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Estimation of mango growing areas using remote sensing

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ABSTRACT

An attempt was made to estimate acreage and to depict the spatial distribution of mango growing areas using linear imaging self-scanning image of remote sensing data for Saharanpur district of Uttar Pradesh. The image was processed using ENVI software. Unsupervised, supervised and decision tree classification were used for the acreage estimation. The study has clearly demonstrated the usefulness of remote sensing image for identifying and acreage estimation of mango orchards. The results also indicated that mango acreage estimation was more accurate in decision tree approach (92.92%) as compared to other two methods (81.73 and 80.43%, respectively). The overall result revealed that the finer resolution the time series data, better the accuracy of area estimation. The above study proves that the remote sensing data could be effectively used for other perennial horticultural crops with finer resolution time series data.

Key words: Mango, acreage estimation, remote sensing, decision tree.

INTRODUCTION

Remote sensing in general term, is described as the act of gathering data from a distance, which involves sensing and recording reflected or emitted energy and processing, analyzing and applying that information. Remote sensing technology has many attributes that would be beneficial for detecting, mapping and monitoring of vegetation. It is a tool offering well-documented advantages including a synoptic view, multispectral data, multi-temporal coverage and cost effectiveness. It has received considerable importance in the field of biological sciences in the recent years. There was wide consensus that remotely sensed data can provide an accurate and repeatable means of land cover mapping and monitoring, especially with respect to areas with rapidly changing land use and land management activities (Townshend *et al*., 13). In particular, remote sensing based approaches make use of the distinct spectral reflectance from different land cover types in association with the temporal variation of reflected radiation caused by the phenological dynamics in vegetation (Justice *et al*., 4; Loveland *et al*., 5).

The use of remotely sensed data in crop acreage estimation has been demonstrated by various researchers in different parts of the world (Saha and Jonna,10; Nualchawee, 8). Atkinson and Lewis (1) reported that this process primarily uses the spectral information provided in the remotely sensed data to discriminate between perceived groupings of vegetative cover on the ground by using the spatial and temporal information included in single date data and time series data, respectively. Gordon *et al*. (2) explored the usefulness of Landsat thematic mapper (TM) data for inventorying trees. They developed a unique signature from the orchard reflectance and subsequently used in area estimation. Gupta and Sharma (3) visually interpreted to delineate the various mango orchards in Malihabad tehsil of Lucknow, Uttar Pradesh using Landsat-5 TM satellite data. Yadav *et al.* (14) estimated acreage and mango production using Linear Imaging Self-Scanning System (LISS) LISS-II and LISS-III data. Temporal Indian Remote Sensing (IRS) Advanced Wide Field Sensor (AwiFS) (spatial resolution was 55 m) data were used to select optimum dates for its identification of apple orchards. IRS LISS III data (with spatial resolution 23 m) was used for area estimation of fruits like apple (Sharma and Shusma, 12), citrus, grapes and plantation crops (Palaniswami *et al*., 9). Sahoo *et al*. (11) have worked out the composition of forest trees from multispectral high-resolution IKONOS data through spectral angle mapper classification technique. Nicolas and Chin (7) reported that supervised classification was done on SAR/ INSAR data set, using training areas selected in the TM image of swamp forest to derive four classes such as forest, rice, coconut and rubber.

Mango is one of the most widely grown fruits and till date very little or no spatial mapping of its growing areas has been done. Remote sensing is a powerful tool for mapping, monitoring and management of agricultural and horticultural resources. The application of remote sensing technology in combination with Geographic Information System (GIS) in area estimation of fruits like mango, banana,

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apple, citrus, grapes and plantation crops are meagre. Therefore, the present study was undertaken to estimate the acreage of mango orchards using multispectral remote sensing data.

MATERIALS AND METHODS

Saharanpur district of Uttar Pradesh lies between 29° 34'45'' to 30° 21'30'' N latitude, 77° 09' to 78° 14'45'' E longitude and has a total area of 3,860 km^2. The major horticultural crops grown are mango and guava, followed by agricultural crops like wheat, rice, maize, *jowar, bajara*, sugarcane, oilseeds, cotton and jute. The data used in the study include satellite and collateral data of Saharanpur district. The later was collected from Department of Horticulture and National Horticulture Database (6). The multispectral satellite data of LISS-III of IRS -P6 was used for the study. The date of satellite pass was November 22, 2007. The path and row of satellite pass was 54 and 96, respectively. The detail technical specifications of the data product are given in Table 1.

Field survey was conducted for collection of detail ground truths about mango growing areas. Location coordinates in terms of latitude and longitude were recorded with the help of hand held GPS (Leica GS 5) under WGS 84 (Lat-Lon) coordinate system. Ground truth information was further used for classification of mango areas from satellite images. The vector map of Saharanpur district was prepared from the hard copies of district map, which were scanned and saved in JPG format. The JPG file was opened in GIS software, ARCGIS (ver 8.3) and digitization was done. The vector boundaries of Saharanpur district were obtained. The projection of the maps was defined as Geographic Latitude Longitude with WGS 84 as datum.

Table 1. Characteristic of data set of LISS III used in the study.

Parameter/ Sensor	Data set characteristics
Spectral bands	
Band 2 (Visible)	0.52 - 0.59 microns
Band 3 (Visible)	0.62 - 0.68 microns
Band 4 (NIR)	0.77 - 0.86 microns
Band 5 (SWIR)	1.55 - 1.70 microns
Resolution	23.5 m (Visible and near IR region)
Revisit	24 days
Swath	141 km (Visible and near IR region)
Path-row	54 and 96
Saturation radiance	B2 28-31
(mw/ cm^2/ sr/ micron)	B3 25-38
	B4 27-30
	B5 6.9

The digital image processing software ENVI (ver. 4.3) was used. The pre-processing involves importing images and geometric corrections, which were done following the routine procedure and using Ground Control Points (GCPs) collected during ground trothing. The image was resized to cover only Saharanpur district using vector map of the study area. Three classification approaches were carried out, namely, unsupervised iso-data classification, supervised maximum likelihood classification and decision tree based classification to retrieve mango-growing areas. In case of isodata classification approach, the image was classified to 10 clusters. The mean spectral profile of each cluster was prepared and drawn together. Based on ground truth information, the spectral profiles were identified and mango-growing areas were classified. The training areas of mango growing and non-growing areas along with urban, river bed sand, agricultural land, fallow land and water bodies was done based on training sites using maximum likelihood classification approaches and the statistics for mango growing areas were generated.

The third approach was the decision tree based classifier, which performs multistage classifications by using a series of binary decisions to place pixels into classes. The spectral ranges of mango growing areas were defined based on training sites. The decision rule was made accordingly to separate mango growing areas from the image. The acreage estimated by remote sensing method was assessed for its accuracy and reliability using the National Horticultural Board (NHB) database (6).

RESULTS AND DISCUSSION

The LISS-III image of Saharanpur is shown in both grey scale and false colour composite (FCC) with district vector boundary in Fig. 1 and zoomed closer view of the mango growing area in red colour is shown in Fig. 2b-c. The iso-data unsupervised classification of the image having 10 classes is depicted in Fig. 3. All these classes were identified based on their spectral profile and ground truth information. The mango growing areas are shown in green colour and its statistics was computed (Table 2). For supervised classification, 8 training sites were identified on the image based on ground truth. Maximum likelihood classification was done and classified image is shown in Fig. 4. The green colour shown in the classified image is the mango growing area. The area statistics was calculated and data is shown in Table 2.

The image was classification based on the decision tree approach and the classified image shown in yellow colour is the mango growing areas extracted from the image and the flow of decision

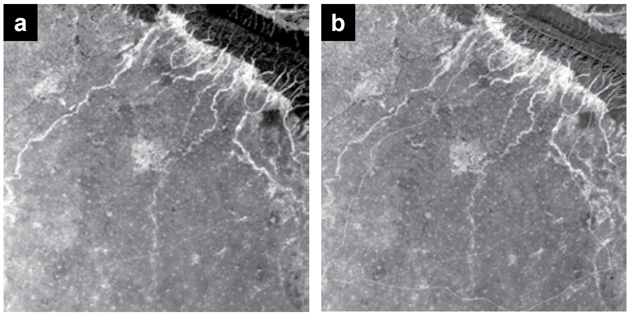

Fig. 1. a) Grey scale image and b) FCC of LISS-III data of Saharanpur district with district vector boundary.

Table 2. Classification accuracy of mango area estimated for LISS-III.

Area (ha)	Actual area (ha)	Estimated area (ha) UNSU	Estimated area (ha) SU	Estimated area (ha) DT
Saharanpur LISS	25,946	32,256 (24)	31,743 (15)	27,922 (8)

used are depicted in decision tree, which is shown in Fig. 5. The total mango growing area calculated is depicted in Table 2. The mango area estimated through different approaches was compared with the statistics of the mango area obtained from the Department of Horticulture, Saharanpur as shown in Table 2.

Different classification approaches were evaluated for getting reliable statistics of mango growing area. While classifying LISS-III image of Saharanpur district and comparing with the ground truth and the statistics obtained from Government agency, it revealed that decision-tree based classification yielded better accuracy followed by maximum likelihood and unsupervised classification approaches. The unsupervised isodata classification approach is mainly based on statistical rules, and ground information has not been considered, thereby accuracy level of the results was very low. In case of supervised classification, *i.e.* maximum likelihood classification, the training sites were selected based on ground

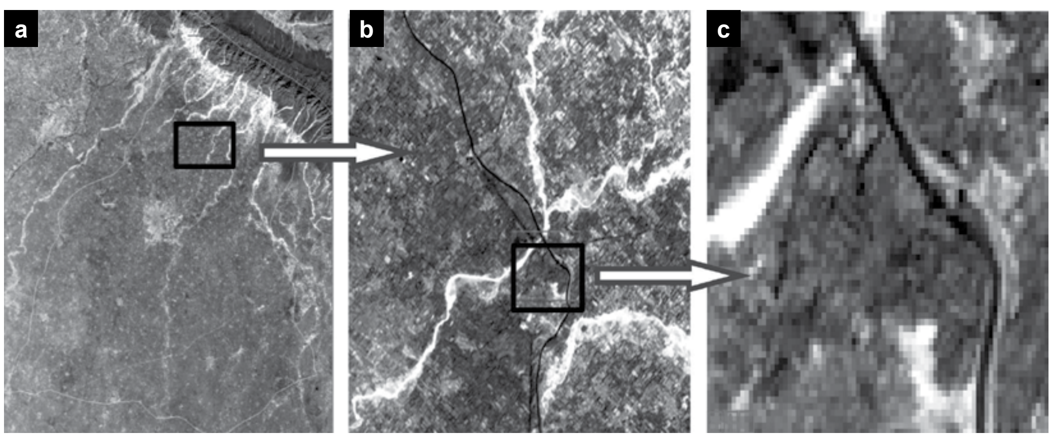

Fig. 2. a) FCC of LISS-III image as seen in zoomed windows (b, c) for an area having mango orchards.

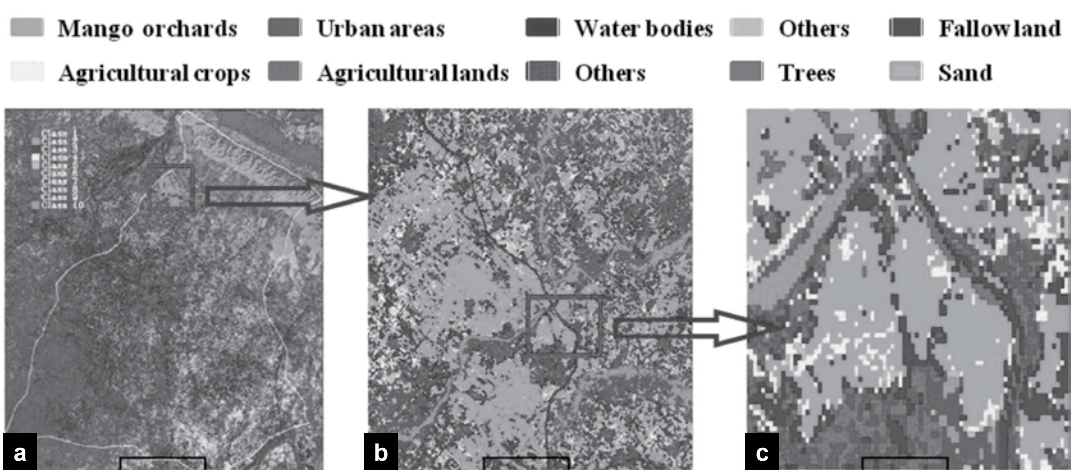

Fig. 3. a) Unsupervised classification of LISS-III image showing 10 different classes in (b) closer view and (c) a zoom of 4X.

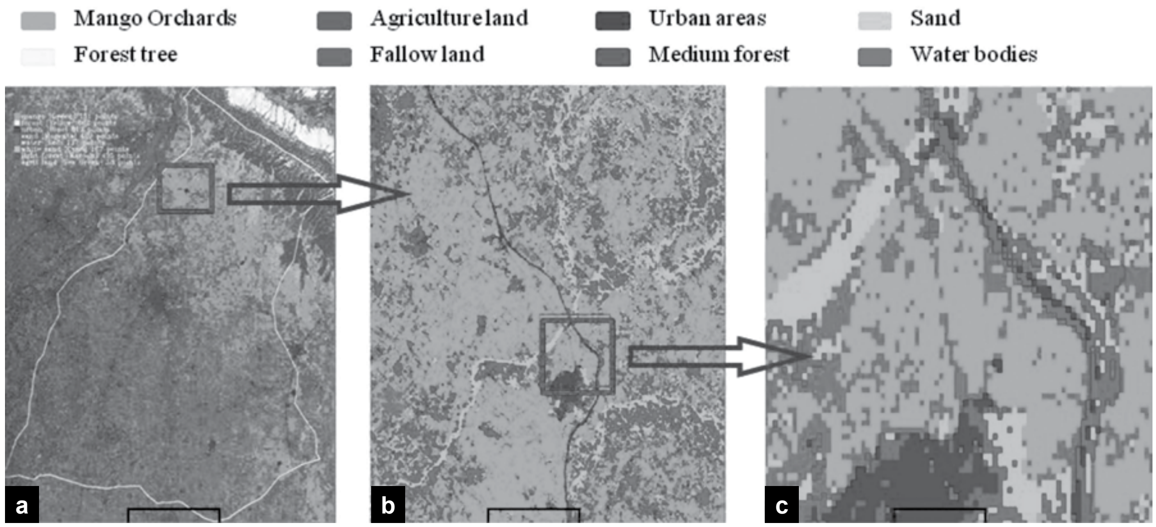

Fig. 4. a) Supervised classification of LISS-III image showing different classes (b) in closer view and (c) a zoom view 4X.

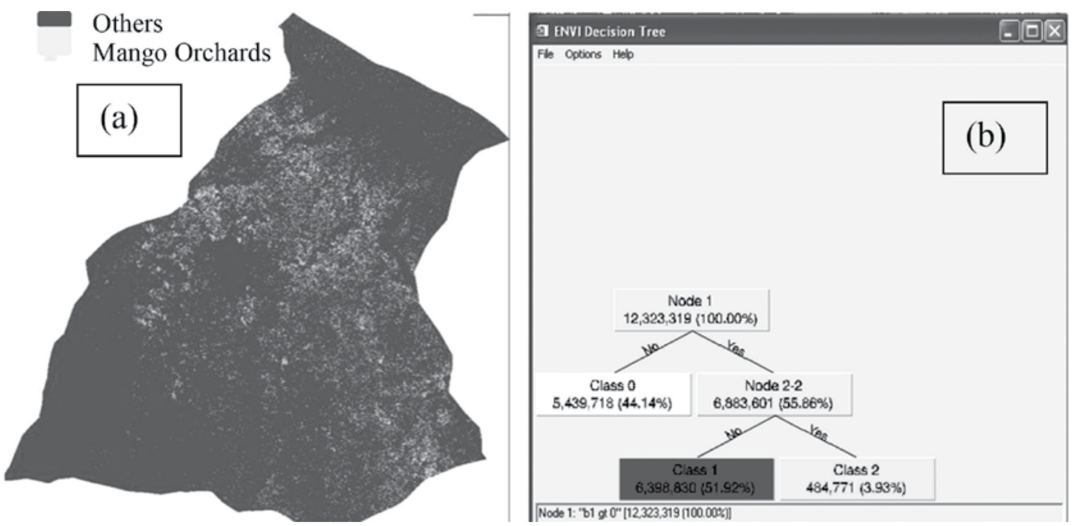

Fig. 5. Decision tree based classification of LISS-III image (a) yellow colours showing mango growing areas and maroon colour non mango growing areas (b) showing the decision tree with each node.

information and classification was done based on the training sites. This improved the accuracy over unsupervised classification. In case of decision tree based classification, the decision rules were made based on the spectral values of the training sites. This classification performs multistage classifications by using a series of binary decisions to place pixels into classes. Each decision divides the pixels in a set of images into two classes based on an expression.

The study clearly demonstrated the usefulness of Indian remote sensing data for identifying the mango orchards and acreage estimation. The decision tree approach was found to be more reliable, *i.e.*, 11.19-12.49% (Table 2) more accurate when compared to supervised and unsupervised classification for estimation of mango acreage. In future, remote sensing data of higher resolution and hyper-spectral data can be used to monitor, estimate acreage, spatial mapping of fruits crops distribution, to monitor the stress of fruit crops and diseases like malformation in mango orchards and other fruit crops.

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