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Real time Crop health monitoring using Remote Sensing and ancillary information using GIS

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Abstract:
To meet the ever increasing demand of food production it is expedient to increase the quality and quantity of produce with optimum input as per the crop demand. So, it is of great significance to monitor the crop health and record information from growing season to harvesting season. Chlorophyll is an excellent indicator of crop health since it allows plants to absorb light and directly reflects the photosynthesis activity. Therefore in this study various chlorophyll indices along with modified vegetation index have been used for assessment of crop health condition and monitoring over a period of time. Satellite has been a paradigm in the field of remote sensing applications such as agriculture, forestry and environment. Data from Landsat-8 with 30m resolution and sentinel-2 images with 10 and 20 meter resolution was acquired for the same period of time. Pre and post processing of images such as classification, calculation of reflectance and indices was performed in Arcmap tool. Results were comparable of both satellites when analysis was performed with NIR, Red and green bands; moreover Results were more satisfactory with Sentinel-2 satellite because of availability of Red-Edge band images and its 20m resolution. Further, this information can be utilized for application of proper amount of nutrients so as to increase the quality and productivity of crop.

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Introduction

The relationship between satellite information and Crop biophysical parameters is researched by the vegetation index, for example, Normalized differnce vegetation Index (NDVI) which can give ancillary information regarding vegetation capacity and land utilize cover and order. The NDVI extracted from the vegetation index is connected with the vegetation parameters on the land surface. Range for NDVI go from - 1.0 to 1.0. Bigger NDVI esteems show that the land surface is secured with thick solid vegetation, while negative qualities demonstrate the nearness of mists, snow, water, or a splendid non-vegetated surface. A run of the mill NDVI fleeting profile for solid green vegetation ascends as plant cover increments in spring, achieves a pinnacle or level amid summer, and decreases with plant senescence in fall. NDVI is given by following formula.

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}}$$

Study Area

The study area selected for this study is Ludhiana district in Punjab region. We have selected Ludhiana as our study site because of rich variability in crops at the sampling time.

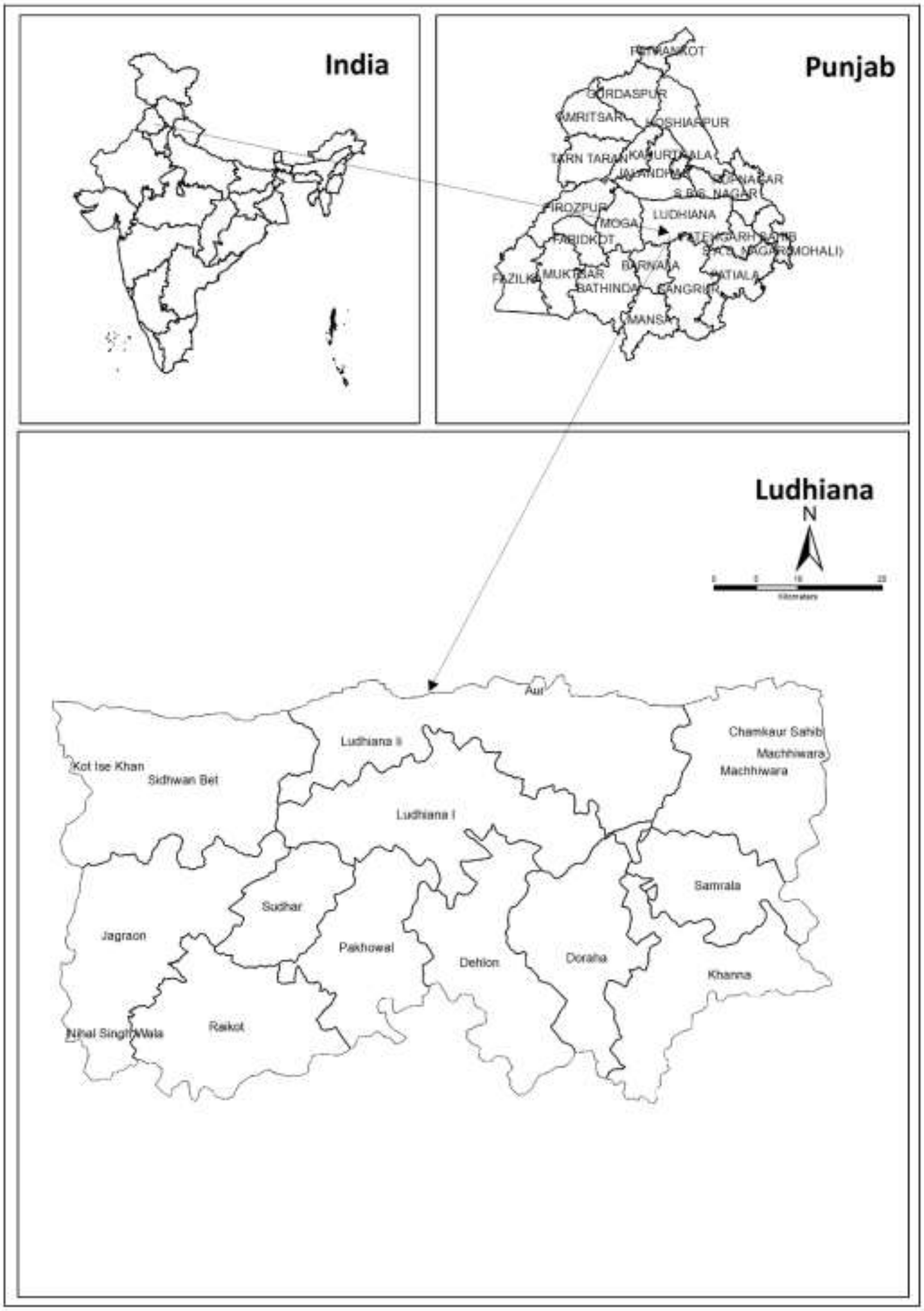

Fig: 2 Study area

Method:

Images of Landsat and sentinel satellites were downloaded from USGS on the coincinding dates of sampling.

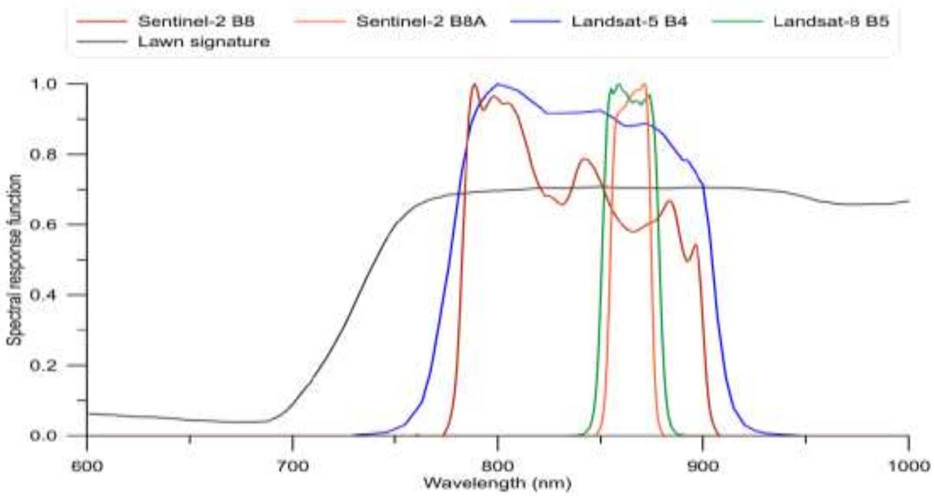

Fig: 1 Spectral response of Multispectral Instruments (MSI) onboard sentinel-2 [7], Operational Land Imager (OLI) onboard Landsat-8 [8], and Thematic Mapper 5 (TM5)

An extensive sampling of the field was performed and 18 samples of different vegetation were collected. Acetone based method of chlorophyll extraction[9] from vegetation was performed in the laboratory to collect the reference data for correlation. Since chlorophyll absorbs the light in red band therefore absorption method was employed to extract the chlorophyll concentration using universally accepted arnon's equations, which are written as follows [10]:

$$\text{Chlorophyll a } (\mu g/ml) = 12.7\ (A_{663}) - 2.69\ (A_{645}) \qquad (1)$$

Where A_{663} and A_{645} are absorbance at 663nm and 645nm wavelength respectively.
Since vegetation spectral signatures are dominant in NIR and red region since they reflects largely in NIR region and Red band is absorbed heavily. Since radiometric correction is required to find out the surface reflectance from these images [11, 12], Images were processed into Arcmap tool of ESri. Normalized difference vegetation index (NDVI) was calculated using Red and NIR band images.

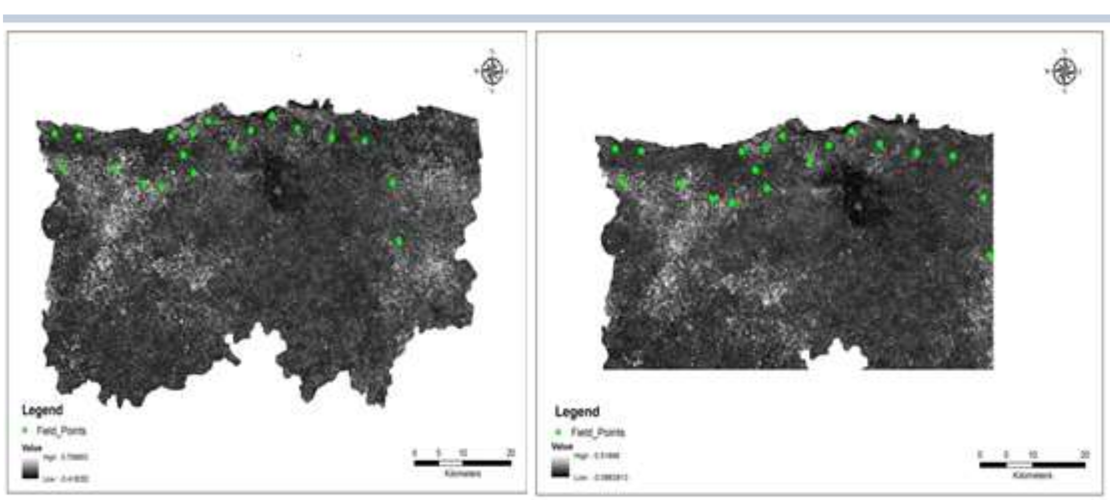

Fig: 2 images of sentinel-2 and Landsat-8 satellite

Table 1 Spectral and spatial resolution of Landsat-8 and sentinel-2 satellites [13]

Landsat 8 OLI			Sentinel-2 MSI		
Band	Wavelength (nm)	Resolution(m)	Band	Wavelength (nm)	Resolution(m)
Coastal aerosol(1)	433-453	30	Coastal aerosol(1)	433-453	60
Blue(2)	450-515	30	Blue(2)	458-523	10
Green(3)	525-660	30	Green(3)	543-578	10
Red(4)	630-680	30	Red(4)	650-680	10
NIR(5)	845-885	30	Red Edge1(5)	698-713	20
Cirrus	1360-1390	30	Red Edge2(6)	733-748	20
SWIR-1(6)	1560-1660	30	Red Edge3(7)	773-793	20
SWIR-2(7)	2100-2300	30	NIR(8)	785-900	10
Panchromatic(8)	500-680	15	NIR narrow(8a)	855-875	20

Results:

NDVI was correlated with the chlorophyll values obtained from reference method.

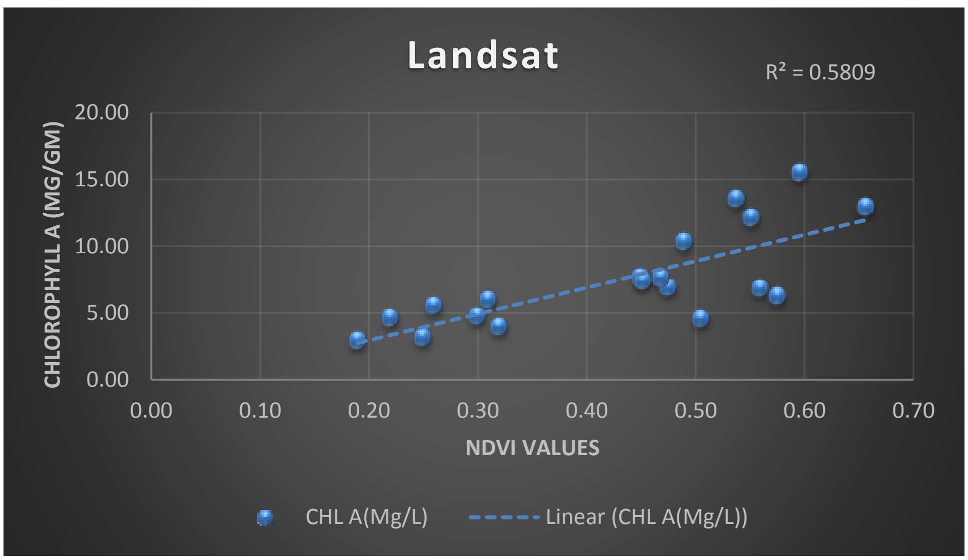

Fig: 4 Regression plot of Landsat-8 NDVI

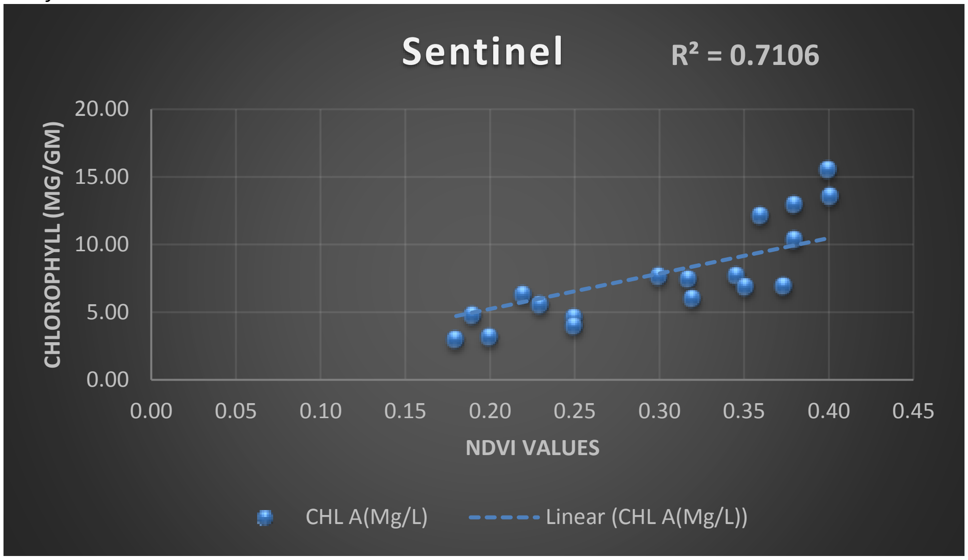

Fig: 5 Scatter plot and Regression results of Sentinel NDVI (Correlation Coefficient= 0.840611)

Results show that Landsat and sentinel can be utilized for chlorophyll estimation in vegetation which is an important biophysical parameter for crop health indication. Results also reveals that sentinel satellite sensor provides a better correlation between chlorophyll a and NDVI values, the reason lies in terms of higher resolution of sentinel i.e. 10m unlike the 30m resolution of Landsat satellite sensor.

Conclusion

The results shows the Estimation of chlorophyll concentration using remote sensing at a large scale with integration of satellite images, field data and regression models to monitor the crop growth throughout the season. To expand the potential of this approach it is required to work with ultra-high resolution images.

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