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Mapping Fruit Crops Diversity in Bilaspur District using Geo Spatial Techniques

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ABSTRACT: A GIS based study was undertaken in Bilaspur district of Himachal Pradesh (India) utilizing the collateral data on geographic boundaries at different administrative levels besides the settlements, drainage/rivers etc. The area and production data of different fruits in that area were also integrated in the analysis. The DEM (Digital Elevation Model) was prepared using SRTM (Shuttle Radar Topographic Mission) data of the NASA downloaded from earth explorer browser. Satellite imageries in digital format were procured from NRSC Hyderabad. The IRS P6 LISS IV was the basic satellite data with spatial resolution 5.8m were used in this study. In general, the crop specific spectral signatures were recorded during the maximum vegetative cover stage. Ground truth data were collected to determine the spectral signatures acquiring information on condition and geographic coordinates of orchards location using GPS. Software ArcGIS 10.5.1 and ERDAS imagine were used for data analysis and interpretation. Normalized Difference Vegetation Index (NDVI) were developed from image reflectance for comparison and editing the classification outputs and was within the range of -0.2 to 0.55 high values indicated dense vegetation and low or negative values showed low vegetation and presence of waterbodies, rocks and settlements. The thematic map showed that the highest area holding blocks were Sadar for mango (1501.91 ha), citrus Ghumarwin for Citrus, Sadar for litchi (251.42 ha) and Ghumarwin for pomegranate (194.15 ha). Whereas, the total production of all the four fruit crops was maximum in Ghumarwin developmental block of the district Bilaspur. This study is a step ahead to utilize the potential and advantages of geospatial technology in mapping fruit crop diversity. Maps will be valuable for researchers and administrators to simplify the process of decision making, orchard planning and evaluation process in more scientific and logical manner. However, further research is necessary for the identification of small patches, multi-cropped regions and assessing the local soil characteristics to reap maximum advantage of artificial intelligence.

Keywords: Fruits, GIS, Digital Elevation Model, spectral signature, supervised classification, NDVI.

INTRODUCTION

Himachal Pradesh is predominantly a horticulture state of India and the importance of horticultural plants is compounded in sloppy and uneven physiography. The conventional farming activities based on cereal crops has become less remunerative and non-profitable, even though climatic variability provides potential for cultivation of a variety of fruits. The immense scope for horticultural crops has not been harvested suitably (Sharma *et al.*, 2015). The district Bilaspur is located in the valley of Satluj in the outer hills of H.P. and covers an area of 1,167 sq. kilometres. Located at an average elevation of 673 meters above sea level and being at a lower elevation means the weather here is warmer than elsewhere in Himachal. Fruit of Bilaspur covers an area of 8086.73 ha with 1779.32 tons of production (Anon., 2018).

Temperature, precipitation, solar radiation, chill duration, growing degree days are key weather components which significantly affect crop growth and production besides physical and chemical properties of soil, land use type, vegetative and reproductive growth, water usage and biotic stress. It is imperative to include these components in geospatial analysis (Schumann and Zaman 2003; Panda *et al*., 2011). Geo spatial technology is one of the techniques which can be used to map fruit trees. They can be used for a variety of applications such as crop inventory, crop condition, crop production forecasts, fruit quality, leaf area index, crown cover, horticultural crop growth and health detection, drought and flood damage assessment and irrigated soil monitoring and management (Min *et al.*, 2008; Mondal and Basu, 2009).

Geospatial technology is a combination of four key tools: remote sensing, Geographic Information Systems (GIS), Global Positioning Systems (GPS) and IT or data management (Lobell *et al.*, 2005). The delineation of orchards and spatial analysis using geospatial technology can GIS can serve as a powerful analytical and decision-making tool for the development of fruit culture with an adequate database, especially in large countries such as India, where agro-ecological zones are so diverse. GIS is one of the techniques most widely used to map fruit trees (Singh *et al*., 2017). The data acquisition and analysis process is very fast compared to conventional methods through the use of Geographic Information System (GIS). Only by delineating, characterizing and mapping fruit-growing regions using geospatial technologies this problem can be solved (Sharma *et al*., 2015). Thus, the study was designed to create basic information related to existing crop status and generate additional inputs regarding the Site-Specific Crop management (SSCM), yield forecast, fertilizer and water usage, pest and disease management as part of decision making strategy for resource optimization and increasing the returns from farming enterprise (Ray *et al*. 2000; Panda and Hoogenboom, 2009).

MATERIALS AND METHODS

The facilities available in the Geo informatics lab, Department of Fruit Science. College of Horticulture and Forestry, Neri – Hamirpur, Himachal Pradesh, during the years 2018-2019, were utilized for this mapping work.

A. Geographical Features

Almost the entire Bilaspur district located within the Shiwalik hills, the peripheral part of the North-West Himalayas. The district geographic extent is between 31°12′30″ to 31°35′45″ North latitude and 76°23′45″ to 76° 55’40″ East longitude at an average elevation of 673m above mean sea level. It has Hamirpur & Una district in its North and North-west by, Mandi in North-East, Solan in South and South-East and Ropar district of Punjab state in South- West.

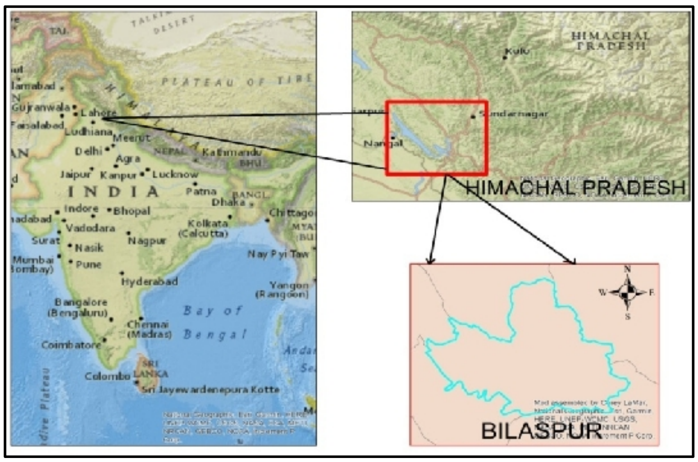

Fig. 1. Location of Study Area.

Data Sets Utilized: The description of data such as spatial and non-spatial utilized during the study is given below:

B. Preliminary survey

Preliminary survey of major fruit growing pockets of district Bilaspur was conducted to obtain information on area under different fruits which was acquired from state department of horticulture, Topography which was determined by visual observation and Location which was noted by using GPS handset.

Ancillary/Collateral Data: These data involved administrative maps depicting borders of state, district, and blocks, and different land features etc. besides the crop statistics (area and production) of different fruits in that area.

Terrain data : Digital Elevation Model (DEM) was used to derive terrain classes. To this end, the NASA Shuttle Radar Topographic Mission (SRTM) was used which provide digital elevation data (DEMs) covering over 80 % of the world. Data were downloaded from earth explorer browser.

Satellite data: Satellite imageries in digital format were procured from NRSC Hyderabad. The IRS P6 LISS IV is basic satellite data were used in this study. Spatial resolution of IRS P6 LISS IV is 5.8m.

Ground truth data: Ground truth plan was based on image data stratification, variation in crop signatures, etc. It was collected to determine the spectral signatures of orchards. It includes condition and geographic coordinates of location. The location specific information was acquired from maps, imagery and Global Positioning System (GPS).

Softwares used: The software used for the study are:

- ArcGIS 10.5.1
- ERDAS imagine

C. Digital data analysis

Image stacking and database: The data utilised during the analysis was sourced from different agencies having varied spatial resolution, hence images used were georeferenced and orthorectified. The UTM projection system with WGS84 (earth model) was used as a referencing scheme. Block boundaries of study area and the ground data on orchards collected using GPS and maps were overlaid with orchard characters on image database with Fig. 2.

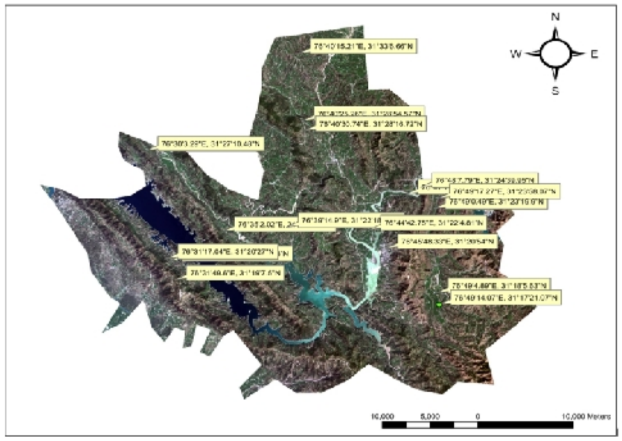

Fig. 2. Training sites of district Bilaspur.

NDVI Generation: The classification results were compared and edited using NDVI worked out from image reflectance. LISS IV satellite imagery was used to generate NDVI map of study area. The map was reclassified in spatial analyst tool using the option reclassify into four classes.

Using the satellite data and ground truth information, the exact value of NDVI for threshold was generated. The calculation of NDVI involved reflectance in vegetation sensitive electromagnetic spectrum, biomass, crop status and density in red and near-infared bands. The NDVI of imagery is calculated using the mathematical formula given below (Sharma *et al.,* 2015).

NDVI = (NIR-Red)/(NIR+Red): The formula above indicates the value of NDVI are unit less and range in a scale with upper limit of +1 and lower limit of -1. The areas having high value of NDVI indicates high vegetation and those with lower values indicates low vegetation and presence of water and settlements. If the NDVI values is less than <0 it is considered as waterbodies, if the NDVI values are between 0 to 0.1 then the area is under Bare soil, rocks, sand and snow and if the NDVI values is between 0.1 to 0.5 then the vegetation is assumed to be sparse vegetation, if the NDVI values are >5 it is assumed to be dense vegetation (Bid, 2016) LISS IV satellite imagery is used to generate NDVI map of study area. The map is reclassified in spatial analyst tool using reclassify option into four classes.

Classification: A gradual classification was used to map the area of orchard. Non-vegetation classes were masked in the first step using Normalised Difference Vegetation Index (NDVI) thresholding. The clustering of orchard classes was done with known ground truth sites. Thus, preliminary mask of orchard was created. Final classification was performed using maximum likelihood supervised classification using known ground truth data.

Unsupervised classification: The pre-interpretation of farm area and was done using ISODATA clustering wherein the non-farm land like forest, water bodies or settlements were masked out. This was used in the vegetated mask area to eliminate forest class. LULC maps of study area were used to classify different areas into different classes.

Supervised classification: Supervised classification was performed on IRS P6 LISSIV data using maximum likelihood classifier algorithm. This involved selecting training areas that represent six major land cover classes viz., fruit crops area, build up/urban, fallow, other crops, wastelands and water. Crop specific and other land use signatures were acquired in accordance to the Ground Truth (GT) sites. This is the final classification which was performed to study area using ground truth data and signatures. To represent each class a number of training areas were selected and was used to identify fruit plantings within probable mask of orchard area. It was ensured that maximum pixels are classified so that there are least unclassified pixels. Schematic flowchart shows the stepwise procedure for identifying fruit orchards.

RESULTS AND DISCUSSION

Fruit crop plantations: Fruit crop plantations include major fruit crops grown in the district Bilaspur (Table 1 & Fig. 3) reveal the area under major fruit crops of district Bilaspur.

Table 1: Area under major fruit crops in district Bilaspur.

Sr.No.	Name of fruit	Block				
		Sadar	Ghumarwin	Jhandutta	Swarghat	Total
1.	Mango	1501.91	857.46	1284.58	472.17	4116.12
2.	Citrus	205.42	512.34	411.81	265.02	1394.59
3.	Litchi	251.42	227.34	125.04	38.88	642.68
4.	Pomegranate	101.45	194.15	159.23	66.66	521.49
	Total	2060.2	1791.29	1980.66	842.73	6674.88

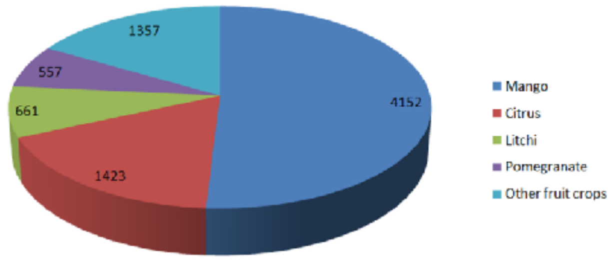

Fig. 3. Fruit crop area (ha) in district Bilaspur Normalized Difference Vegetation Index (NDVI) generation.

The specific spectral signature of the vegetation is distinguished by low reflectivity in visible and high reflectivity in infrared (IR) region of the solar optical spectrum. Higher range of green vegetation on corresponds to higher NDVI and usually the lower NDVI refers to non-vegetation.In general, NDVI of non-vegetation were generally lower than the classes of vegetation. The ground and satellite data were used to generate exact threshold value of NDVI.

As shown in the Fig. 4. NDVI of the study area was found to be within the range of -0.2 to 0.55. Higher values represent dense vegetation whereas negative and lesses values of NDVI implies low vegetation characterised by waterbodies, rocks and settlements etc. Different classes of NDVI are presented in (Bid, 2016) Table 2.

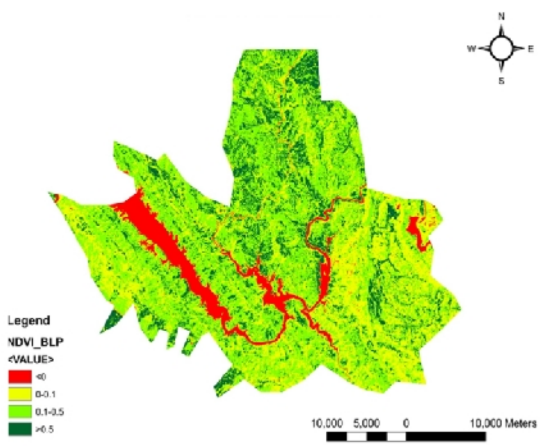

Fig. 4. Normalized Difference Vegetation Index (NDVI) of study area.

Table 2: Different classes of Normalized Difference Vegetation Index (NDVI).

S.No.	Class	Vegetation Indices
1.	Dense Vegetation	>0.5
2.	Sparse Vegetation	0.1-0.5
3.	Bare soil, Rocks and Sand	0-0.1
4.	Waterbodies	<0

The mango plantations of district Bilaspur which was revealed in the present study was presented in Fig. 5. The thematic map of the study area revealed that total area under mango in the district is 4116.12 ha. Out of this, Sadar block occupies 1501.91 ha which is the highest mango holding block followed by Jhandutta with an area of 1284.58 ha. The least area under mango is in Swarghat block covering 472.17 ha.

Fig. 6 indicates the Citrus plantations of district Bilaspur which was revealed in the present study. It was evident from the thematic map of the study area that a total of 1394.59 ha is under citrus in the district and maximum area is in Ghumarwin block (512.34 ha) closely followed by Jhandutta block (411.81 ha). Minimum area among the blocks is covered in Sadar block (205.42 ha).

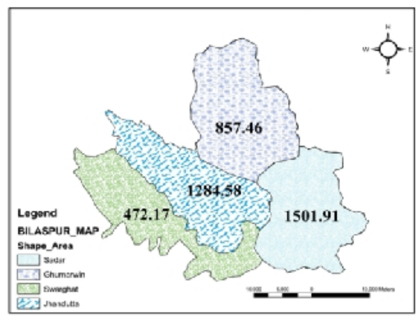

Fig. 5. Thematic Map of Mango area (ha) in Bilaspur District.

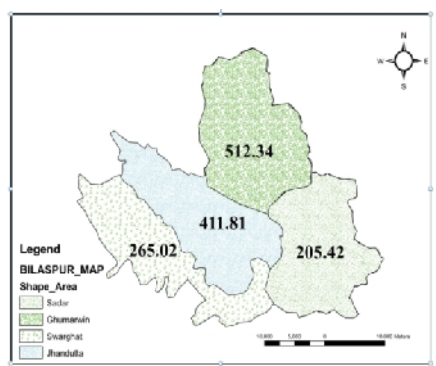

Fig. 6. Thematic Map of Citrus area (ha) in Bilaspur District.

The Litchi plantations of district Bilaspur which was revealed in the present study was depicted in Fig. 7. It is observed from the thematic map of the study area that out of total litchi area i.e 642.68 Hectares. Sadar block with 251.42 ha is the highest litchi holding block followed by Ghumarwin with an area of 227.34 ha while Swarghat block occupies the least area as low as 38.88 haunder litchi in district Bilaspur.

Fig. 8 indicates the Pomegranate plantations of district Bilaspur which was revealed in the present study. It is observed from the thematic map of the study area that out of total pomegranate plantation area i.e 521.49 ha. Ghumarwin block with 194.15 ha is the highest pomegranate holding block followed by Jhandutta with an area of 159.23 ha. Swarghat block in district Bilaspur has lowest Pomegranate area 66.66 ha.

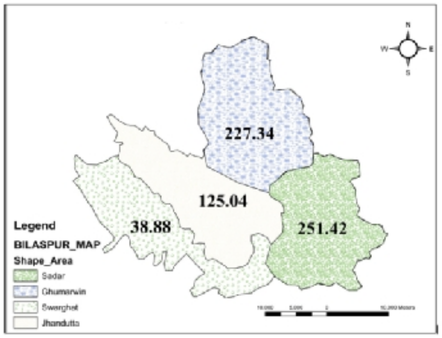

Fig. 7. Thematic Map of Litchi area (ha) in Bilaspur District.

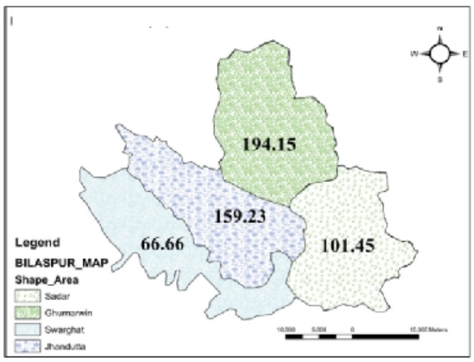

Fig. 8. Thematic Map of Pomegranate area (ha) in Bilaspur District.

CONCLUSION

The present study was conducted to explore the potential and advantages of geospatial technology for mapping of fruit crop diversity and change in cropping pattern. The generated data maps will be valuable for researchers and administrators to simplify the process of decision making, orchard planning and evaluation process in more scientific and logical manner. This methodology applies to delineate homogeneous planting patches and shows limited usefulness especially for heterogeneous patches, younger plantations and identification of plantations under agro-horticultural systems and multi-cropped regions.

However, further research is necessary for the identification of small patches, multi-cropped regions and assessing the local characteristics of soil moisture if maximum benefits are to be acquired. To better manage existing crops, systematic planning and decision-making requires an updated and accurate database. The use of geospatial technology has becoming important today for the general detection of orchard growth and health on a wider scale.

Conflicts of Interest. None.

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