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Acreage estimation of mango orchards in Jabalpur district of Madhya Pradesh using Sentinel-2 imagery

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ABSTRACT

An approach was made to evaluate the area and perform spatial mapping of mango orchards using satellite image obtained from Sentinel-2 for Jabalpur district of Madhya Pradesh. The image was processed using ERDAS IMAGINE software. Supervised classification was performed for acreage estimation. An area of 1217 ha was found to be occupied by mango orchards, covering 0.24% of total area of Jabalpur district. The study has distinctly exhibited the adequacy of remote sensing imagery for identification and area estimation of mango orchards.

***Key words**: Sentinel-2, Spatial mapping, Supervised classification, Temote sensing*

Introduction

Mango *(Mangifera indica* L.), a member of the Anacardiaceae family, is the country's most significant commercially cultivated fruit crop having delightful flavor and taste among the tropical fruits. India is the world's leading mango-producing country, accounting for almost half of the total mango production. During 2017-18, the total area and production of mango in India was 2258 thousand ha and 21822 thousand MT, respectively whereas, in Madhya Pradesh the total area and production of mango was 45.52 thousand ha and 654.79 thousand MT, respectively There are numerous mango-growing areas in Madhya Pradesh including Betul, Katni, Alirajpur, Rewa, Singrauli, Balaghat, Chhindwara, Harda etc.

Accurate mango orchard categorization and area estimation is critical for government policy decisions such as expanding and monitoring the orchard's area, providing growers with subsidies, crop insurance, and yield estimation. The mango sector's development is still hampered by lack of precise and adequate horticultural measuring techniques, resulting in low data dependability in this region. Generally, for estimating the area and output of horticultural crops, sample survey approaches are used, which is time intensive, requires a lot of field work, and is less precise. With the advent of contemporary techniques such as Remote Sensing (RS) and Geographic Information Systems (GIS), estimating area under horticultural crops, may be easier and faster.

Satellite images play crucial role in nearly accurate classification and area estimation of horticultural crops. The crop categorization is influenced by the resolution of the satellite image. Both spatial and temporal resolutions play an important role in orchard monitoring and area estimation. Different

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objects reflect different amounts of energy in different wave lengths of the electromagnetic spectrum depending on their structural, chemical, and physical properties. When a beam of light or radiation falls on any object, it releases a spectrum of electromagnetic radiation that contains information about that object. An image with a high spatial resolution captures far more information about the ground surface. Satellite images have several applications such as classification and monitoring of agricultural crops, horticultural plantations and orchards, change detection, crop acreage estimation, crop stress assessment, and yield prediction, etc. Satellite images are also playing an important role in orchard monitoring where orchards have become uneconomic and require rejuvenation practices in order to boost their economic yield. In India, remote sensing has been crucial in assessing orchard inventories.

The application of remotely sensed data in crop acreage estimation has been demonstrated by various researchers in different parts of the world (Saha and Jonna, 1994 and Nualchawee, 1984). Atkinson and Lewis (2000) 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. Yadav *et al.* (2002) 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, 2012), citrus, grapes and plantation crops (Palaniswami *et al.* 2006).

Moreover, area estimation using RS and GIS technique for mango fruit crop is lagging in Jabalpur district of Madhya Pradesh Therefore, the present study was undertaken to estimate the acreage of mango orchards using multispectral remote sensing data.

Study Area

Jabalpur district is situated on the banks of Narmada River in the Central Indian state of Madhya Pradesh. It is spread over 22° 49' 42" N to 23° 37' 5" N and 79° 20' 56" E to 80° 35' 10" E. The district is expanded over 5198 km². It consists of a long narrow plain running north-east and south-west and shut on all sides by highlands. The plain forming an offshoot from the Narmada valley, is shielded in its western and southern segment by a rich alluvial deposit of black cotton soil. At Jabalpur city, the soil is black cotton soil, and water plentiful near the surface. The district of Jabalpur comprises of 1457 villages divided into seven blocks *i.e.*, Jabalpur, Sihora, Majholi, Patan, Shahpura, Panagar and Kundam. Fig. 1. Represents the study area

Methodology

Sentinel-2 consists of single multispectral instrument with 13 spectral channels in visible, near infrared and short wave infrared spectral range. In this study, total eight Sentinel-2 satellite images were acquired of two different months, *i.e.* February 2020 and April 2020. To cover the whole district of Jabalpur, four tiles were required. The satellite data of February month was downloaded in order to prepare a better LULC classification. The satellite image of this month provides very clear imagery of agricultural areas in the region of Jabalpur district because of the high to low ratio of cropped agricultural land and fallow agricultural land. A high percentage

Table 1. Details of acquired satellite data

Archiving date	Attribute name	UTM zone
8 February 2020	L1C_T44QLL_A024183_20200208T051227	44N
8 February2020	L1C_T44QLM_A024183_20200208T051227	44N
8 February2020	L1C_T44QML_A024183_20200208T051227	44N
8 February2020	L1C_T44QMM_A024183_20200208T051227	44N
8 April 2020	L1C_T44QLL_A025041_20200408T051453	44N
13 April 2020	L1C_T44QLM_A016204_20200413T051427	44N
13 April 2020	L1C_T44QML_A016204_20200413T051427	44N
13 April 2020	L1C_T44QMM_A016204_20200413T051427	44N

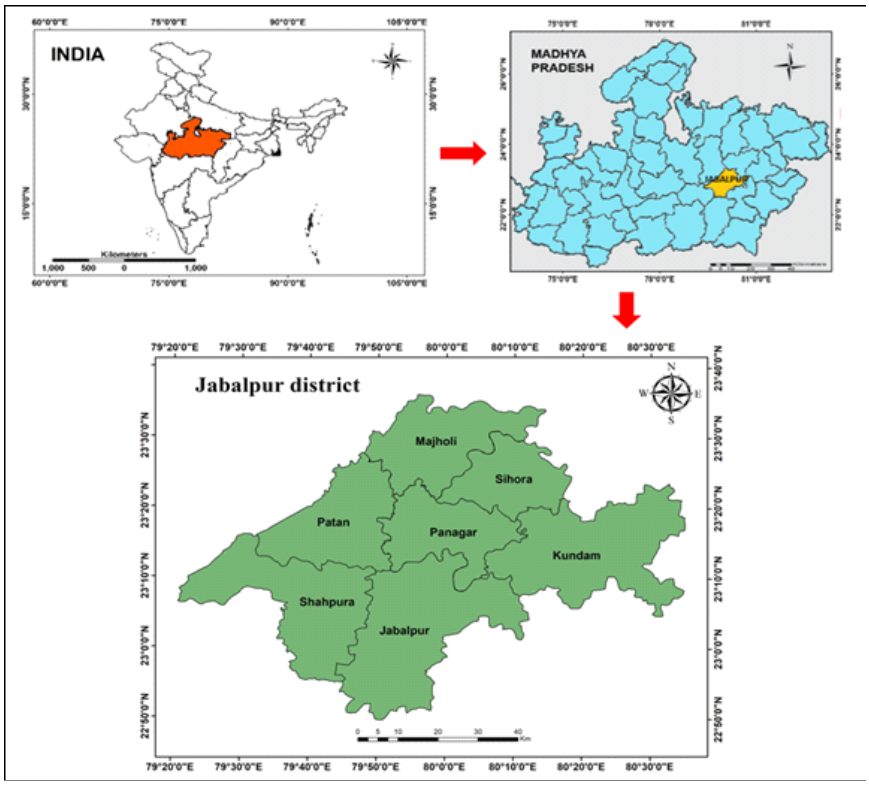

Fig. 1. The study area (Jabalpur district of Madhya Pradesh)

of fallow agricultural land may impact overall classification since it may be mixed with non-agricultural open area. Satellite data of April was downloaded with the purpose of sub-setting the vegetation area. Table 1 provides details on each of the eight tiles.

In the present study, the ground truth data was collected by visiting and surveying several mango orchards around the Jabalpur district. The exact position of mango orchards was determined by using Global Positioning System (GPS) device. The latitude, longitude and area of mango orchards were determined through ground trothing.

In digital image processing, data from sources other than remote sensing, used to assist in analysis and classification or to populate metadata is referred to as ancillary data. In the present study district boundary of Jabalpur was used as ancillary data. It was digitized using Arc-GIS software.

The LULC map of Jabalpur district, which was classified by minimum distance algorithm was further classified for acreage estimation of mango orchards. With the use of ground truth data, it was found that mango orchards lay in the vegetation class of classified LULC map. Therefore, it became necessary to differentiate the mango orchards from the vegetation area for the area estimation of mango orchards. Thus, from the classified map of Jabalpur district, the vegetation area was extracted and saved as new AOI. The saved AOI was then used to subset the vegetation area from the satellite image of April month which was further used to differentiate the area of mango orchards from vegetation area through supervised classification. Ground truth data (latitude and longitude) were employed to identify the mango orchards for creating ROIs.

Result

Applying remote sensing and GIS, a Land Use and Land Cover map of Jabalpur district was produced from a satellite image. This classified satellite image was further utilized to determine the area of mango orchards in Jabalpur district with the help of ground truth data. LULC map with mango orchards is presented in Fig 2.

Through the above LULC map of the year 2020, it is discovered that the study area comprises of 48.78% of area covered by agriculture followed by 34.04% of fallow/open/ barren land, 12.97% occu-

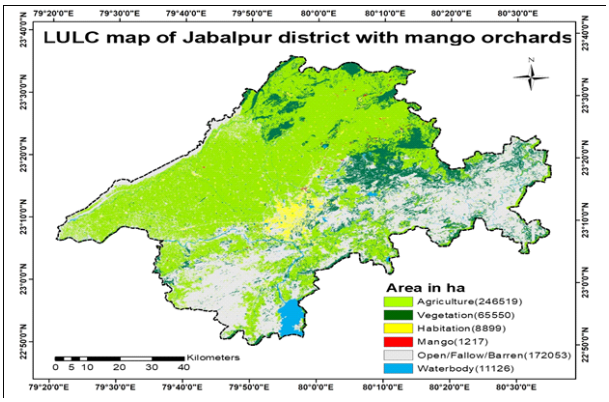

Fig. 2. Land use/ land cover map of Jabalpur district with Mango orchards

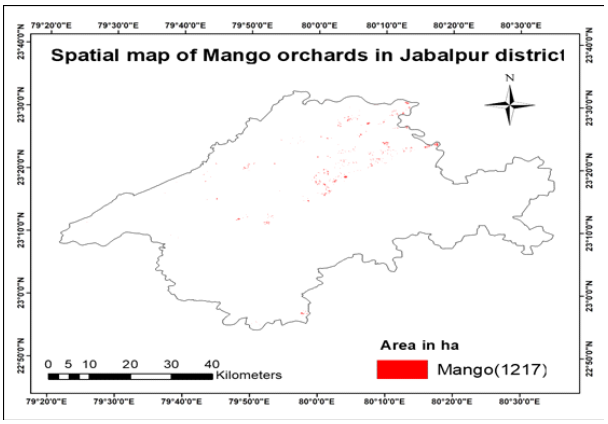

Fig. 3. Spatial map of mango orchards in Jabalpur district

pied by vegetation (excluding mango orchard area), 2.20% covered by water body, 1.76% under habitation, and 0.24% area consisting of mango orchards. In accordance with the classified LULC map of Jabalpur district, the six classes namely, Agriculture, Vegetation, Mango orchards, open/fallow/barren land, Habitation, and Water body occupies 246519 ha, 65550 ha, 1217 ha, 172053 ha, 8899 ha and 11126 ha, respectively. Different LULC classes along with their area is presented in Table 2 with a flow diagram Fig 3.

Table 2. Area of different LULC classes

Class	Area in (ha)	Area in (%)
Agriculture	246519	48.78
Vegetation	65550	12.97
Mango orchards	1217	0.24
Open/fallow/barren land	172053	34.04
Habitation	8899	1.76
Water body	11126	2.20

Conclusion

Acreage assessment of mango orchards employing pioneering scientific tools like remote sensing and GIS has manifested that it provides an expeditious interpretation of a particular area in a short time interval in comparison with manual surveys. The area evaluated implementing survey techniques may be additionally refined by amalgamating survey data with satellite data. Total area of mango orchards in Jabalpur district was evaluated by executing the Maximum Likelihood Classification algorithm. The computed area of mango orchards in Jabalpur district was found to be 1217 ha which comprises of 0.24% of the total area of Jabalpur district. The accuracy of estimated area of mango orchards was assessed using ground truth points, which was found to be 87.75% accurate. It is quite easy to estimate the occupied area of different fruit crops through remote sensing and geographic information system than the methods of manually surveys. With the advantages of broad area coverage, spatial mapping and characterization of horticultural crops, remote sensing has shown to be effective and beneficial in supplying information in much less time. The use of remote sensing and GIS to estimate the area of orchards provides virtually correct information in a short amount of time which will be beneficial for decision makers.

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