Land use, land cover assessment and discrimination of wheat crop using remote sensing in *Tarai* region of Uttarakhand

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ABSTRACT : In the present study, wheat has been discriminated after land use or land cover mapping using multispectral LANDSAT-OLI data. Udham Singh Nagar district, the largest plain area of Uttarakhand with a geographical area of 3,055 km^2 has been chosen for the research purpose. Maximum vegetation cover and visual image interpretation based techniques have been adopted in mapping heterogeneity of land cover classes. A satellite image of the peak vegetation period (*rabi season)* for wheat season was chosen for discrimination of wheat (*Triticum aestivum* L.) crop at US Nagar, Uttarakhand. The LANDSAT-OLI image of 21^{st} February, 2015 was used to demonstrate the capability of remote sensing to discriminate crop from other spatial features. The image was acquired freely from the website (http://glovis.usgs.gov/) and processed using ENVI-4.8 software. QUAC technique was employed to accurately compensate the atmospheric noise in the image. For land use and land cover mapping, 11 different feature objects such as wheat, fallow land, wet land, forest, tree/orchard, weed, built-up land, barren land, floating weed, water body/river bed and other crops were classified via maximum likelihood algorithm. Out of the total geographical area of the district, wheat contributes for a major share (35.3 %) followed by forest (20.9 %) and other agricultural crops (19.6%). Wheat crop was discriminated by using both ground truth data and spectral property of different entities. Correspondingly, cloud free SPOT images were downloaded for the same year to generate the spectral library of wheat. For generating wheat growth profile, wheat areas were first selected by overlaying the wheat mask and secondly the curve was plotted using mean NDVI data obtained from SPOT images throughout the crop season.

Key words: ENVI-4.8, growth profile, LANDSAT-OLI, maximum likelihood algorithm, supervised classification

Discrimination of different crops and their yield estimation should be done as early as possible during the agricultural season as it proves quite helpful in management of agricultural crops and also framing of policies. The use of remote sensing imagery for land use/ land cover mapping and monitoring of agricultural crop conditions and production has been steadily increasing in recent years. Advances in the spatial, spectral and temporal resolution of remote sensing (Johannsen *et al*., 1998) as well as potential positive changes in cost (availability of remote sensing images of various resolutions free of cost) and availability of remotely sensed data makes it a profitable tool for farmers. The remarkable developments in space borne remote sensing technology and its application during the recent past have firmly established its immense potential for mapping and monitoring of various natural resources. Data obtained from remote sensing satellites have been used for various applications of resource survey and management under the National Natural Resources Management System. The first multi-spectral airborne study for identification of root-wilt disease in coconut in the country was conducted jointly by Indian Space Research Organization and Indian Council of Agricultural Research. Since then, there have been many investigations carried out on various aspects of crop identification and acreage estimation using air-borne to space borne sensors for different crops and agricultural applications in India.

The use of remote sensing has proved to be very important in monitoring of crop, condition assessment and their yield estimation. Crop discrimination and yield prediction are just few examples of how satellites can be of great value to agriculture. Remote sensing technology has been increasingly considered for standardization and possibly cheaper and faster tool for crop discrimination surveys (Bauman, 1992). The crop discrimination and mapping using satellite data is carried out either by visual or digital interpretation techniques. Visual techniques generally are based on standard FCC (False Color Composite) generated using green, red and near infrared bands and assigned blue, green and red colors respectively, in the satellite image. The digital image interpretation techniques are applied to each pixel and full dynamic range of observations are used for crop discrimination. A multi-temporal approach is used as single date data set does not permit accurate crop discrimination. The nature and amount of electromagnetic radiation reflected, absorbed or transmitted from a leaf depends on the wavelength of radiation, surface roughness, angle of incidence, differences in the optical properties and biochemical content of the leaves (Kumar *et al*., 2001). Remote sensing is largely concerned with measurement of surface reflectance of energy from individual entity and drawing inference from such reflectance for identification of the object. NDVI has been used extensively in vegetation monitoring, crop yield assessment and forecasting (Hayes *et al*., 1982; Benedetti and Rossinni, 1993; Quarmby *et al*., 1993). An understanding of the physical and physiological properties of plants and their interaction with the incident radiation are the key elements in crop identification through remote sensing.

MATERIALS AND METHODS

Present study deals with the LULC mapping of Udham Singh Nagar district of Uttarakhand and discrimination of wheat (*Triticum aestivum* L.) from other rabi season crops. Wheat crop is sown in Uttarakhand as a winter crop from November to December. Wheat is a quantitative long-day crop which reaches flowering stage around mid February and harvesting commences from April. The crop duration is about 120-135 days active out of which the vegetative phase continues for the first 60 days wherein early 30 days accounts for active growth phase followed by tillering stage. The crop attains maximum flowering stage of around 60-70 days.followed by soft dough formation, grain filling and grain maturation, each of about 20 days duration.

Wheat was discriminated by using both ground truth data and spectral property of different entities Discrimination was performed with the help of supervised classification algorithm (Maximum Likelihood) embedded in ENVI-4.8 software. Onboard OLI sensors of Landsat satellite images of path 145 and row 40 for the year 2014-15 have been downloaded and processed for generation of land use or land cover map of US Nagar. A sample of subset FCC Landsat-OLI satellite image of US Nagar used as a base image for LULC mapping has been shown in fig. 1. While classifying, entire image has been segregated into separate classes or region of interests and thus the wheat crop was discriminated. Wheat area of US Nagar was selected for creation of spectral library of wheat. A year (2014-15) having maximum number of cloud free remote sensing images has been selected and the SPOT images available at an interval of every 10 days during the entire wheat/crop season (from germination to maturity) were processed to obtain the normal (average) spectral growth profile of wheat crop. Eighteen dates of satellite pass SPOT images starting from 1st November, 2014 to 21st

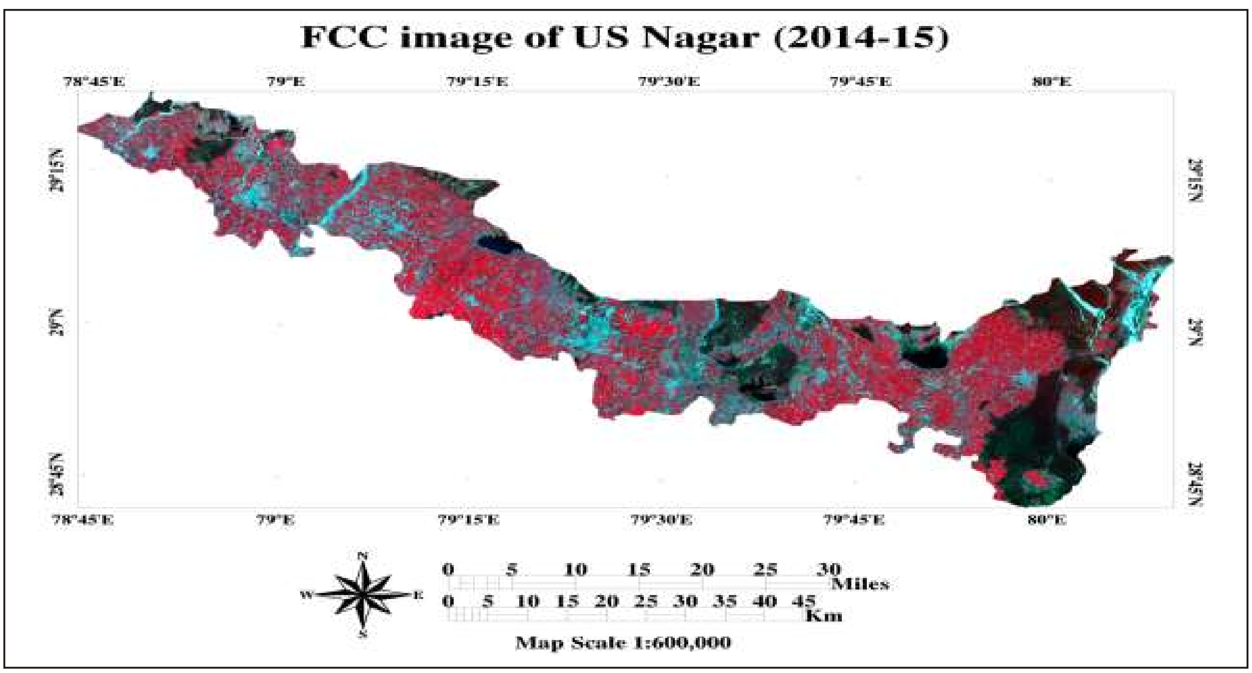

Fig. 1: False Colour Composite LANDSAT-OLI (30 m resolution) Image of US Nagar

April, 2015 have been used for the research purpose. Spectral profiles/ spectral behaviour of objects were generated by showing relationship between numbers of days after sowing and mean NDVI. This spectral behavior helps to differentiate between the diseased and healthy wheat. The peak of this profile corresponds to peak of vegetation cover of the crop. NDVI, which is a widely accepted index for differentiate vegetation analysis was considered to represent the growth of crop.

RESULTS AND DISCUSSION

Supervised classification was carried out over Landsat-OLI satellite data to generate LULC map of Udham Singh Nagar by taking RoIs (Region of Interests) of individual entity. Shape file of permanent land use and cover features viz., Builtup land, water bodies, forest, tree/orchard were generated via Google earth image. Mask of each shape file was prepared using build mask module of ENVI-4.8. The mask was applied on the classified image of respective year in order to remove the pixel similarity and derive the best results. While classifying, entire image has been segregated into separate classes or region of interests and thus wheat was discriminated. The classified image of US Nagar with their different land use/land cover categories has been shown in fig. 2. Total 11 LULC classes including wheat, other crops, fallow land, wet land, forest, trees, built-up land, barren land, weed, water body/riverbed and floating weed were delineated. After supervised classification class stats was generated and the area under different feature objects was measured. A pie diagram showing different classes including wheat and their areal extent in per cent has been portrayed in fig. 3. Out of the total geographical area of US Nagar, majority of the areas are covered with wheat (35.3%) followed by sandy/barren land (20.9%).

The spectral response of the crop at different stages is very important for crop discrimination. It is not always possible to perform ground truth as in some case, time is very pressing and field survey is not possible, so already existing spectral response of the crop at different stages can be exploited under such situations. Therefore, the spectral profile, which is the response of the crop in different bands at different phenological stages was recorded and analyzed for wheat crop. It can be concluded, from the figure that with the increasing vegetation cover the reflectance in Near Infrared band (NIR) increases and reaches to a maximum level at peak vegetation (60-70 days after sowing) stage of the crop. With the onset of flowering stage, the reflectance starts to decrease continuously in NIR band due to the decay of older leaves. There is a slight increase in reflectivity around green band because the pigments are least absorptive there. There is a negative correlation of

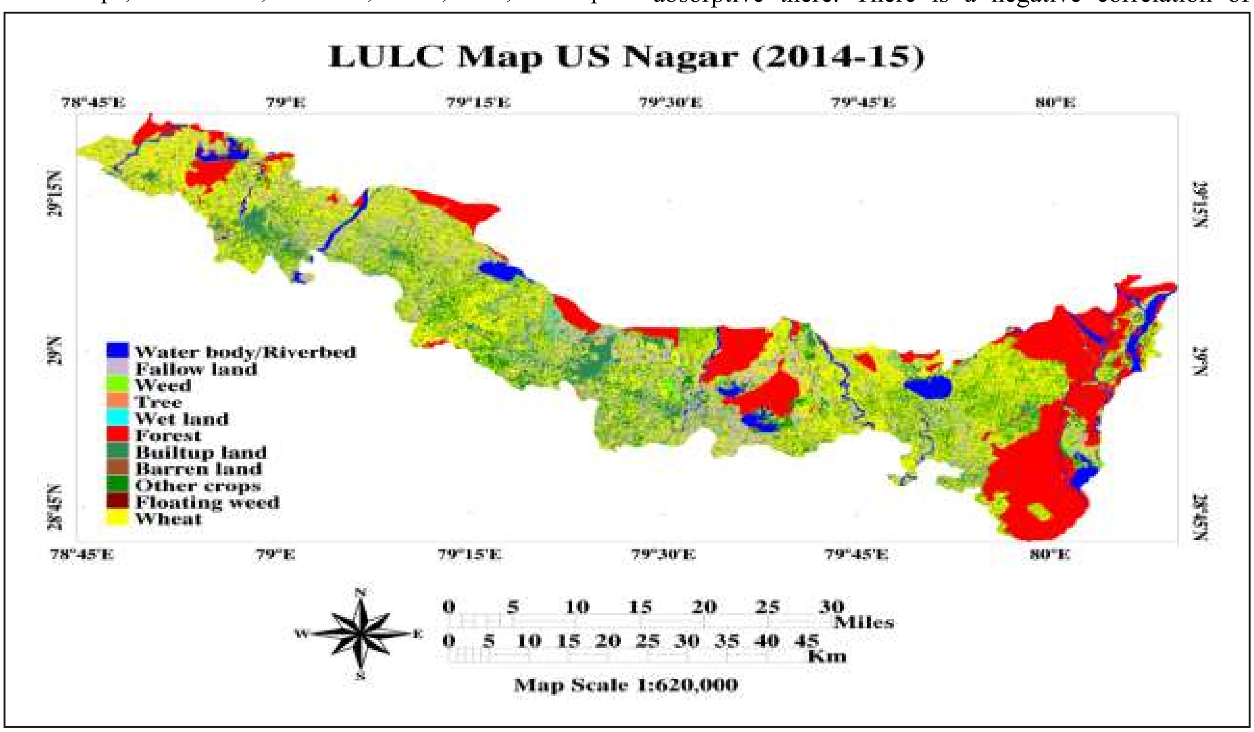

Fig. 2: Land Use and Land Cover Map of US Nagar Showing Different Classes

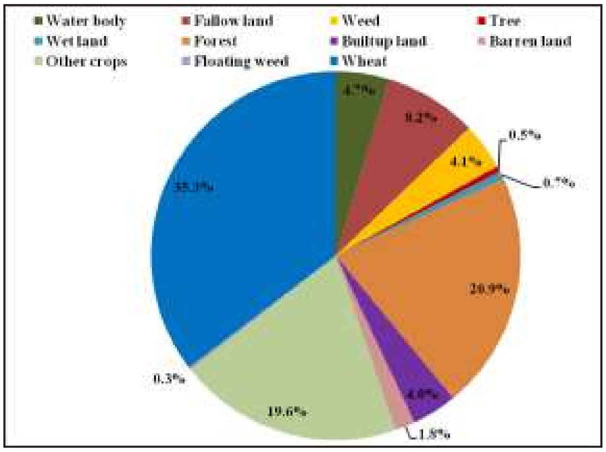

Fig. 3: Pie diagram showing LULC categories and their areal extent of US Nagar

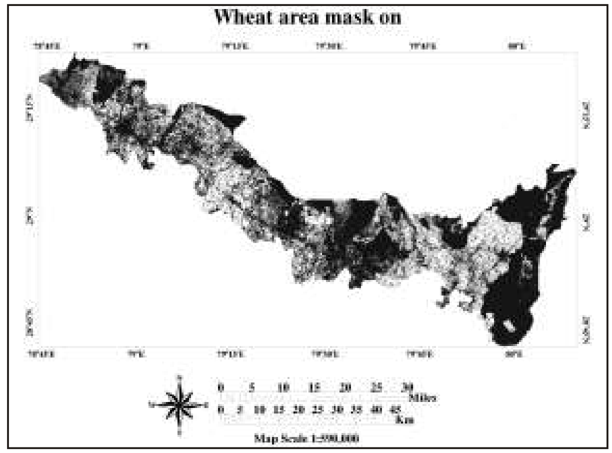

Fig. 4: SPOT NDVI image of US Nagar showing wheat pixels only in white colour

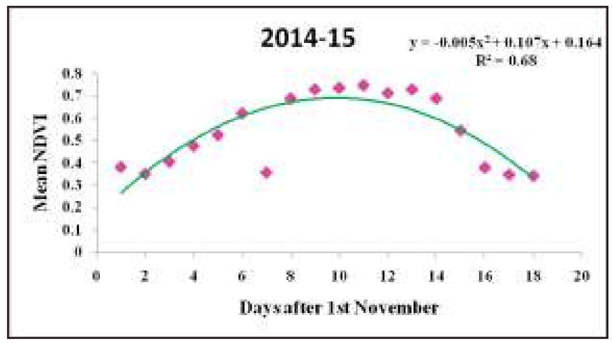

Fig. 5: Temporal behaviour of mean NDVIs (growth) of the wheat crop

reflectance in visible band with the crop condition and yield; the lower the values of blue, green, or red reflectance, more the chlorophyll and healthier the vegetation resulting in better crop condition. As the canopy cover of wheat increases or in other words as there is more utilization owing to photosynthesis process, there is an increase in red band absorption *i.e.* reflectance decreases with increasing greenness of the plant. At the age of 60-70 days, maximum absorption occurs in red band and as soon as flowering commences reflectance increases in red band.

Crop growth profile

Growth profile of the crop is very important for many applications like, to establish the phenological stages of the crop, to assess the crop condition *etc*. However, spectral indices such as NDVI which is derived with the help of NIR and red band can be directly used to represent the growth of plant. In order to construct the growth profile for the year 2014-15, 18 cloud free spot images were taken. The NDVI images were generated for all the eighteen dates and the different NDVI layers were stacked together. The mask of wheat NDVI was created and overlaid on each SPOT NDVI image. The area under mask was kept active so that the output image only shows the wheat pixels (Fig. 4). Finally, growth profile was constructed using temporal NDVI values against these eighteen satellite pass dates. Fig. 5 depicts the temporal behavior of the wheat crop in terms of the mean NDVI values. From the figure, it can be concluded that as the number of days increases, wheat canopy increases linearly till the peak vegetation growth stage is attained. When the plant reaches maturity stage, NDVI decreases slowly due to decreasing greenness in the plant and afterwards it starts to decline rapidly owing to yellowing of leaf.

Discrimination of wheat crop using remote sensing

The LANDSAT-OLI image of the 21st February, 2015 has been used here to demonstrate the capability of remote sensing in discriminating the crop from other spatial features. By this time (January- February), the sugarcane and mustard crops get harvested and wheat is in its peak vegetation stage (at the stage of physiological maturity) in the plains of Uttarakhand. The wheat crop has been discriminated accurately after training of image processing software (ENVI-4.8) for 11 different categories and using Maximum Likelihood classifier. After LULC mapping and development of growth profile, it was found that the observed area of wheat crop in U.S. Nagar was (97813 ha). Spectral profile of wheat crop has also been developed using mean NDVI of landsat data (Jha *et al*., 2012) and wheat crop at pantnagar & adjoining regions was discriminated using both temporal behaviour of wheat and its spectral response (Ranjan and Nain, 2013). The comparison between observed and reported area given by the state governmental agencies (98911 ha) showed a variation of 1.12%. Thus, it can be inferred that maximum likelihood algorithm can be applied accurately for the discrimination of wheat/crops from other features. The Maximum Likelihood Classifier (MLC) is a well known parametric statistical classifier and is widely used for pattern classification (Duda and Hart, 1973).

CONCLUSION

Wheat class had a narrow band and non overlapping range of values, making it separable from other classes. However, it is important to mention here that images for different months are required to discriminate different crops while the image of end February is important for wheat discrimination only. Hybrid approach (both ground truth data and spectral property) was used for discrimination of wheat.

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