MENTHA CROP ASSESSMENT USING MULTIDATE REMOTE SENSING DATA: A CASE STUDY FOR BARABANKI DISTRICT, UTTAR PRADESH

S. Mamatha[1]and M.M.Kimothi[2]

[1]Mahalanobis National Crop Forecast Center (MNCFC), DAC&FW, Pusa Campus, New Delhi 110 0102, India
Email: mamatha.ncfc@nic.in
[2]Randstad India Ltd., New Delhi
Email: drmmkimothi@gmail.com

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ABSTRACT: Mentha (*Mentha arvensis)* area assessment was carried out for Barabanki district, Uttar Pradesh, under the CHAMAN project, for the year 2015-16. Mentha is generally grown from March to June in this area. The major crops, other than Mentha were Orchards and Vegetables. Multidate Resourcesat-2 LISS-III data during March to May 2016 was used for crop area assessment, crop condition monitoring and crop phenology study. Ground truth (>50 sites) was collected during May, 2016 for crop signature identification and validation. A combination of unsupervised and supervised classification of multi-date NDVI data was used for area estimation. Crop area was separated into different health classes, based on NDVI values. The multi-date data also helped to identify the maximum vegetative stage, which can be useful information for harvesting. The Mentha area in the Barabanki district has been estimated around 67627 ha. The accuracy of the estimation was verified with the data of State Horticulture Department, Government of Utter Pradesh for the same year. The deviation has been observed around 0.43 %.

1. INTRODUCTION

Mentha (Mentha arvensis) a aromatic plants also known as Mint belong to family lamiaceae is a cash crop grown for producing Mentha oil, which is used in pharmaceuticals, dentifrices, cosmetics, mouth-washes and flavouring of beverages etc. India is the highest producer and exporter of mentha oil and its derivetives in the world. The other major producers are China, Brazil, the US and Japan. During the last fiv years, India has exported nearly 15,00 tonnes to 20,000 tonnes of mentha oil and its derivetives each year (Pal e t al., 2015, MCX, 2015).

Mentha arvensis is cultivated in India mainly in the state of Punjab, Haryana, Himachal Pradesh, Uttar Pradesh and Bihar. Uttar Pradesh state contributes around 80 percent of the total Mentha production in the country and in the State of Uttar Pradesh Barabanki and its surrounding districts produce around 60% of mentha oil produced in India (MCX, 2015). Mentha oil price in influenced by an increase or decrease in mentha crop acreage and production, prevailing agroclimatic conditions. Because of its high commercial value and export potential, the accurate assessment of its area, condition and production is essential for advance planning (MCX, 2015).

In recent time, availability of Earth Observation (EO) satellite data at different spatial, spectral and temporal resolution have played a significant role in crop classification, crop health and yield estimation in cost-effective, timely and faster manner than conventional ground survey method. Such information, integrated with national statistics, in situ (ground) observations and secondary (ancillary) data and information, show potential for mapping crop acreages (Ray & Neetu 2017, Ray et.al 2015, Dadhwal et.al., 2002, Navalgund & Sahai, 1985, Gollego, 2004).

However, delivering an accurate inventory of crops requires the selection of appropriate satellite data, the collection of quality ground information, the application of suitable pre-and post-processing methods and the implementation of robust methodologies.This is a challenge because cropping systems are often diverse and complex, and the types of crops grown and the timing of their growth vary from region to region, as do the management practices implemented. Consequently, the success of remote sensing approaches requires their adaptation to local cropping systems and environmental conditions (Davidson et al, 2017). There have been some efforts and study conducted by Space Applications Centre for identification and acreage estimation of *Mentha arvensis* using IRS –1C LISS – III data as no government estimates are made for this crop (Patnaik *et al*. 1998).

In recent years at National level Department of Agriculture, Cooperation & Farmers' Welfare (DAC&FW) of Ministry of Agriculture & FW formulated a programme called CHAMAN (Coordinated Horticulture

Assessment and Management using Geo-informatics) for better horticulture inventory & management in selected districts of major states (Ray et. al. 2016). In this context, a pilot study has been conducted in Barabanki district under part of CHAMAN programme, to identify and estimate mentha crop acreage using multi-date Resourcessat-2 LISS III data vis-a vis ground truth for the 2016 cropping season

2. MATERIALS AND METHODS

2.1 Study Area

In Uttar Pradesh Mentha is produced in Barabanki, Faizabad, Sitapur, Moradabad, Rampur, Udhamsingh Nagar, Bareilly and Budaun districts. Among these districts, Barabanki is the higest producer of Mentha, hence chosen barabanki as a study area for current analysis. The district Barabanki is situated about 29 Kms in the East direction of Lucknow the Capital of Uttar Pradesh and lies between 27°19' and 26°30' north latitude, and 80°05' and 81°51 east longitude (Figure 1). The District consists of seven sub-division, 139 Nayay Panchayat, and 2091 revenue villages. Geographically it is situated in one of the most fertile tracts of Ganga and Jamuna basins Agriculture continues to be the most important occupation of the district. About 72.6% working force is farmers and agricultural labour. Wheat and rice are main crops of rabi and kharif respectively. Other major crops are oilseeds, pulses and maize. In horticulture, fruits like mango, muskmelon, and watermelon are cultivated alongwith guava and banana. Moreover, in vegetables, potato, cucurbits are the most important crop followed by chilli, pea, tomato, okra, brinjal, onion, garlic. Mentha covers significant area under zaid season. The district receives an average rainfall of 1056 mm (Comprehensive –District Agriculture Plan (C-DAP), Barabanki).

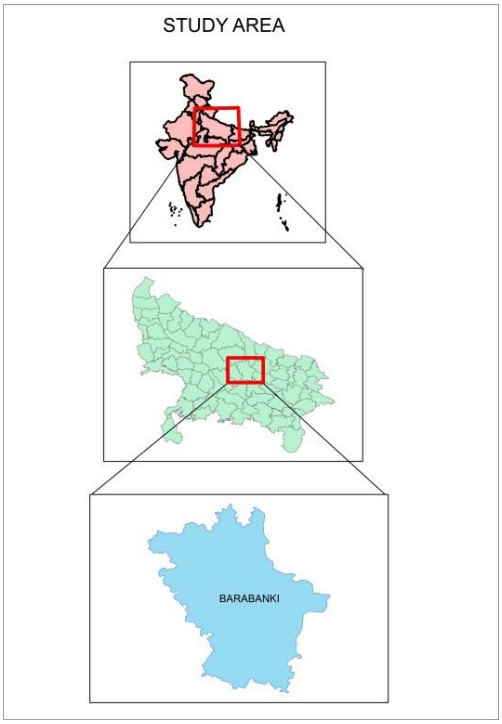


Figure 1:Study area Map

2.2 Data Used

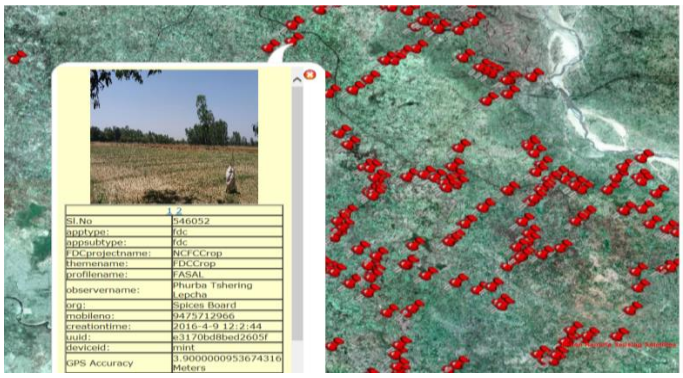
2.2.1 Remote sensing data used: Moderate resolution temporal satellite data of Resourcesat -2 LISS III have been used for this study. The details of satellite datasets are given in **(Table – 1)**

Table 1: List of satellite imagery used

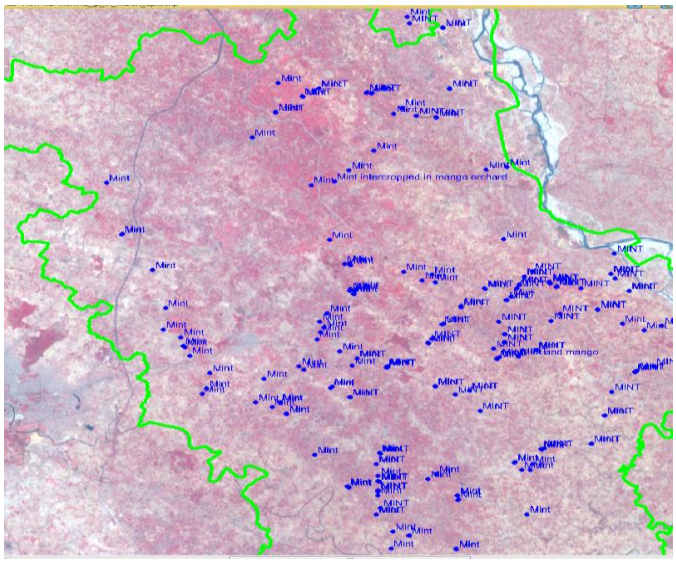
Satellite	Sensor	Spatial Resolution (m)	Spectral Bands	Path/Row	Date
Resoursat-2	LISS-III	23.5	Green, Red, Near Infrared	100/52,53	11 March, 2016 28 April, 2016 22 May, 2016

2.2.2 Softwares used: i) Erdas Imagine 2011 for satellite image analysis.and ii) Arcgis 10 for GIS and Mapping.

2.2.3 Ground Truth: Ground truth (GT) survey was carried out on the basis of varying spectral signatures as discernible on the satellite image as well as those marked in google earth engine to identify the competing crops (orchards, plantations and vegetables) in the study area. Around 74 GT points were collected during March-June 2016 season using FASAL FDC app in Android phone for recording the geographic coordinates of mentha crop and fields (Figure 2). Other ancilliary information such as time of sowing, mint production & management practices etc were also noted down in GT performas.



a) Groundtruth on Bhuvan Portal



b) Ground truth points on LISS III Image

Figure 2: Ground truth points distributing for Barabanki Districts Methodology

2.2.4 Collateral and Statistical data: District level statistical data of mentha during the last 4-5 years was collected from the office of Director State Horticulture Department, Lucknow and district horticulture department , Barabanki.

2.3 Data Processing

The dates of the satellite pass have been decided as per the cropping season of mentha and other crops in Barabanki region. Generally after harvesting of wheat and mustard crops, farmers sown mentha crop in the region. Based on the crop calendar (March-Mid June), data was selected and indented. Each image indented has been first checked for its quality. Some of the preprocessing of satellite data consisted of selecting of cloud free multi season crop calendar data, ortho-rectification, radiometric normalization etc.

2.3.1 NDVI Generation: NDVI (Rouse et al. 1974) images were generated from the reflectance images using the equation given below:-

$NDVI = (Reflectance_{NIR}-Reflectance_{Red}) / (Reflectance_{NIR}+Reflectance_{Red})$

The image, thus obtained comprised of pixels with values ranging between +1 and -1. This image was then scaled into a 8- bit range of 0-200 for ease in multi temporal image comparison as well as in digital classification. The scaling converts NDVI's lowest possible value from –1 to 0, median value of 0 to 100 and highest value of +1 to 200 (Mather *et.al.*, 2011).

2.3.2 Temporal Growth profile: Three dates (March to May 2016) temporal NDVI imageries/ outputs (LISS III) were stacked in chronological order and then the NDVI values corresponding to GT points of different vegetation classes (Mentha, orchards, vegetables and other land cover classes) from all the three dates were extracted using Erdas Imagine and Arc GIS software. Mean values were then computed for all the classes and a graphical plot was made for the same.

2.3.3 Crop Classification: Identification and discrimination of mentha and other land cover classes in the area require the use of subtle differences in their spectral data and therefore rely mostly on digital image processing techniques (Lillesand et al. 2004 Jensen, J.R. 1986). The methodology used is shown in the figure 3. two-step classification approach was used to discriminate and map the Mentha area. In the first step, a non-agricultural class has been masked using NDVI thresholding. After masking non-vegetative area, unsupervised classification technique (K means algorithim) was used to carry out preliminary discrimination of mentha and othervegetation classes. The known ground truth sites were used to assign cluster to menthe classes. Thus a preliminary mask of menthe area was created. This was used for detailed ground truth data classification. Final classification was carried out using using the maximum likelihood supervised classification using known ground truth data as training area. Efforts were made to use the many class variation so as to reduce the number of unclassified pixels an dachived atleast reasonable percent of accuracy.

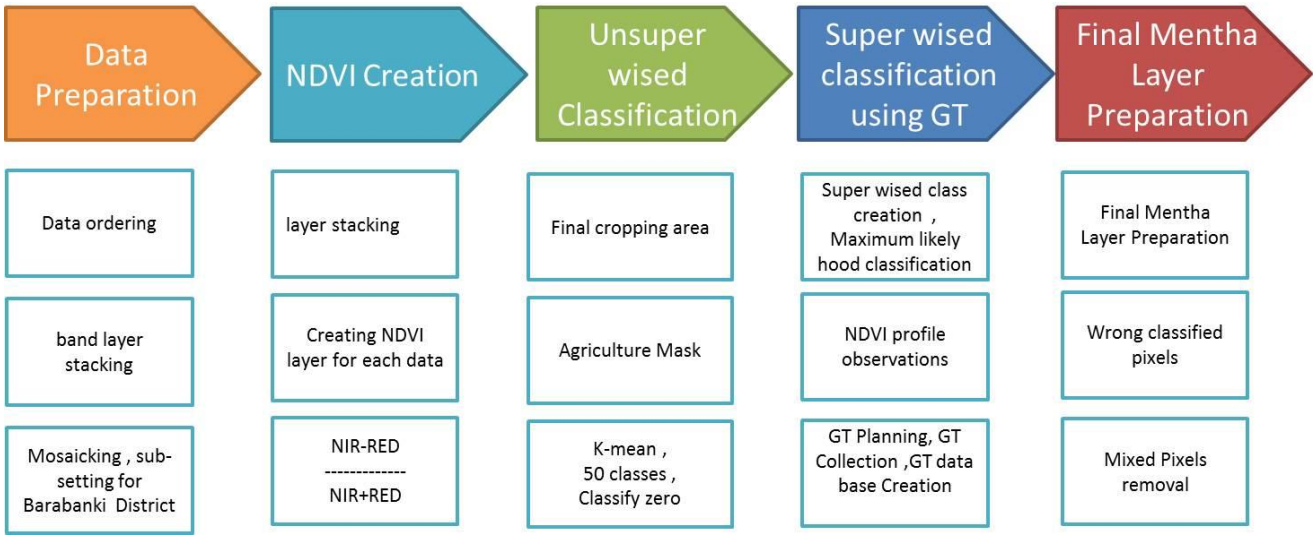


Figure 3: Flow chart showing the methodology followed

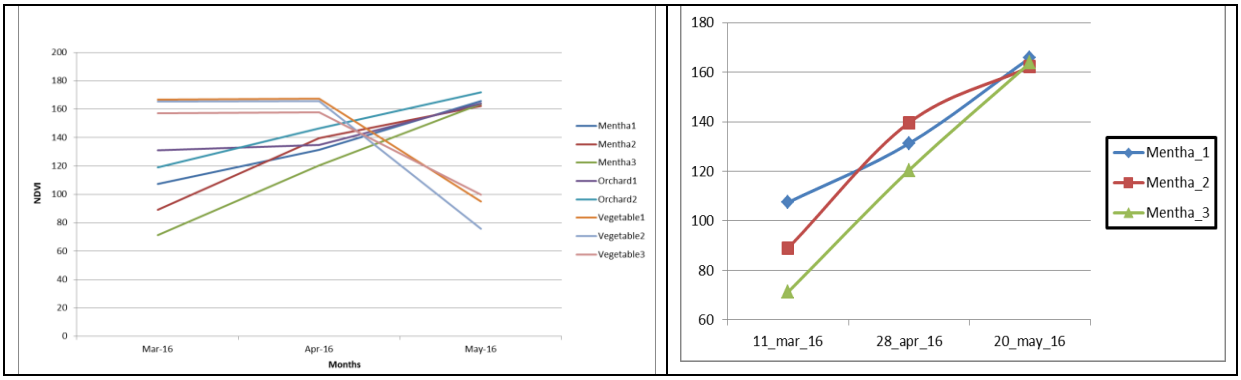


Figure 4: NDVI (scaled values) profiles of a) diferent vegetation classes, and b) Mentha classes, occurring in the study area

2.3.4 Error correction (mixed pixels): For error correction, the final layer produced after the supervised classification the mixed pixels at the river and near orchards have been removed manually. The final layer again compared with that year's wheat and the Mustard layer of MNCFC for verifying its phenological growth and the Mentha new area sown in that season. GT points collected in March and May of 2016 were also checked with those points.

2.3.5 Area Estiamtion Validation: The remote sensing derived mentha area statistics was validated with the statistics obtained from State Horticulture Department, Uttaer Pradesh and the relative deviation was computed between the remote sensing based and statistically based estimates.

3. RESULT AND DISCUSSION

Mentha is an herbaceous aromatic plant sown in the month of Feb./March and harvest in the month of May-June. Identification and discrimination of mentha crop during March to May season from other land use/land covers in the study area were carried out following NDVI thresholding of the Resourcesat-II LISSSIII data. Temporal NDVI profile of mentha shows maxima in the month of May, which may be due to good vegetation growth and better moisture condition through irrigation in mentha area. The vigor of a crop is manifest by the ratio of absorption in the red and the reflectance in the near infrared region (Navalgund et al. 1991). The distinct signature of mentha crop has also appeared on LISS-III FCC image as the reddish tone from March onward because during this period most of the field crops are harvested except vegetables and orchards.

The classified output map of mentha crop has shown the crop is sown in almost all part of the of the district (Figure 6). The remote sensing derived estimated area of Mentha crop in the Barabanki district was found around 67627 ha as compared to statistical area reported i.e. by State Horticulture Department, Uttar Pradesh. Strong correlations have been found between the statistically available data and the area estimated from Resourcesat 2, LISS III data for the year 2015-16. The deviation has been observed around 0.43 (%).

Table 4 Mentha area estimation in Barabanki

RS based Estimate (Ha)	Governemnt Estimate (Ha)	RD %
67627	67920	-0.43

The analysis showed that the crop area has reduced, though it was slightly higher than the previous year. Barabanki and surrounding districts produce more than 60% Mentha oil production in India, which is reflected in table 5. Therefore an accurate estimation and production in advance using moderate resolution data is important for proper import and export planning.

Table 5 Status of Mentha area and Mint oil production in Barabanki district

Year	Area (ha)	Mentha Oil (in Ltr)
2012-13	75950	11392500
2013-14	76500	11475000
2014-15	66572	9320080
2015-16	67920	9508800
2016-17	70206	

Statistics reported by State Horticulture Department

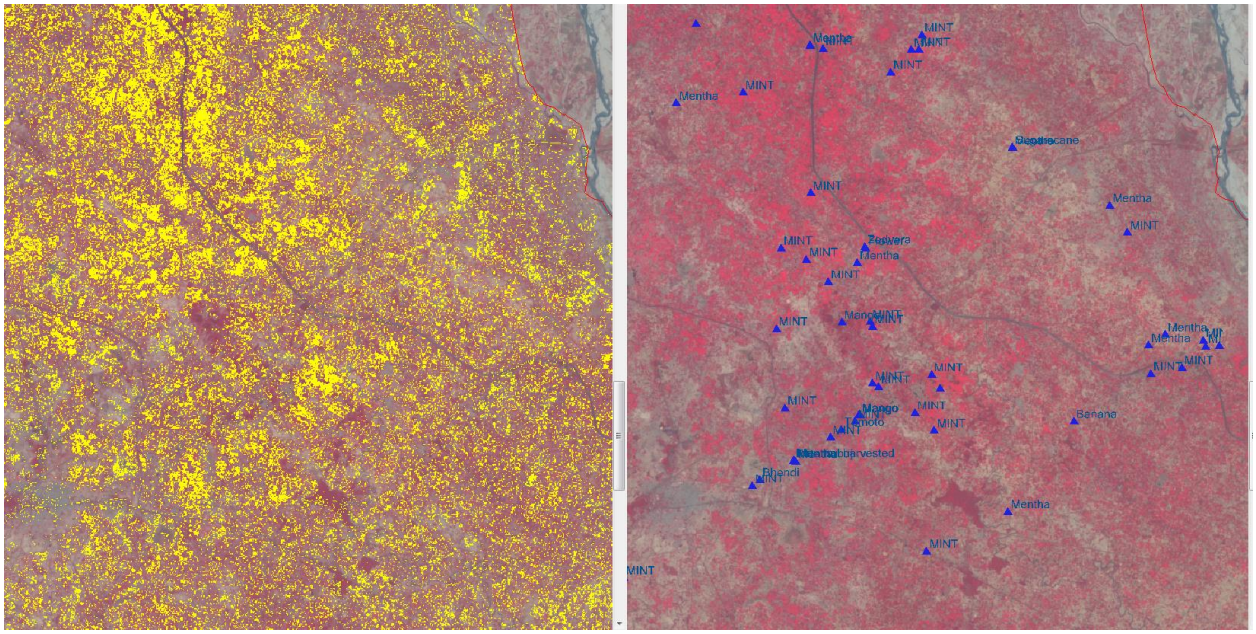


Figure 6 : Depiction of Main Mentha Belt in Barabanki Districts, Uttar Pradesh at the time 22May 2016 FCC and GT

4. CONCLUSIONS

The Study demonstrated the use of moderate resolution (spatial, spectral & temporal) Resourcesat-2 LISS III data for mentha crop mapping and acreage estimation at reasonable accuracy at the district level.The remote sensing derived estimated area of Mentha crop in the Barabanki district have found around 67627 ha as compared to statistical area reported by State Horticulture Department, Uttar Pradesh i.e .67920 ha. Strong correlations have been found with the deviation of 0.43 (%).The analysis showed that the crop area has reduced, though it was slightly higher than the previous year. This experience may be led to the incorporation of more districts for mentha crop estimation and production at the state and national level under CHAMAN phase II. Mint is the cash crop and lifeline for the farmers. Viewing the commercial aspect of the crop, it is proposed that area estimation and production of the major district could be obtained in advance for proper import and export planning purposes.

5. ACKNOWLEDGEMENT

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