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Co-Relation of MNDVI Values, Yield and Soil Texture: Integrating RS, GIS and Land Based Observation

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Abstract The spectral reflectance of crops is strongly related to canopy parameters, which are related to the final yield. These are influenced by factors such as soil characteristics, cultural practices and other biotic factors i.e. spectral data is an integration of all factors affecting crop growth. MNDVI (Modified NDVI) value is directly related to spectral reflectance of crops. Most studies have revealed that there is a correlation between MNDVI and yield, therefore, MNDVI can be used to estimate yield before harvesting. Soil texture plays an important role for yield estimation. By considering this relationship between yield and MNDVI, one relationship is tried to be developed here between soil texture and MNDVI values for wheat crop. The primary objective is to establish the relationship between remotely sensed MNDVI measurement and soil texture of wheat crop. The study was conducted in Haridwar district in Uttarakhand state in India. The district covers an area of approximately 2360 km^2. Satellite images used for this study include an IRS-P6, LISS-III IRS images taken on March 2009, 2010, 2011, 2012, 2013 and March 2014. MNDVI images has been generated and then different models for different years have been developed to get only wheat crop rather than other crops, for above mentioned years, based on MNDVI values, in 3 categories range has been divided; Low cropping intensity, Medium cropping intensity, and High cropping intensity. Soil map have been digitized and total 38 classes based on National Bureau of Soil Survey and Land Use Planning have been associated with that area in soil map. To find the relationship between soil texture type and MNDVI range, both the layers have been overlaid, and findings have been made accordingly.
Keywords *Spectral Reflectance; MNDVI; Yield; Soil Characteristics; Spatial Model*

1. Introduction

During the recent years GIS and remote sensing techniques has been proved to be very effective in understanding, and regular monitoring of various landuse features, thus improving the planning and policy making processes in more effective manner.

Using remote sensing data various techniques had been developed for monitoring and assessing various land related features such as water, vegetation, soil etc. Some of the indices developed using Remote sensing data are Normalized Difference Vegetation Index (NDVI), Transformed Vegetation Index (TVI) and Ratio Vegetation Index (RVI). NDVI technique uses infrared and visible part of the electromagnetic spectrum of remotely sensed data for the identification of green vegetation. Transformed Vegetation Index (TVI) technique is the modified version of NDVI technique to remove negative values from it. Ratio Vegetation Index (RVI) is used for the separation of vegetation from soil background and is the simplest vegetation index developed. Thus these are the techniques used for the assessment and monitoring of drought, wetness of soil, and impact of climate on different vegetation and thus assessing the health of different vegetation (Unganai and Kogan, 1998; Singh, et al., 2003).

MNDVI and LAI have been considered to be useful indices for crop yield assessment models using various approaches from simple integration to more complicated transformation. MNDVI reflects vegetation greenness, thus it indicates levels of healthiness in the vegetation development. Although vegetation development of crop fields may differ from those of natural vegetation because of human influences involved such as irrigation, use of fertilizers and pesticides, MNDVI is considered as a valuable source of information for the crop conditions. Soil texture is one of the main environmental factors that influences crop productivity because of its direct effect on soil water and complex interactions with other environmental factors so indirectly we can say that there should be a co-relation between MNDVI and yield and so also with Soil texture.

Remote sensing provided a means of classifying land cover and for identifying agricultural regions within the county, while the GIS allowed the spatial organization of soil and weather data inputs to the model. Satellite images are used to overcome most of these limitations with a need to better find the calibration between the data and real field situations. The spread of modeling techniques using distributed parameters has largely encouraged the use of input data from remote sensing with the support of GIS for manipulating large data sets. A timely forecast of any crop helps the government in framing policies regarding its storage, distribution, export-import and procurement of price. With the advancement of space technology, remote sensing images provide access to spatial information at global scale at almost real-time basis. They have the potential not only in identifying crop classes but also of estimating crop yield (Mohd., et al., 1994): they can identify and provide information on spatial variability and permit more efficiency in field scouting (Schuler, 2002). Remote sensing could therefore be used for crop growth monitoring and yield estimation.

Wheat is an economically important Rabi crop in Uttarakhand state, which is grown around 26% of total available agriculture area in the state, out of thirteen districts; wheat crop area wise Haridwar comprises under third rank after Udham Singh Nagar and Almora. Efforts are being done to improve the accuracy and timeliness of yield protection methods. Many studies have revealed that there is a correlation between remotely sensed MNDVI and yield. This study applied satellite based MNDVI to predict wheat crop yield and relationship between soil.

2. Objectives and Study Area

The study area is as shown in Figure 1, Haridwar with the latitude and longitude values are 29.956^0 N and 78.17^0 E, has been selected as the study area due to its political, religious, historical, economical and social importance, and due to its major part covered under agriculture land. Haridwar is also ever changing in its land features which effects its environment thus it motivate us to select the study area. Thus agricultural is one of the important livelihoods for the people of Haridwar which has an area of about 2360 km^2. Apart from other crops grown, wheat is one of the major crops shown and covers an area of about 10.66% of Haridwar district.

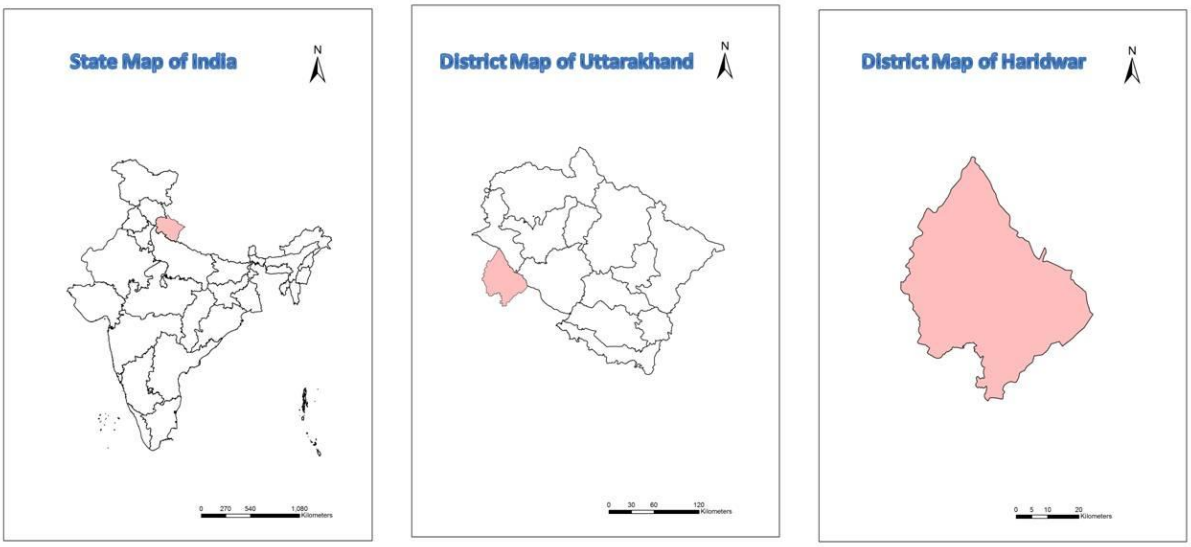

Figure 1: *Study Area*

The major objectives of the study are as follows:

- To establish relationship between remotely sensed MNDVI measurement and soil under wheat crop areas.
- To estimate pre-harvest wheat acreage/production with the help of relationship developed between MNDVI and soil using last 5 years data for the year 2013-14.

3. Data Used

3.1. Satellite Data

IRS-P6-Resourcesat-2: LISS-III data

3.1.1. Collateral Data

- Wheat Acreage statistics from Agriculture department
- Historical district level wheat statistics from 2005 to 2008 for all 13 districts
- Shape file of the boundary of districts of Uttarakhand state from SOI has been used
- Topo-sheets and images of the study area were also used for GT (Ground Truth)
- Ground truth sheet
- Rainfall
- Soil map
- Aspect
- Temperature
- DEM

Ground Truth

Satellite data has been very effectively used for the identification and interpretation of landuse features of remote areas without the need of physical presence. But due to some technical reasons field validation of the interpreted data is needed to be carried out. Ground truthing of various wheat grown areas are carried and latitude and longitudes are recorded to be identified in the satellite data.

Ground truthing is also carried out to identify the extent of crop grown, and percentage of ground cover along with the crop stage. Other related data are also collected during field visit are district/state/village names of study area, date and year of observation, size and health of crop, crop cover, and free hand field sketches, and field photographs (overviews, and close views) on the G.T. Sheets for the time period from February 2008 till February 2013 is been carried out.

4. Methodology

4.1. To Establish Relationship Between Remotely Sensed MNDVI Measurement and Soil under Wheat Crop Areas

✓ Acquisition of satellite data

✓ Data processing

- Pre-processing of the raw satellite data is needed to be carried out to make it usable, which includes Geometric correction, radiometric correction, Atmospheric correction, image enhancement. The raw satellite data thus collected for different time period of the study time interval that is from 2009 till 2014 has been Geo-referenced and co-registered using the referenced points collected from the field of the study area and using the other geo-referenced satellite data. The root mean Square error is below 0.5 which is acceptable.
- Mosaicing of all the geo-referenced temporal satellite data is carried out wherever needed.
- The geo-referenced and Mosaiced satellite data thus generated has been used to clip the study area of all the temporal data. All data are clipped using the district boundary.

✓ Field work: Field work is carried out for the identification and collection of GCP points. Around 600 points were collected for the said study time period of 6 year that is from 2009 till 2014.

- Analysis
  The enhanced and corrected satellite data thus produced are used for the generation or assessment of modified NDVI image using the following formula.
  NDVI=NIR-R/NIR+R
  NDVI values ranges from 0 to 200.
  The same methodology used above is used for all the six year satellite data. G.T points are also overlaid on the generated MNDVI images along with the soil map of the district of Haridwar.
- A relationship is finally analyzed using the overlaid soil texture and calculated MNDVI images for all the 6 year using spatial modeling technique of GIS.
- A final relationship between MNDVI and soil texture has been generated by combining the above model for all the six years.

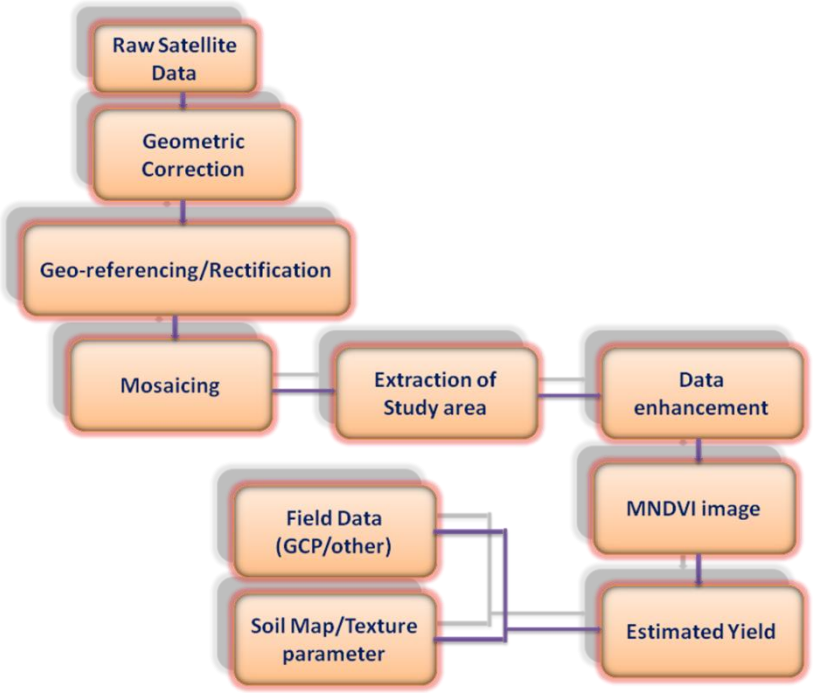

Figure 2: *Flow Chart of Methodology*

4.1.1. To Estimate Pre-Harvest Wheat Acreage/Production with the Help of Relationship Developed between MNDVI and Soil Using Last 5 Years Data for the Year 2013-14

Pre-processing has been done for the IRS P6 LISS III satellite imagery for the year 2013-14. Relationship, between MNDVI and soil texture from above mentioned methodology (Figure 2) has been used to find out Pre-harvest wheat acreage/production estimation for the year 2013-14.

5. Results

5.1. Geo-Referencing of Satellite Data

Image-to-image registration was done with an accuracy level of less than half a pixel.

5.1.1. Relationship between MNDVI and Yield and Soil Texture in Haridwar District is given for The Crop of Wheat is shown in the Following Tables:

Table 1: *Low and Very Low Cropping Intensity*

MNDVI Range	Yield (qtl/ha)	Soil Texture
137-145	24	Loamy skeletal on steep slope with severe erosion
		Loamy with mod. stoniness and slight stoniness
		Loamy with severe erosion and mod. stoniness

Table 2: *Medium Cropping Intensity*

MNDVI Range	Yield qtl/ha	Soil Texture
145-150	28	Loamy-skeletal with severe erosion
		Sandy-skeletal on steep slopes with severe erosion and mod. stoniness Erosion and slight stoniness

Table 3: *High and Very High Cropping Intensity*

MNDVI Range	Yield qtl/ha	Soil Texture
More then 150	30 -35	Loamy with mod. erosion
		Calcareous loamy with mod. Erosion and slight stoniness

Pre-harvest wheat acreage/production estimation for the year 2013-14 of Haridwar district is given as follows:

Table 4: *Estimated Acreage/Production of Wheat Crop*

Year	Acreage (ha)	Production (m-t)
2013-14	41748.78	109258.6

6. Discussion

The results as shown in the above four tables clearly shows that MNDVI maps have a strong relationship for the assessment of wheat yield in relation to the soil texture. After analyzing the output for all the 6 years it has been found that MNDVI techniques can be used for the assessment of crop yield for different soil properties such as texture. Seeing the results in Table 1. It was found that MNDVI values ranging between 137 to 145 with soil texture properties of Loamy skeletal on steep slope with severe erosion has yield value of 24 qtl/ha. For the MNDVI value between 145 to 150 as shown in Table 2 the yield estimated is 28 qtl/ha for the soil texture of Loamy-skeletal with severe erosion. When the MNDVI value increases to 150 as in Table 3 the yield goes up to 30 to 35 qtl/ha for the soil texture of Loamy with moderate erosion. Thus the overall wheat production which has an area of 41748.78 ha for the year 2013-14 is 109258.6 m-t as shown in Table 4. It is thus found that MNDVI is an effective Remote Sensing technique which can be used

7. Conclusion

Thus it is concluded that MNDVI technique can be best used for the estimation of crop production yield in relation to some land properties such as soil texture, or soil erosion. Different value range of MNDVI can be used for the assessment of crop yield in relation to other land properties. Thus these results can be used for identification of different standard environmental parameters to be used to increase crop yield.

The study can be elaborated to other soil properties such as soil depth, soil drainage, etc. Apart from soil properties other landuse properties can also be used in relation to MNDVI to identify other parameters with their range effecting crop production. This study can also be extended not only to other crops but also to forest vegetation to identify its health and understanding its environment. Remote Sensing techniques can further be explored for different nick assessment.

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