fields such as agriculture, geology, Forestry, Military, Urban management etc. effectively use the capabilities of Earth Observation (EO). In agriculture and natural resource management is widely explored with satellite remote sensing-based Earth Observation (EO). In agricultural practices, it uses for crop monitoring, soil moisture condition, vegetation health analysis, Yield prediction and so on. Integration of earth observation and sustainable agriculture practices can be used as an effective tool with minimum depreciation cost with optimum output generation. Digital images derived from Satellite-based earth observation helps to generate various indices such as NDVI (Normalized Difference Vegetation Index), EVI (Enhanced Vegetation Index), NDWI (Normalized Difference Water Index). These indices enhance the scope of earth observation in agriculture through assessing crop monitoring, crop health status, water stress, yield prediction etc. in a cost-effective way. Normalized Difference Vegetation Index (NDVI) is a widely accepted index for vegetation health studies with the help of reflectance derived from Near Infrared (NIR) and Red Regions of the electromagnetic spectrum(Rouse, Haas, Schell, & Deeering,

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1973). Normalized difference vegetation index derived from satellite sensors plays a pivotal role in understanding the crop growth rate. MODIS data provides vegetation indices such as EVI (Enhanced Vegetation Index), NDVI etc.are widely using for the plant growth analysis as well as a health condition(Grzegozewski, Johann, Uribe-Opazo, Mercante, & Coutinho, 2016). Vegetation Condition Index (VCI) has excellent ability to detect drought and to measure the time of its onset, intensity, duration, and impact on vegetation. (Kogan, 1995). Vegetation Health Index derived from the satellite images is effectively utilized for drought monitoring in India. (Singh, Roy, & Kogan, 2003). Vegetation condition Index can be a significant parameter for drought analysis in a time series analysis(Kundu, Dwivedi, & Dutta, 2016). The information obtained from this study can be effectively utilized for the planning and management of sustainable agriculture practices in the study area.

2. Materials and methods

2.1 Study area

The study area is located in the Kalaburagi district(17.33 ° N 76.83 ° E), Karnataka, India. With 10941.2 Km^{2}area. There are Seven Taluks in the districts including Afsalpur, Aland, Chitapur, Chincholi, Gulbarga, Jewargi, and Sedam (Fig1).

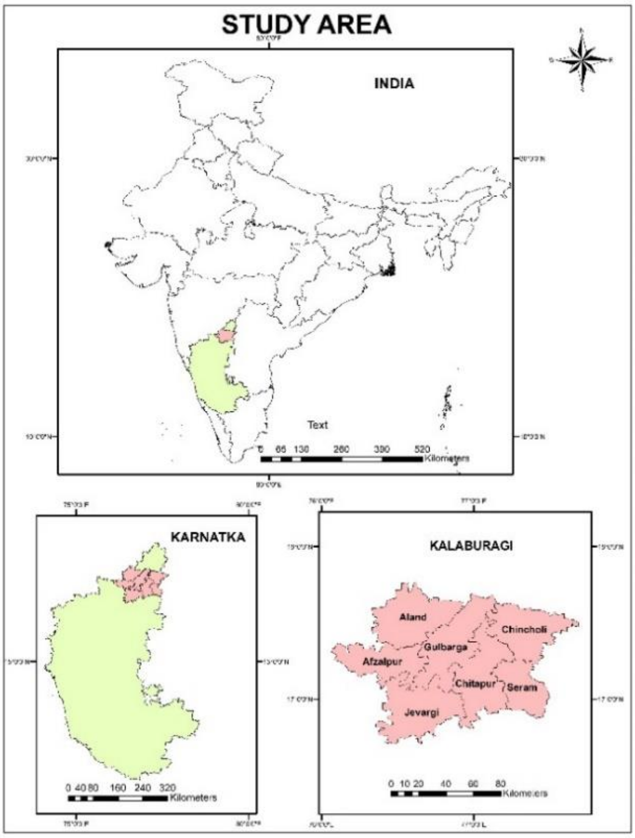

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Figure1: Location Map of Kalaburagi District with Taluk

The area receives the annual rainfall of 832mm and temperature range between 15-40℃. North Eastern Dry Zone is the major agro-climatic divisions in the district. (DOA, Karnataka,2014)There are three seasons prevalent in the study area including Rainy season (June-November), Winter Season (December-February) and Summer Season (March-May)Monsson rainfall is the major source of precipitation in the area which extends from June to November. The South-West Monsson rainfall from Mid June to Mid September will bring the maximum rainfall to the district.(DES, Karanataka 2018).The major agriculture crops of the study area including Pigeon Pea, Sorghum, Cotton, Sunflower, black gram and Sesame etc (CWRD,2008)

2.2 Data and Methods

MODIS Terra satellite images were used for the present study. Two cropping season such a Kharif and Rabi season. Kharif season is associated with the Monsson rainfall (June-November)and Rabi is associated with winter(December-February).Kharif is largest cropping season, and it extends over six months. Rabi Season extends only three months. Tabular data of the NDVI values obtained from the archives of Mahalanobis National Crop Forecasting Centre. This gives the single value of the NDVI of every month in Taluk and District Level. Microsoft Excel is used for the analysis of this data. The data for spatial analysis is obtained from USGS Earth Explorer. MYD13Q of MODIS data with 16 days of temporal resolution and 250 m spatial resolution. Geographic Information Environment provided by Arc GIS 10.3 is used for the spatial analysis purpose. Kharif and Rabi cropping season data from the year 2006-07 to 2017-18 were used for the study. In the Kharif season of the study area is starting with the Monsson rainfall and it extends from June to November. The month of December to March is predominate with Rabi season in the district (DOA, Karanataka). NDVI composite derived from MODIS has been utilized for the study. Total 9 images / 9 months were taken for each year and divided it into Kharif and Rabi Season Respectively. Mean NDVI is derived for each month. (2 images have been obtained for each month). Mean NDVI was generated for both Kharif (June to November) and Rabi Season (December to February) for the study area. NDVI has widely accepted indices for assessing the vegetation health using reflectance of the near-infrared and red band.

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$$\text{NDVI} = \frac{\rho Near\ Infrared - \rho Red}{\rho Near\ Infrared + \rho Red} \qquad \text{(Eq: 1)}$$

The NDVI values expressed in a scale of -1 to +1. Chlorophyll content in the vegetation is sensitive from 0.2 to 1. Higher the values in the NDVI depicts healthy vegetation (Rouse et al., 1973) ranges from 0.4 to 1.Vegetation Condition Index has been derived from the NDVI values has been used for this study. MODIS data is successfully used to determining Vegetation Condition Index studies in regional scale (Yang, Di, Yu, & Chen, 2011). The value of the vegetation condition is expressed in percentage. The area is above 50%, and more is coming under less stress in the vegetation, and less than 30% are severely stressed. This index is used for monitoring the vegetation health condition and drought prevalence for the particular region. (Ray et al., 2014).VCI has been generated for both Kharif and Rabi season for the period of 2006-07 cropping year to 2017-18 cropping year. Descriptive statistics tools were used for the analysis of the result.

$$\text{VCI} = \frac{NDVI\mathrm{j} - NDVI\mathrm{min}}{NDVI\mathrm{max} - NDVI\mathrm{min}} * 100 \qquad \text{(Eq: 2)}$$

Smoothed NDVI value of the week is used for $NDVI_j$ (Kogan, 1995). NDVI smoothened values of the Kharif and Rabi season were used for the study. $NDVI_{min}$ for the minimum NDVI value for the particular cropping season and $NDVI_{max}$ used for the maximum NDVI value obtained for the study period. Integrating both Kharif and Rabi area has been done for generating the Vegetation Condition Index of the study area for a particular cropping year. NDVI and VCI generated for both district and taluk levels. A detailed analysis was done for the crop vegetation condition Index and drought prevalence in the study area.

3. Results and Discussion

3.1 Analysis of MNCFC NDVI composite

This study mainly evaluating the existing drought condition trend in the Kalaburagi district in Karnataka. NDVI is used as a primary indicator for the vegetation health analysis of this study.

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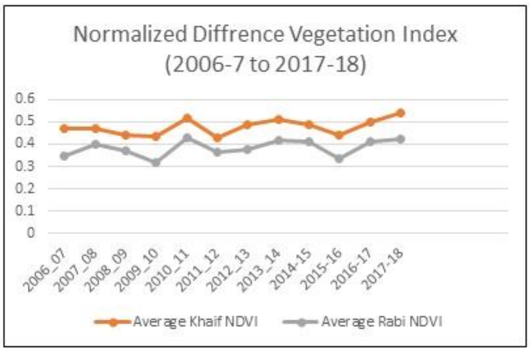

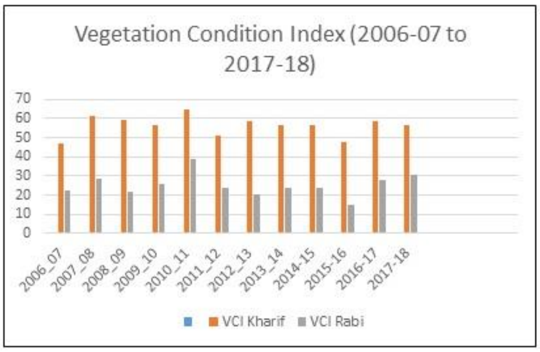

Figure:2.a MODIS Mean NDVI Figure 2.b MODIS Mean VCI

Mean NDVI value derived from the MODIS for both cropping seasons having a significant difference in the NDVI values. In Kharif season (Fig2.a) shows comparatively higher NDVI ranges (0.4-0.5) compare with the Rabi cropping season (0.3-0.4). Vegetation health status in the study area is higher in the Kharif season compare with the rabi season. Kharif and Rabi season shows the same trend in vegetation health status every year. Years such as 2009-10 and 2015-16 has a sharp decline in the NDVI values. Vegetation Condition Index of the study area is high in the Kharif Season and it keeps more than 50 throughout the years except 2006-07. Vegetation health condition is less than 30 in rabi season and which depicts the poor vegetation health during Rabi Season.

In the Taluk Level analysis, NDVI values ranges from up to 0.6 in Kharif season(Fig.3.a) signifies the healthy vegetation in the season. In Rabi season (Fig.3.b) the maximum NDVI values drop to 0.4-0.5 range. Jewargi Taluk experiences higher NDVI values derived from MODIS throughout both Kharif Season and Rabi season. Afsalpur,Sedam and Chincholi taluks experience better NDVI. Taluks such as Chitapur,Aland and Gulbarga having lower NDVI values. There is significant dip in the NDVI values during 2006-07 and 2015-16. The Rabi Season also shows the same trend in NDVI value. VCI values of the Kharif season (Fig. 3.c) extends up to 70. In Rabi season VCI values range between 15- 35 (Fig. 3.d). Kharif season experiences better vegetation health in all Taluks. Jewargi, Afsalpur. Chincholi experiences more than 60 throughout the Kharif season. In the year 2015-16 having a significant dip in VCI values. In Rabi season there is a significant decrease in VCI values. In this period Taluks such as Aland, Gulbarga and Chitapur having high vegetation stress. VCI values range between 20-15 for these taluks.

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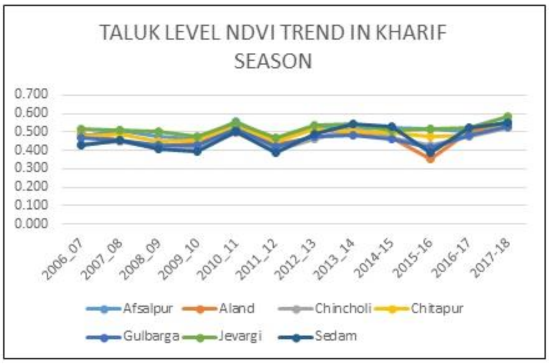

Figure:3.a Kharif NDVI

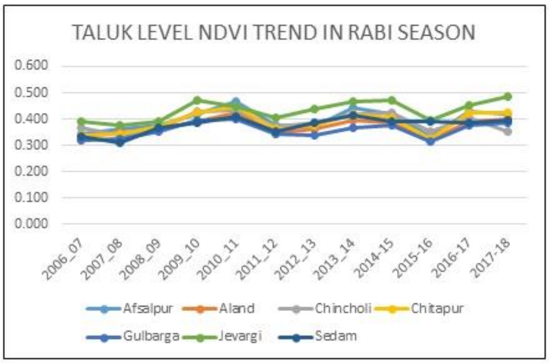

Figure:3.b Kharif NDVI

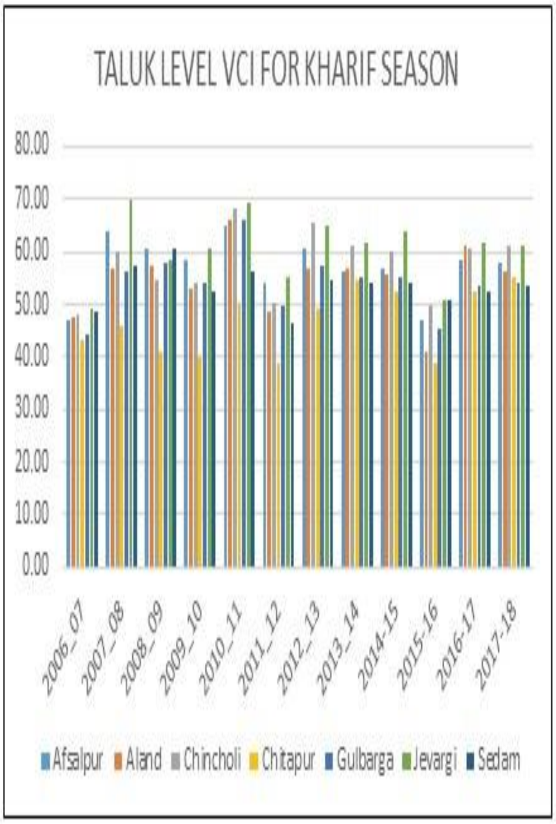

Figure:3.c Kharif VCI

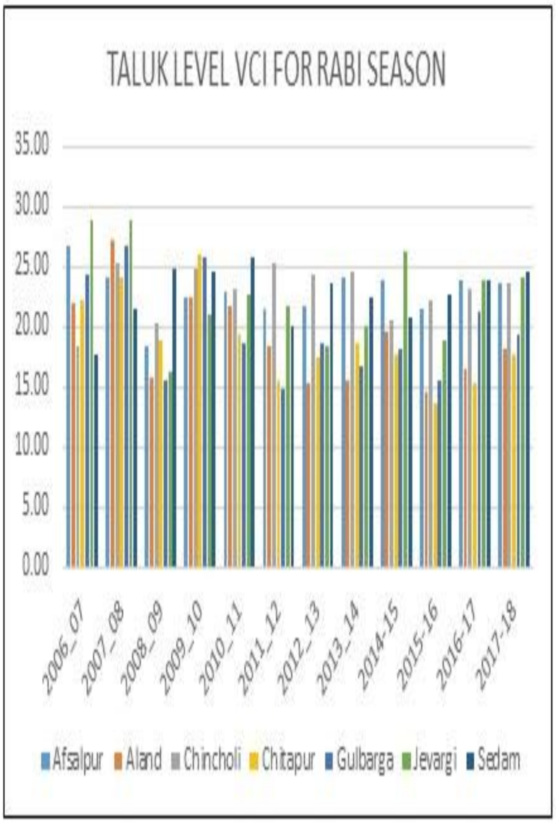

Figure:3.c Kharif VCI for the

3.2 Spatial Analysis of the NDVI and VCI

In the satellite image analysis Mean NDVI values derived from the MODIS data (Fig.4) of each month of Kharif and Rabi cultivation period. Monthly average of NDVI from 2006-07 to 2017-18 depicts the vegetation health status of the study area.

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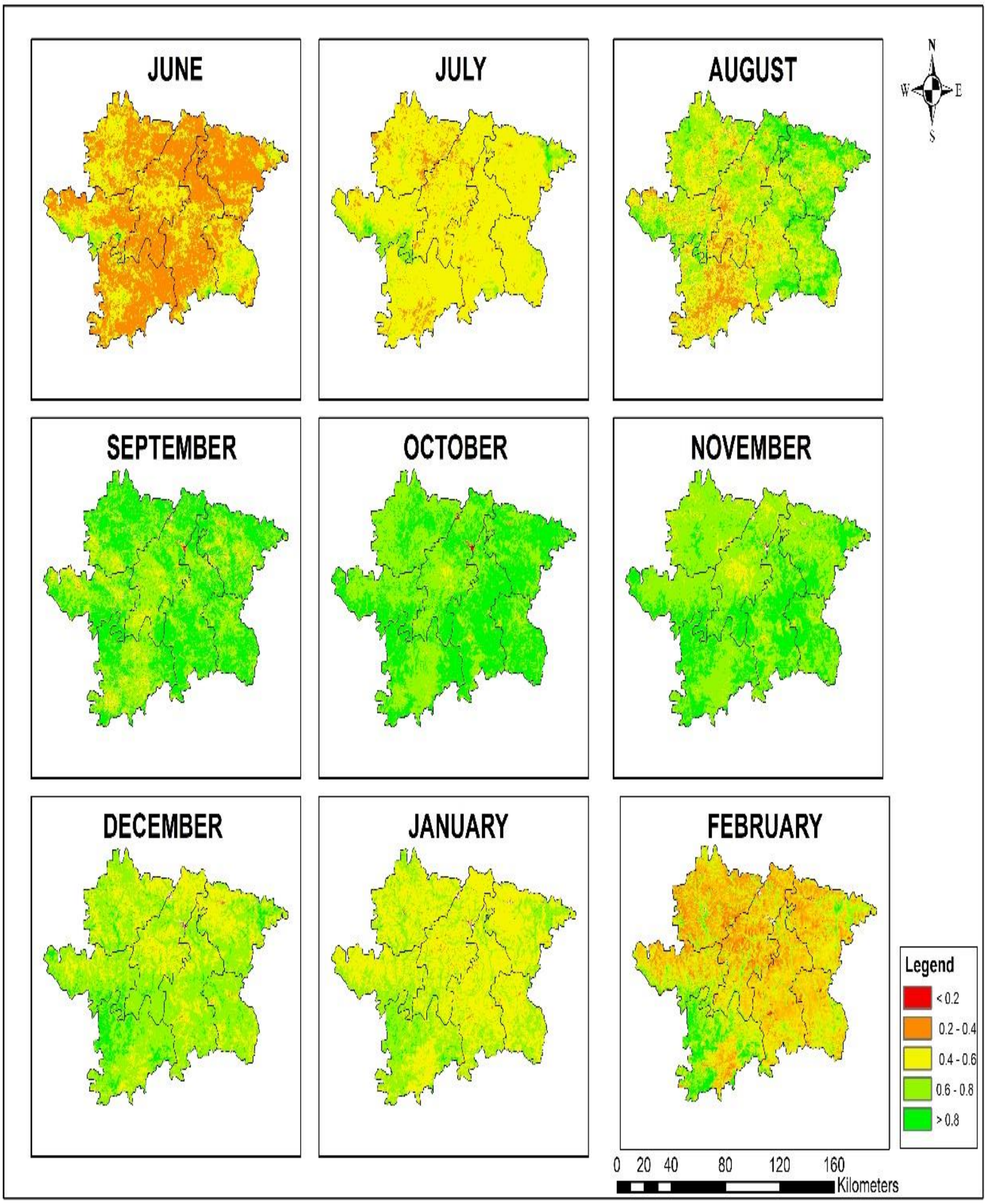

Figure:4 Spatial Distribution of NDVI Composite Values of the Kalaburagi district from 2006-07 to 2017-18

In the beginning of Kharif Season (June) having Lower NDVI values in the whole region. It is gradually increasing from August and reaching higher values in September-October -November months November.It receding from December and reaching lower values by February. In June all the Taluks having Lower NDVI values derived for the Rabi cropping season. The spatial analysis gives the Taluk wise NDVI in a broad perspective.

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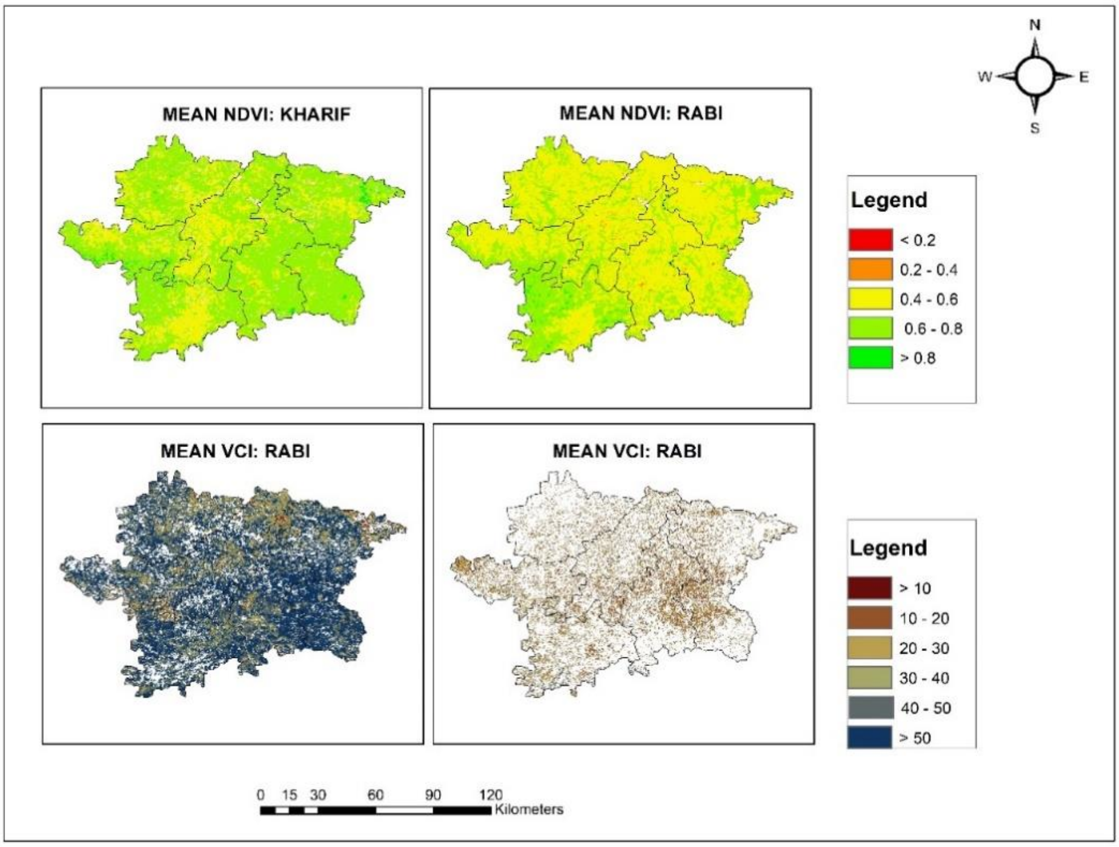

Figure:5 Spatial Distribution of NDVI Composite Values of the Kalaburagi district for Cultivation Months from 2006-07 to 2017-18

In the Kharif season most of the Taluks having higher NDVI and VCI values (Fig.5). Some parts of the Taluks having higher high NDVI values in the Kharif season and some pockets of the same Taluk experience Low NDVI values. In Rabi Season NDVI dominating with .4 to 0.6 showing the moderately healthy vegetation. Spatial variation of VCI values taken for the healthy vegetation. cover. In Kharif season the values are VCI is more than 60 and it decreases to 20-30 range in the Rabi season.

4. Conclusion

NDVI and VCI are important parameters for explaining vegetation health in the study area. The Kalaburagi Taluk having more vegetation stress in Rabi season. Higher NDVI values associated with an increase in the VCI values. VCI values in the study area can be an indicator of the prevalence of drought(Iman et al., 2016). VCI values in the Rabi season depicts the existence of drought in the study area Taluk such as Aland, Gulbarga and

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Chitapur experience more vegetation stress. Jewargi, Afsalpur, Sedam and Chincholi having a better vegetation health condition. Higher NDVI values associated with an increase in the VCI values. VCI values in the study area can be an indicator of the prevalence of drought. VCI values in the Rabi season depicts the existence of drought in the study area. Time series analysis of the Vegetation health study brings detailed information of the district in a Taluk level. Data obtained from the MNCFC depicts the single point value of NDVI for the study area. Earth Observation provides extensive details of vegetation health and in District and Taluk level information of vegetation health. There is significant variability in the vegetation health in the same taluk. It can be an early indicator of drought existence in a micro-level area. In the same time, some pockets of the Taluks having higher vegetation health also. These locations can be significantly utilized for effective drought management practices.The information obtained from the Earth Observation can provide effective supporting information to policymakers to implement sustainable agriculture practice at a micro-level.

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