ASSESSMENT OF LEAF CHLOROPHYLL CONTENT IN PARTS OF THAR DESERT USING REMOTE SENSING TECHNIQUE

Suraj Kumar **SINGH**[1], Niyamotulla **MONDAL**[2], A. K. **BERA**[3], Manish Kumar **VERMA**[3], Shruti **KANGA**[2*]
[1]Centre for Sustainable Development, Suresh Gyan Vihar University, Jaipur
[2]Centre for Climate Change and Water Research, Suresh Gyan Vihar University, Jaipur
[3]Regional Remote Sensing Centre-West, Indian Space Research Organization, Jodhpur
[2*]shruti.kanga@mygyanvihar.com

Abstract
The leaf chlorophyll content is not only an important biochemical parameter for determining the rice photosynthetic capacity but also a good crop stress indicator of nutritional status. Vegetation indices (VIs) obtained from remote sensing-based marquees are quite simple and effective algorithms for quantitative and qualitative assessments of the plant cover, vigor, and growth dynamics, among other applications. Therefore, custom algorithms were developed and tested against a variety of applications based on specific mathematical expressions that combine visible light radiation, mainly green spectral region, vegetation, and non-visible spectra for quantification of the proxy surface vegetation. In real-world applications, the optimization VIs are generally tailored to the specific application requirements coupled with appropriate tools and validation methods in the ground. In the study, vegetation indices (VI) i.e. Normalized Difference Vegetation Index (NDVI), modified chlorophyll absorption ratio index (MCARI2), Chlorophyll Red-edge Model and Chlorophyll Green Model were used to reduce the effect of the saturation spectral area and then used to evaluate the chlorophyll content.

Keywords: Chlorophyll, NDVI, Vegetation Index, Remote Sensing

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1. INTRODUCTION

Chlorophyll, an important natural pigment in green plants, and its content (mostly in leaves) is a crucial variable to assess a plant's physiological status (Jackson, 1983). Chlorophyll content (Chl) acts as the main indicator of the photosynthetic process, which converts light energy into chemical energy for growth, survival, and as an indicator of mutations, torments, and nutritional state. It occupies a singular role within the physiology, productivity, and economy of green plants (Broge and Mortensen, 2002; Gitelson and Merzlyak, 1996). The rate of photosynthesis of a plant depends on the quantity of chlorophyll per unit area. The amount of chlorophyll in leaf tissue is influenced by nutrient availability and environmental stresses like drought, salinity, cold and temperature, etc (Daughtry et al., 2000; Le Maire et al., 2004).
The study of remote sensing spectroscopy leaves is relevant because the spectral characteristics are related to the non-destructive monitoring of plant growth and health and are partly correlated with components plant biochemical (Houborg et al., 2009). Several attempts have been made to use spectral measuremnts remotely to determine leaf chemistry both in leaves and the canopy (Gitelson et al., 2002; Danson et al., 1995). Leaf chlorophyll (Chl) content, as one of the parameters most important vegetative, provides valuable information not only on the physiological state but also on the phenotypic manifestations of plants (Lichtenthaler et al., 1996). Therefore, it is necessary to precise methodologies, effective, and practical to estimate non-destructive remote determination of the chlorophyll content of the leaves (LCC) is used to measure the Chl variation over time for one sheet and avoids time-consuming and costly measures content traditional Chl (Demetriades-Shah et al., 1990). Decades of research have been devoted to finding Chl sensitive regions from the spectrum of vegetation that can be extracted in a non-destructive (and quantify) using combinations of wavebands. VIs were introduced to phenotyping large scale biomass, as well as studies on the green, the nitrogen content, the composition of pigment, and

photosyntheticstate (Croft et al., 2014; Quan et al., 2011). Several studies have demonstrated that the neighboring wavelengths of maximum absorption bands Chl (700 nm) and green bands (550 nm) are most sensitive to a wide range of Chl contents. Several researchers have also worked to develop an algorithm that would be insensitive to differences in leaf structure to avoid the specific cash-calibration (Cui and Zhou, 2017; Datt, 1999). However, the authors are aware of some studies that have attempted to assess how the estimation accuracy of Chl content depends on the adaxial (upper) and abaxial (lower) surfaces of the spectral bands of leaves. In this study for the assessment of Leaf Chlorophyll Content, four different types of vegetation indices (Table 1) were used for estimating of Chl from vegetation. Normalized Different Vegetation Index is widely used for estimating the vegetation cover area. The values of NDVI vary between –1 to +1. Modified Chlorophyll Absorption Ratio Index 2 is an important vegetation index that measures the depth of chlorophyll in plants. The other two indices are Chlorophyll Green Model and Chlorophyll Red-edge Model.

2. MATERIALS AND METHODS

The study area is the field of Luni Upper Basin, the lower part of Rajasthan and a little upper part of Gujarat (24°23’50.5” to 27°21’35.36” N and 70°44’29.58” to 75°05’07.09” E) beside India-Pakistan. The study area, Luni Upper Basin has covered 70174 Sq.-km area including two states, Rajasthan and Gujarat. It covers a region of one-third part of Rajasthan and a little upper part of Gujarat. The ten Districts (one is full and the other nine are partly) of Rajasthan and two districts (party) of Gujarat belong to this study area. The total twelve districts of Rajasthan and Gujarat, Ajmer (2.66%), Barmer (29.60%), Jodhpur (18.98%), Jaisalmer (2.87%), Jalor (14.65%), Nagaur (8.68%), Pali (16.94%), Rajsamand (0.57%), Sirohi (2.85%), Udaypur (1.67%), Kachchh (0.93%), Banaskantha (0.95%) are included in this region, and also fourth-six sub-division of these twelve districts are in the study area (Figure 1).

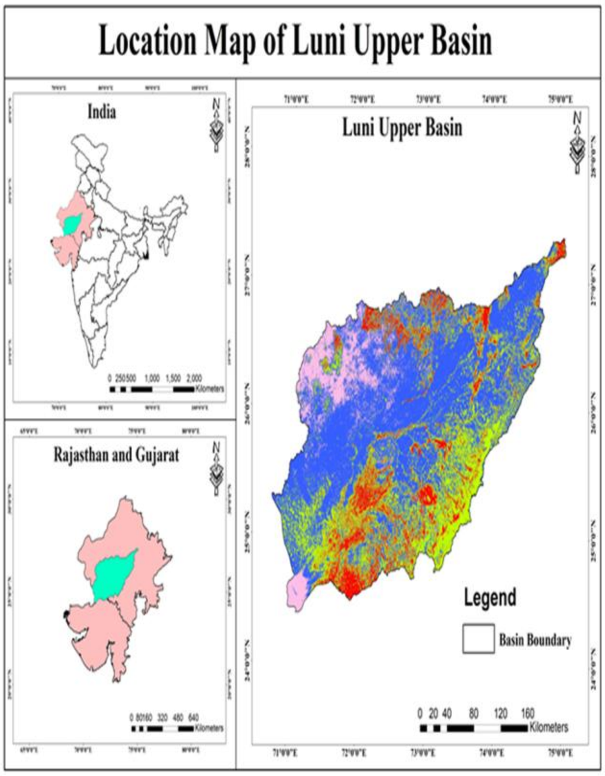

Figure 1:Location Map of Luni Upper Basin

The methodology is that the systematic, conceptual exploration of the methods applied to a field of study. It comprises the theoretical experiment of the body of methods and principles related to a branch of information. Typically, it encompasses ideas like paradigm, theoretical model, phases, and quantitative or qualitative techniques. A process of broad principles or regulations from which specific methods or procedures could also be derived to explain or solve different problems within the scope of a selected discipline. With the help of remote sensing image classification algorithm, we can identify the total vegetation/green in our study area (Figure 2).

3.RESULTS AND DISCUSSION

NDVI

Vegetation indices are among the oldest and most widely used tools to estimate Chl and LAI.

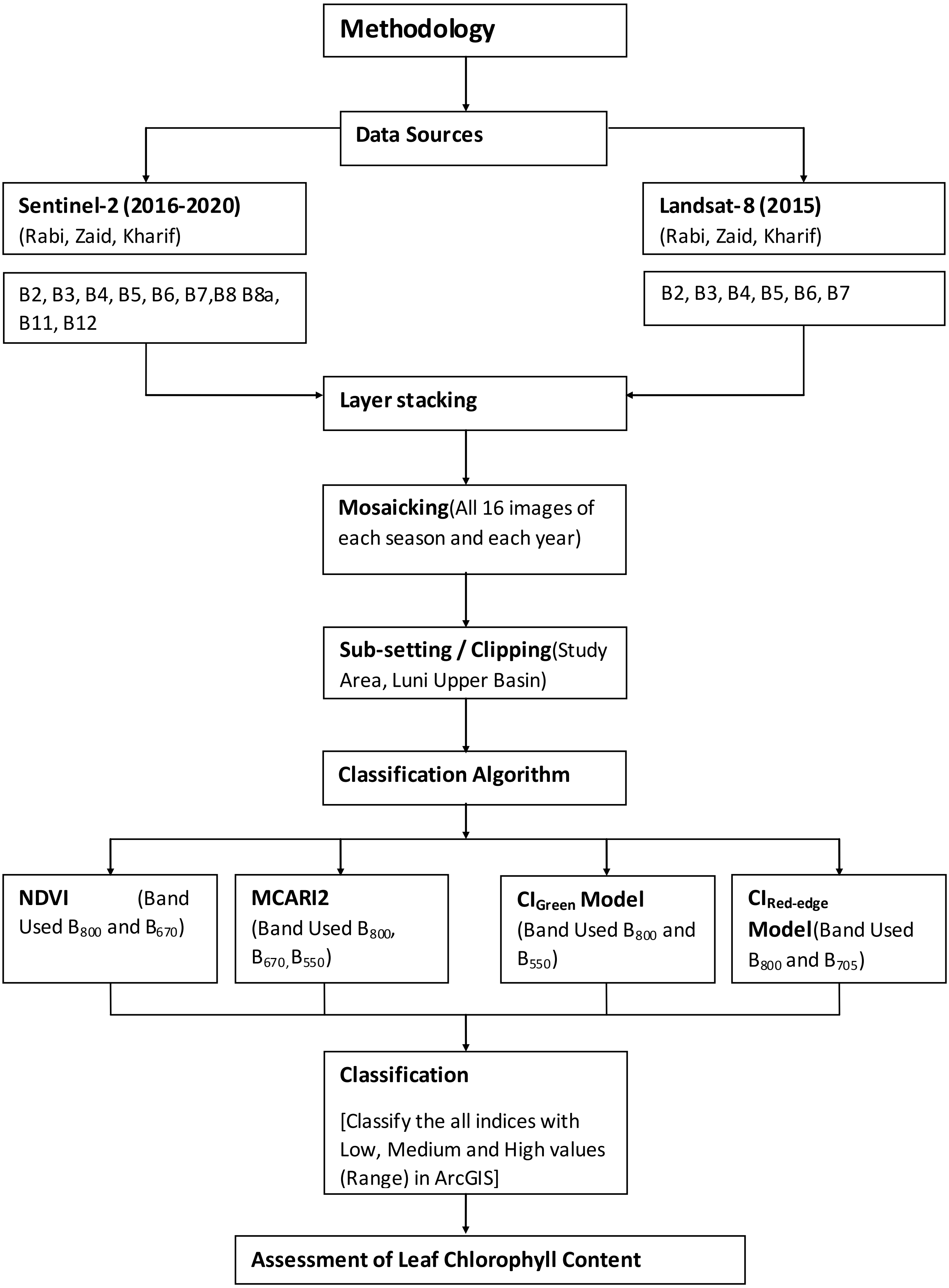

Figure 2 Flowchart of Methodology

Table 1: Formula used for vegetation index

Vegetation index	Formula
Normalized Different Vegetation Index	NDVI = $R_{800} – R_{670} / R_{800} + R_{670}$
Modified Chlorophyll Absorption Ratio Index 2	MCARI2= $1.5[2.5(R_{800}-R_{670})-1.3(R_{800}-R_{550})]$ / $SqRoot[(2R_{800}+1)^2-\{6R_{800}-5SqRoot(R_{670})\}-0.5]$
Chlorophyll Green Model	$CI_{Green} = (R_{800} / R_{550}) -1$
Chlorophyll Red-edge Model	$CI_{Red\text{-}edge} = (R_{800} / R_{705}) -1$

Vegetation indices are easy numerical indicators that reduce multi-spectral (two or more spectral bands) data to a single variable to guess and assess vegetation characteristics. The Normalized Difference Vegetation Index (NDVI) is one of the most important and useful vegetation indexes and its usefulness in satellite monitoring and evaluation of global greenery cover has been well exhibited over the last two decades. The NDVI is interrelated with particular biophysical characteristics of the vegetation canopy, such as vegetation leaf area index (LAI), fractional vegetation cover, the condition of vegetation, and biomass. NDVI and LAI are proportional to each other, NDVI and LAI increase with near-consistently. In NDVI the pixel value in the resultant image changes between – 1.0 and + 1.0. NDVI with dense vegetation show positive values (say 0.3 to 0.8) and water-bodies, clouds, and snowfields will be characterized by negative values. Other targets show values near 0: e.g., soils generally show values between 0.1 and 0. 2, very high positive values (say 0.6 to 0.8) indicate healthy vegetation, while value-range 0.3 to 0.6 may be considered as stressed vegetation. However, this may vary from species to species and season to season (Figure 3-6).

MCARI2

Modified Chlorophyll Absorption Ratio Index 2 (MCARI2) is the same as MCARI but it is deliberated a better predictor of green leaf area index (LAI). It includes soil adjustment factor while conserving sensitivity to Leaf Area Index and resistance to chlorophyll influence. The MCARI2 is more sensitive to leaf chlorophyll concentrations. In vegetation cover, plant growth is directly related to water supply and plant water status. When the soil water supply is not sufficient, plants will be underwater stress, which leads to reduced vegetation yield and even vegetation failures under extreme drought conditions.

It is very important to assess the crop water status in a timely and accurate manner, which has direct implications on crop growth, yield, and quality of produce (Figure 7-10).

CHLOROPHYLL INDEX GREEN MODEL

Vegetation monitoring is a relevant topic in science and remote sensing applications. Several satellite missions have been launched with the specific aim of tracking the evolution of the vegetation cover on the surface of the Earth.In this sense, recently much attention has been paid to the development of methods to derive cards distributed in the content space chlorophyll (Chl) in vegetation using remote sensing techniques.sheet is one of the most important parameters of the vegetation. It is of great interest in many fields of study such as precision agriculture, since Chl sheet is an indicator of photosynthetic activity, and can also be used to indirectly estimate the content nitrogen in the soil or to define the optimal fertilization. Besides, knowledge of Chl a regional and global scale are important in ecology, in studies on climate change, and the study of plant stress, among other applications. The study of the reflection sheet provides information on Chl and others such as agricultural varied leaf surface, vegetation cover, biomass, crop type, nutrient status, and performance. Thus, the use of spectral data from satellites allows the study of these variables on a biophysical regionally. Several multi-spectral vegetation indices have been proposed to the general study of the state of vegetation, as the ratio vegetation index (RVI) and Normalized Difference Vegetation Index (NDVI), which have proven predictive value in the evaluation of Chl and other pigments sheets. Also, were developed some specific clues to the study of Chl based on the reflection of the leaves. Due to the recent development of hyperspectral sensors, which acquire a spectrum of near-continuous reflection, new and more robust detection methods Chl and indices have been and are being developed. One such example is a spectral index based on standardized many full spectral bands initially developed for Chl mapping heterogeneous growing areas (Figure 11-14).

CHLOROPHYLL INDEX RED-EDGE MODEL

The red-edge region is defined as the spectral region between 680 and 750 nm, where there is a sudden change in the reflectance of the vegetation. This is due to the transition from the absorption of chlorophyll in the cell broadcast red region in the NIR. The promise and potential of the red spectral region-edge for Biophysical variable recovery vegetation motivated design as well as the introduction of spatial image sensors having red band-edge including hyperspectral satellites such as Hyperion, the hyperspectral imager for the coastal ocean, and the top Compact Resolution Imaging Spectrometer (CHRIS) and multispectral satellites such as MERIS, RapidEye, and recently, Sentinel-2. Chlorophyll is the pigment found in green leaves and plays an important role in photosynthesis to say the conversion of light energy into chemical energy. Therefore, it is a direct indicator of primary production and the photosynthetic potential of the plant. It can also be used to understand the nutrient status of the plant senescence and stress due to water, epidemic disease, etc. The chlorophyll index is used to calculate the total chlorophyll content of the leaves. The Chlgreen and Chlred-edge peak values are sensitive to small changes in chlorophyll content and uniform in most species. The red band-edge is a narrow strip in the reflectance spectrum of the vegetation between the red to near-infrared transition. The total chlorophyll concentration is linearly related to the difference between the reciprocal of reflectance bands green / red-edge band and the near-infrared. Therefore, a ChIgreen-calculated using the observation in the green region (570 nm) and a CIRED boat - using the observations of the red peak (730 nm) are widely used (Figure 15-18).

Remote sensing of vegetation is mainly carried out by obtaining the reflectance information of the electromagnetic waves from windows using passive sensors. It is well known that the reflection of the light spectra of plants varies with the type of plant, the water content in tissues, and other intrinsic factors. The reflectance of the vegetation in the electromagnetic spectrum (or spectral reflectance of the vegetation emission characteristics) is determined by the chemical and morphological characteristics of the surface of organs or sheets. Indices extracted from this range of light spectra can be assigned to a set of characteristics beyond growth and quantification of plant vigor related to water content, pigments, sugar and carbohydrate, protein content, and aromatics, among others. The information on vegetation from remote sensing images is mainly interpreted by differences and changes of green plant leaves and spectral characteristics of the cover. The most common validation process is through direct or indirect correlations obtained VIs and vegetation characteristics of interest measured in situ, such as vegetation cover, LAI, biomass, growth, and assessing vigor. The most established methods are used to evaluate VIs using direct methods and georeferenced monitoring sentinel plants compared with VIs obtained from the same plants for calibration purposes.

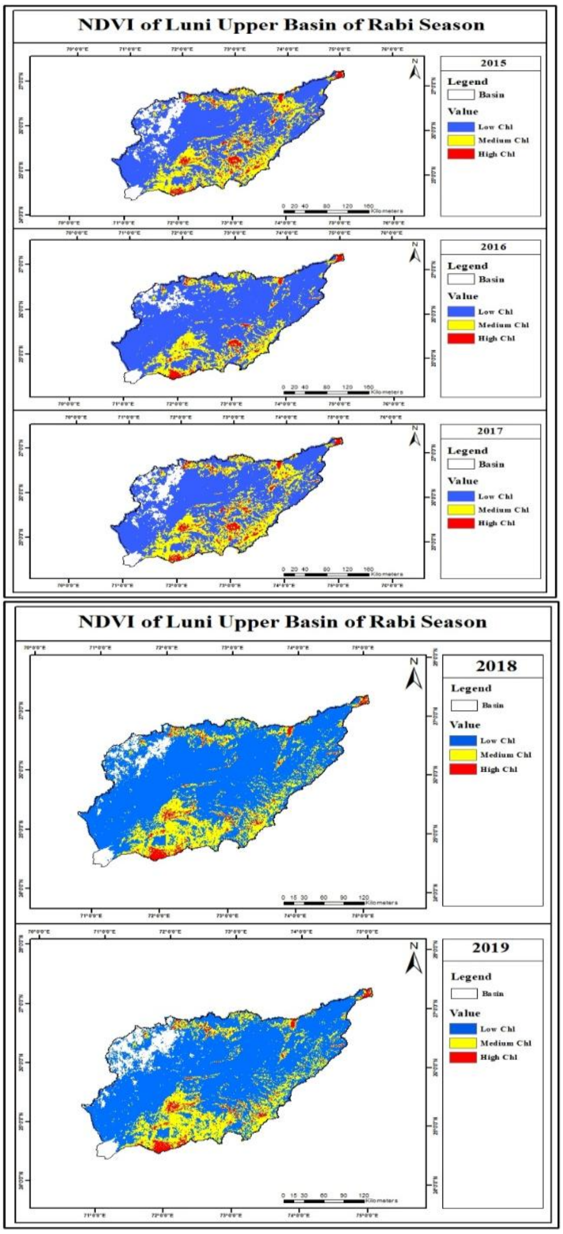

Figure 3 NDVI of Luni Upper basin (Rabi season)

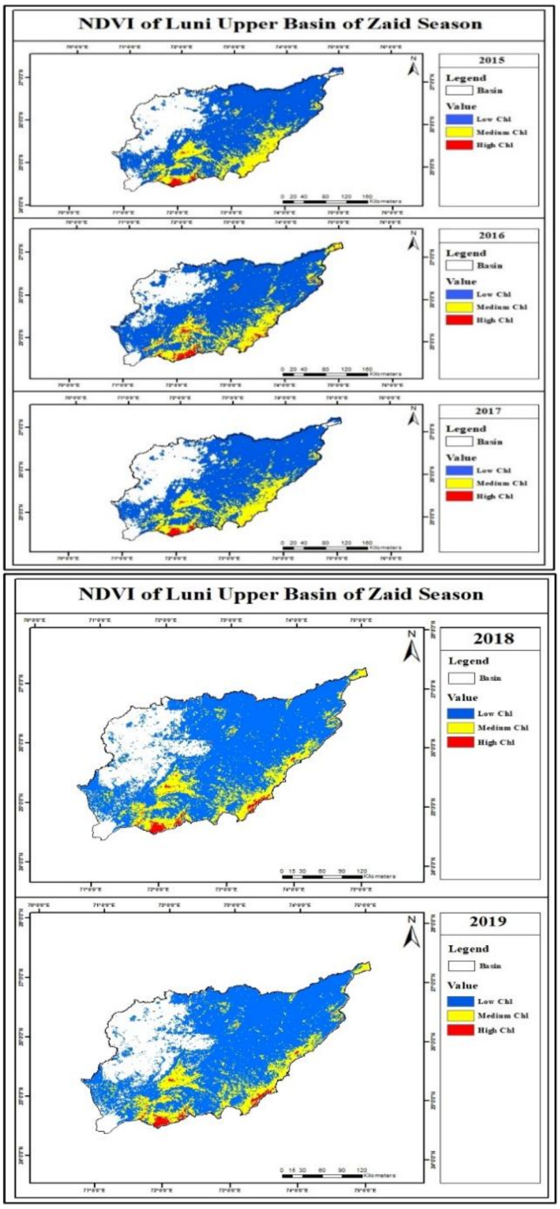

Figure 4 NDVI of Luni Upper basin (Zaid season)

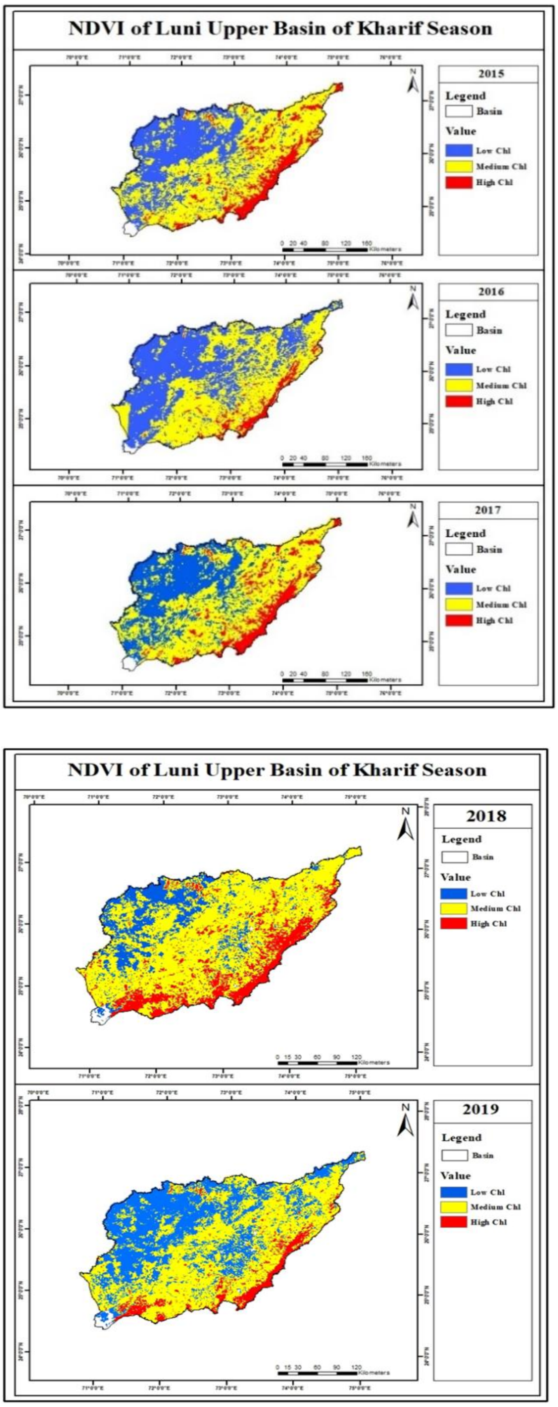

Figure 5 NDVI of Luni Upper basin (Kharif season)

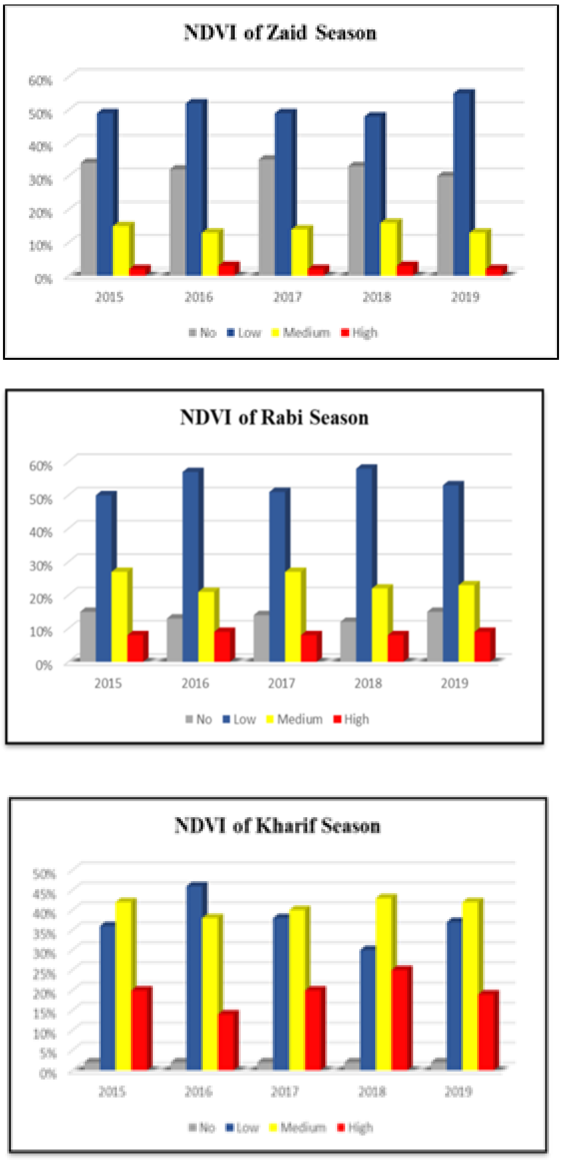

Figure 6 Area statistics of NDVI during three seasons

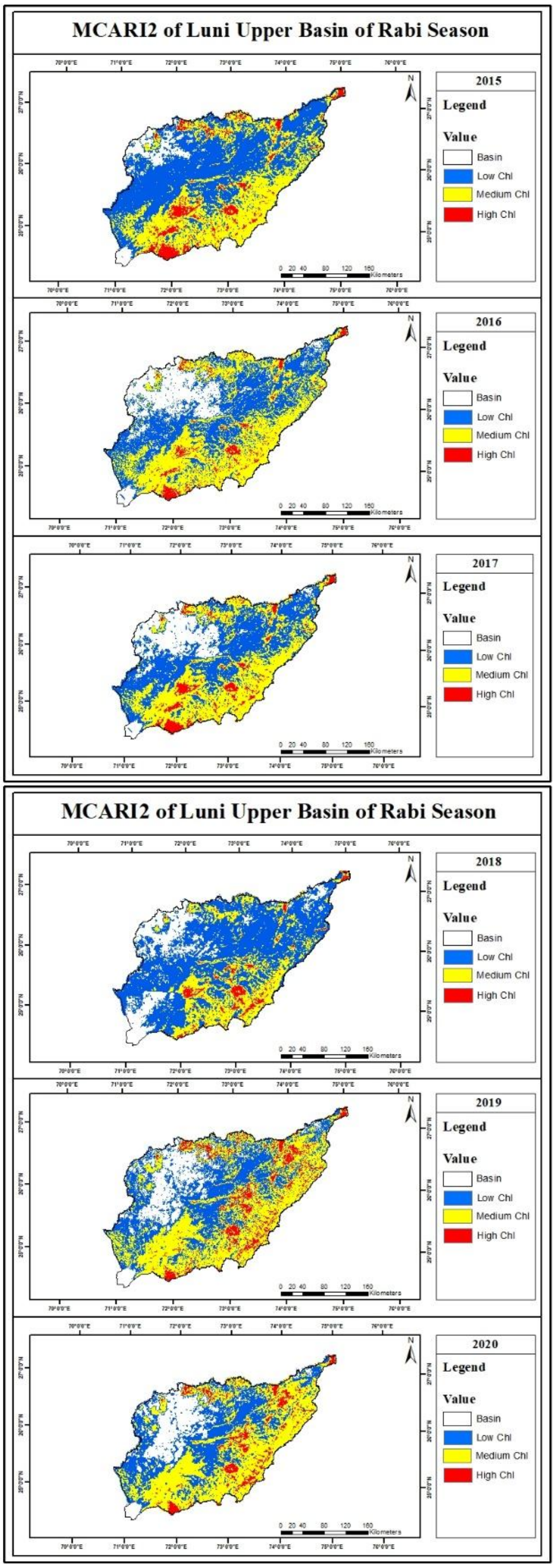

Figure 7 MCARI2 of Luni Upper basin (Rabi season)

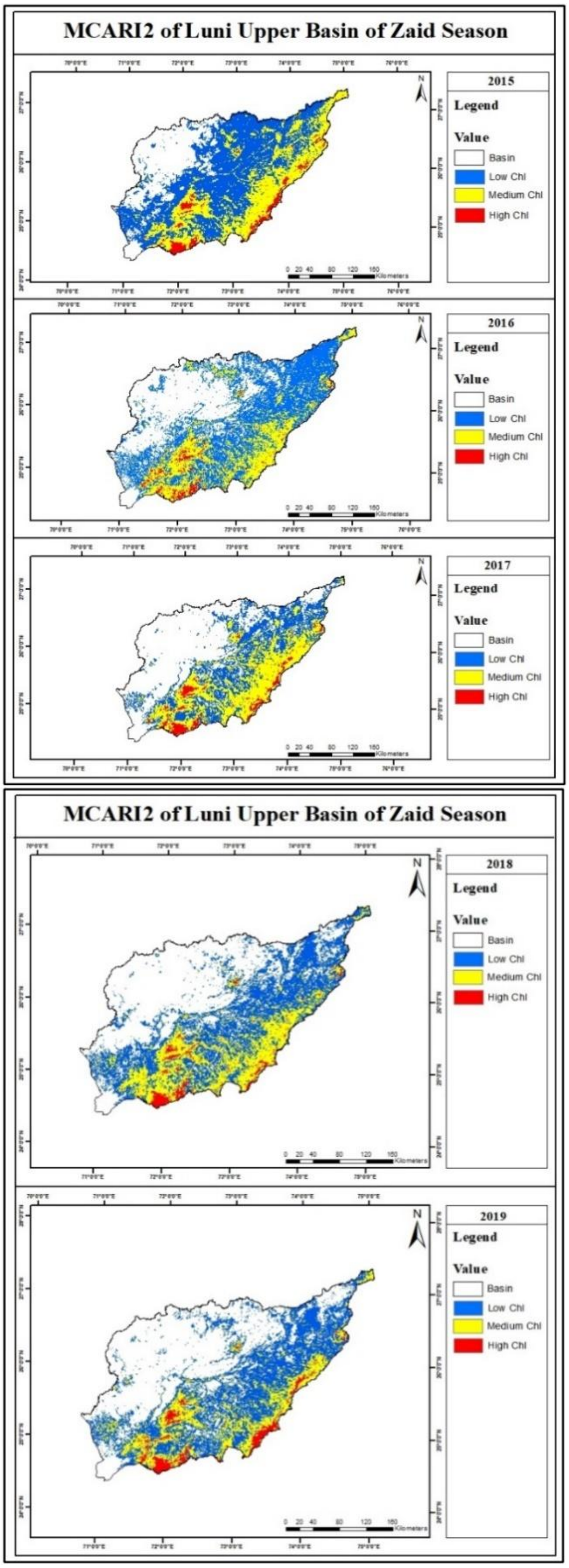

Figure 8 MCARI2 of Luni Upper basin (Zaid season)

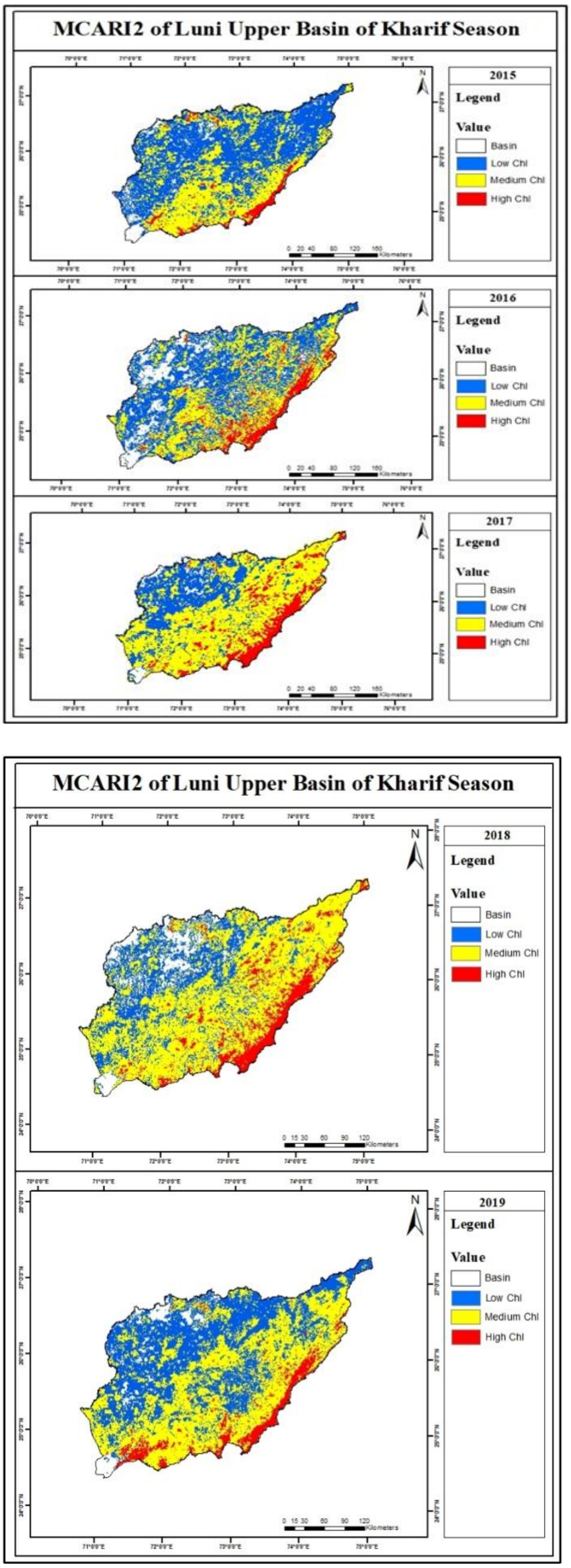

Figure 9 MCARI2 of Luni Upper basin (Kharif season)

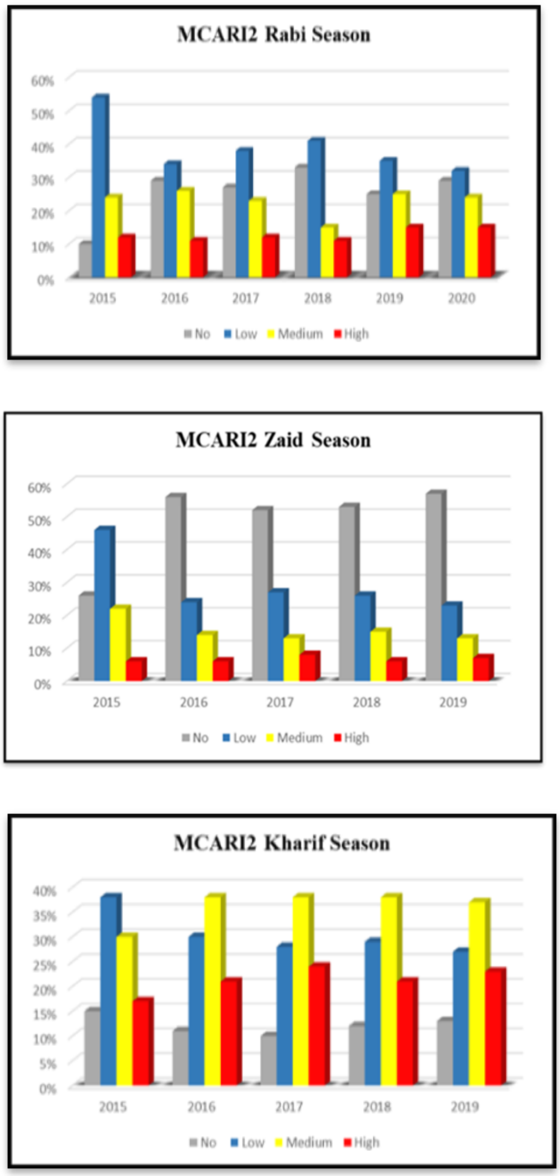

Figure 10 Area statistics of MCARI2 during three seasons

4. CONCLUSIONS

Chlorophyll content of crops/vegetation is one of the parameters, which are necessary to determine more physiological parameters of the plants. For example, low nitrogen content cultures generally have a high ratio of carotenoid chlorophyll. Variations in these parameters can modify the spectral response of plants, which makes it possible to quantify them using spectral indices.Simple VIs combining the visible and near-infrared bands have greatly improved the detection sensitivity of the green vegetation.Different environments have their variable and complex characteristics that must be considered when using different VIs.Therefore, every VI has its specific expression of green vegetation, its ability to specific uses, and some limiting factors.

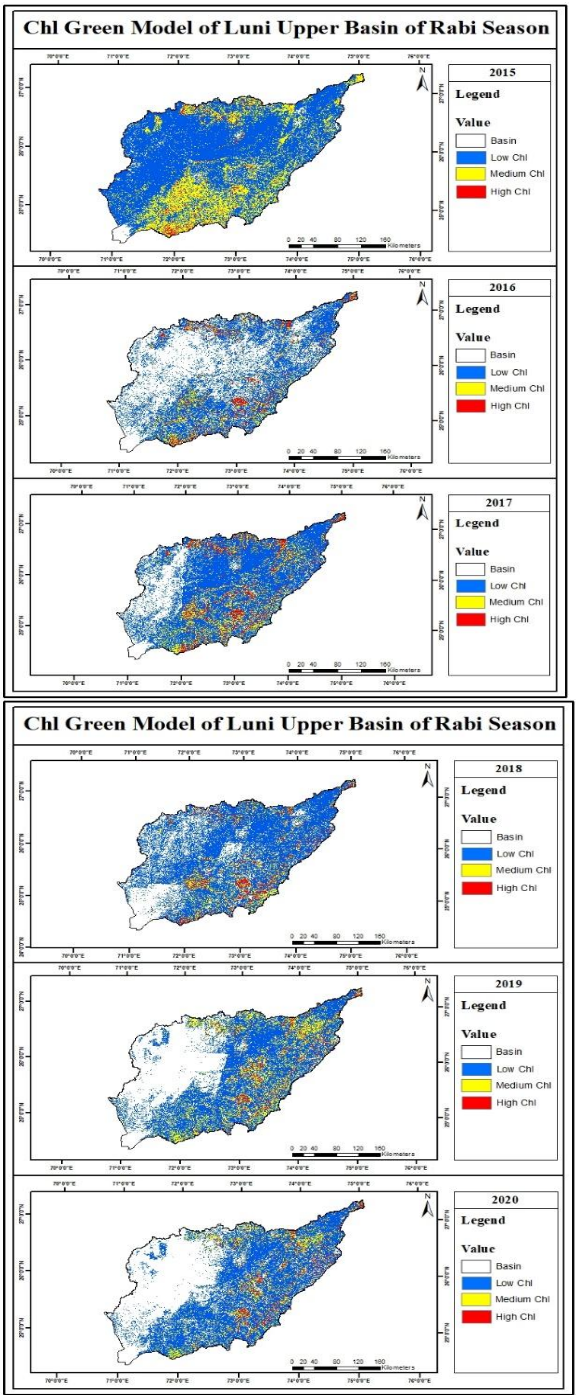

Figure 11 Chl green model of Luni Upper basin (Rabi season)

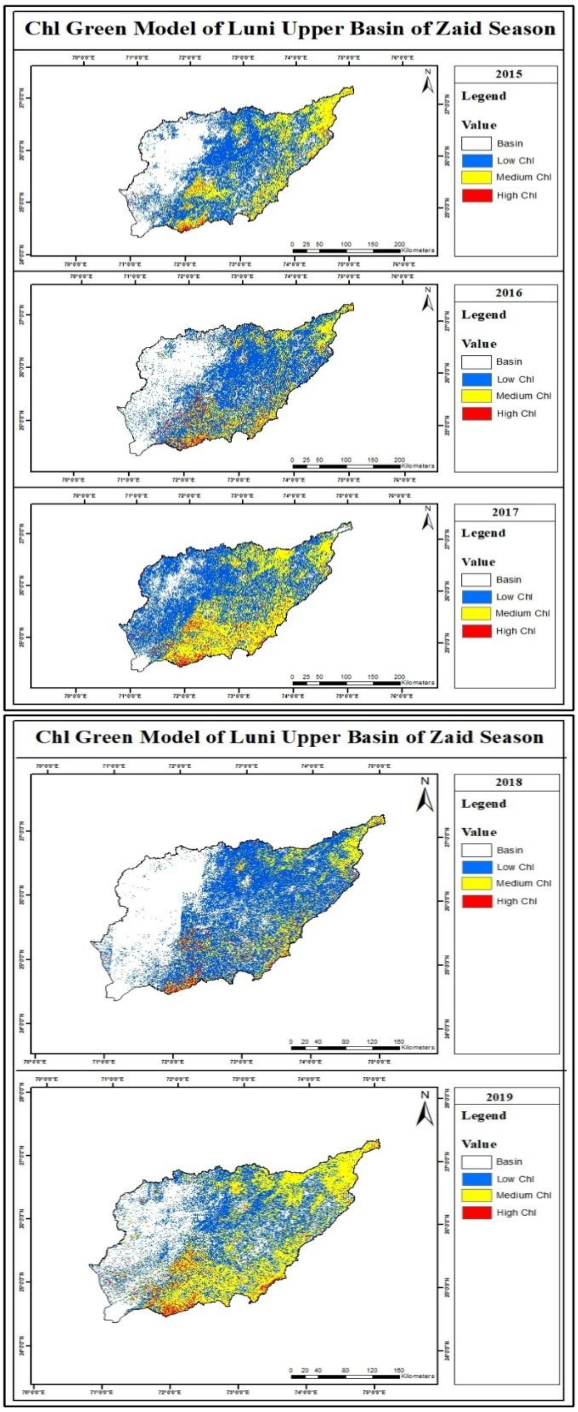

Figure 12 Chl green model of Luni Upper basin (Zaid season)

Therefore, for practical applications, the choice of a specific VI needs to be done with caution, taking into account comprehensively and analyze the advantages and limitations of existing VIs and then combine them to apply in an environment-specific. In this way, the use of

VIs can be adapted to specific applications, the instruments used, and platforms.

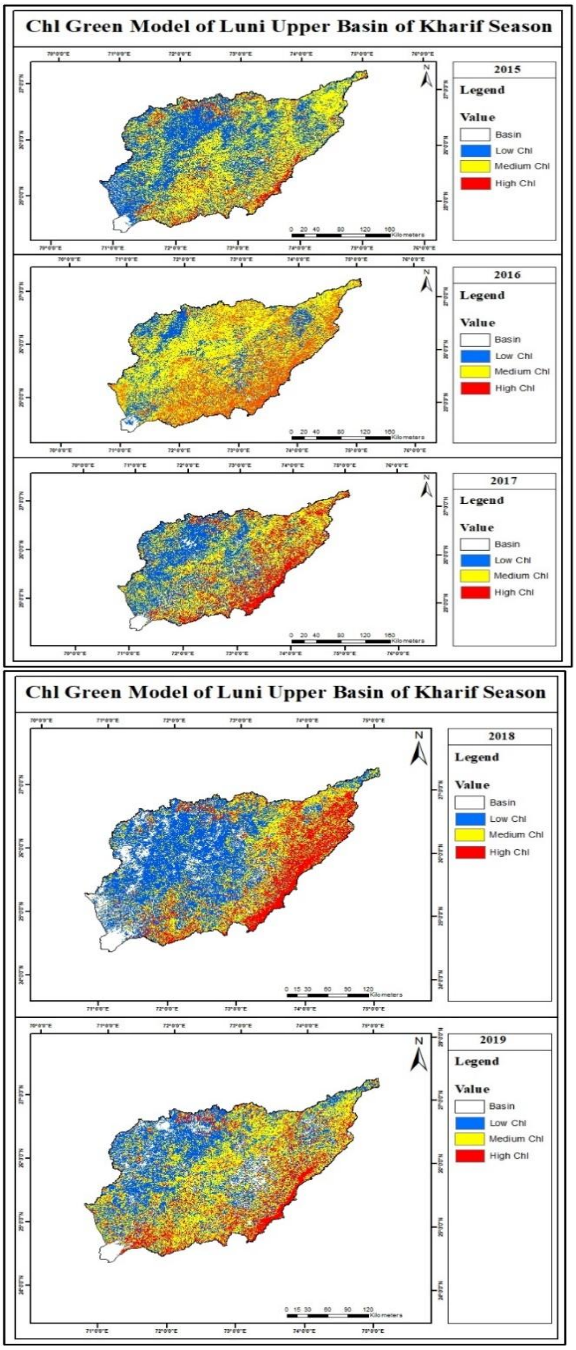

Figure 13 Chl green model of Luni Upper basin (Kharif season)

With the development of technology of hyperspectral and multispectral remote sensing, new VIs can be developed, which will expand the research. It is expected that these new developments will be easily applied and adopted by UAS platforms and become one of the most important remote sensings in aerospace research areas shortly. remote sensing information growth, vigor, and dynamics of terrestrial vegetation can provide information useful for applications in environmental monitoring, conservation of biodiversity, agriculture, forestry, urban green infrastructure, and other related fields.

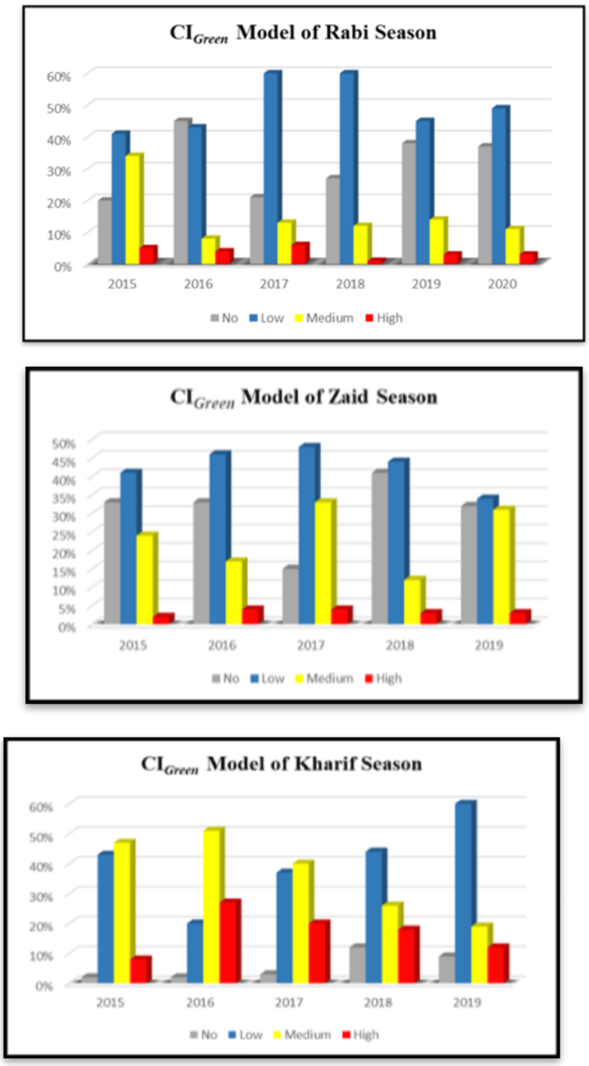

Figure 14 Area statistics of Chl green model during three seasons

Specifically, these kinds of information applied to not only provide an objective basis Agriculture (depending on resolution) for macro and micromanagement of agricultural production but also on many occasions the information needed to estimate performance cultures.

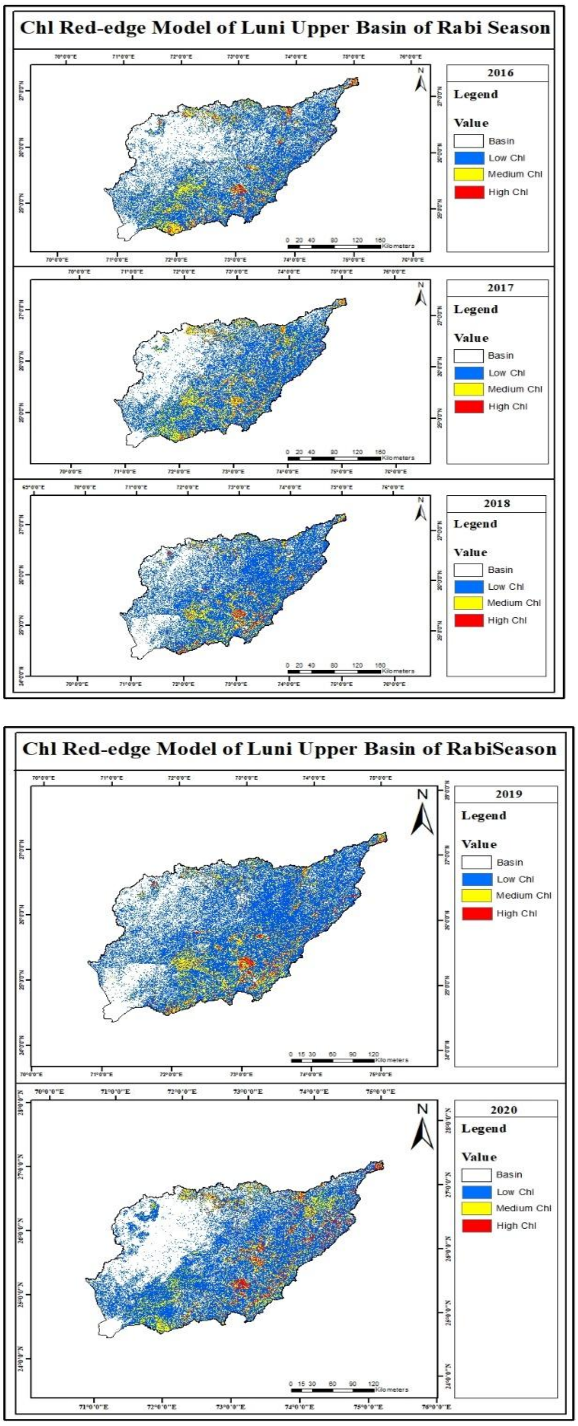

Figure 15Chl Red-edge model of Luni Upper basin (Rabi season)

These applications have been developed for a category of well-known discipline, precision agriculture, which could be tracked three decades ago. However, the applicability of remote sensing and its various VIs extracted from these techniques generally relies largely on instruments and platforms to determine what is the best solution for a particularproblem.

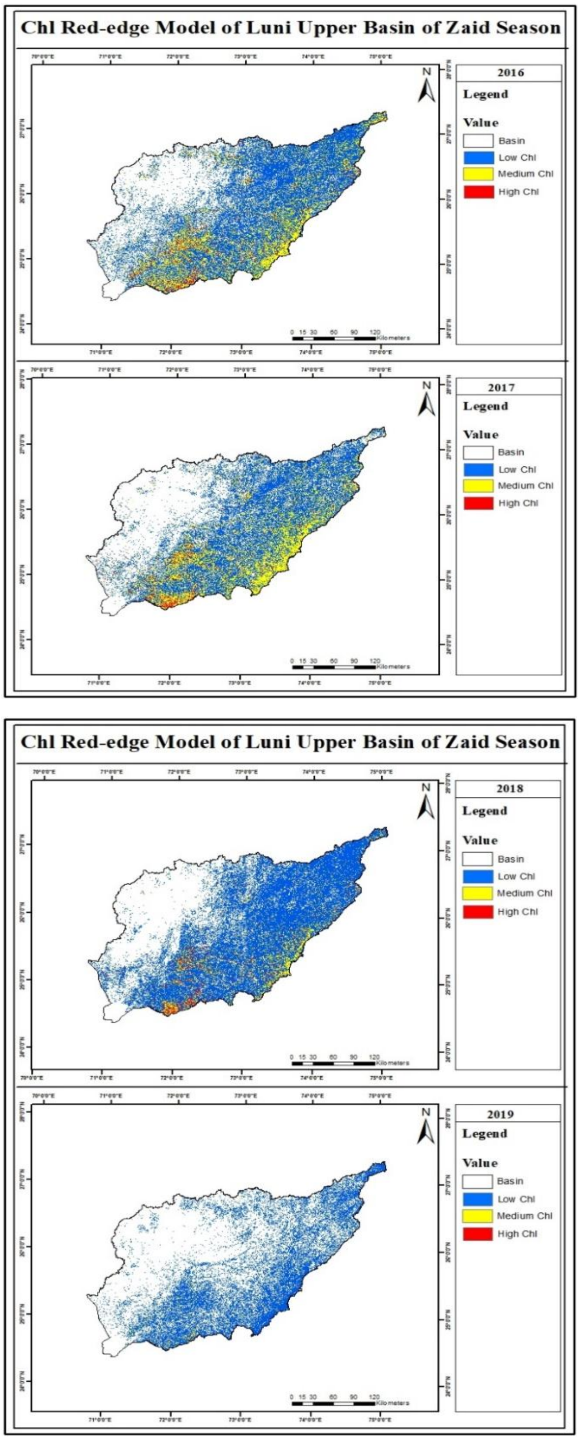

Figure 16 Chl Red-edge model of Luni Upper basin (Zaid season)

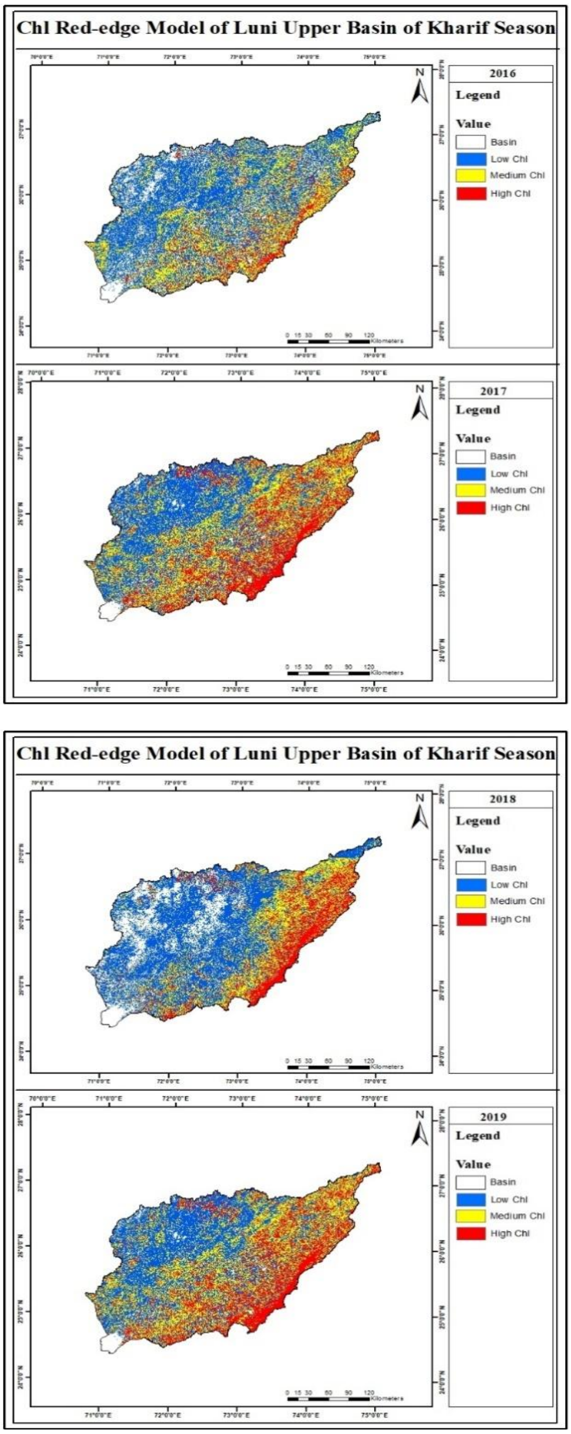

Figure 17 Chl Red-edge model of Luni Upper basin (Kharif season)

5. ACKNOWLEDGEMENT

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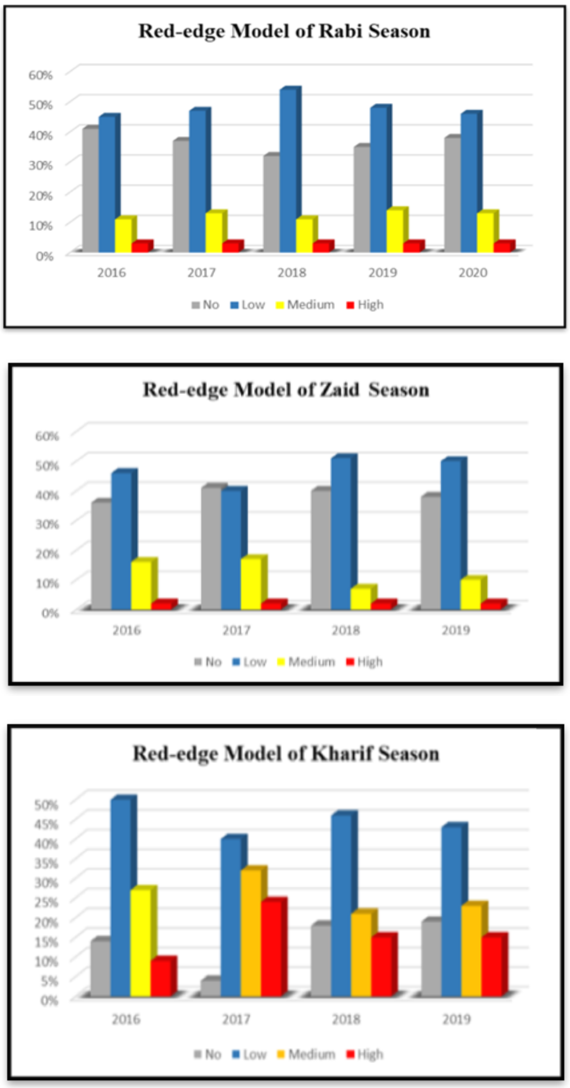

Figure 18 Area statistics of Chl Red-edge during three seasons

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