



## **High resolution Sentinel-2 crop type mapping 2018-2019 A case study in Ahmednagar district**

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## **High resolution Sentinel-2 crop type mapping 2018-2019**

### **A case study in Ahmednagar district**

**Objective:** Crop type mapping using high resolution Sentinel-2

#### **Major Activities**

- Satellite imagery acquisition/ procurement and pre-processing (Sentinel-2, 10&20 m spatial resolution).
- Field information (ground reference data) and farmer interviews at selected locations and collection of validation points.
- Satellite Imagery analysis and interpretation for land use / land cover areas including cultivated areas.

**Study Area:** Ahmednagar is the largest district of Maharashtra in terms of area and population. It lies in the central part of the state of Maharashtra which is having common boundaries with seven adjoining Districts. The total geographical area of the district is 17.41 lakh ha. The net cropped area is 12,56,500 ha, out of which an area of 3,30,000 ha. (26.27 %) is under canal (84,000 ha) and well irrigation. About 9,26,500 ha. (73.73 %) area is rain fed. The area under Kharif crops is 4,60,000 ha. (36.6 per cent) while 7,58,000 ha (60.32 per cent) area is under Rabi crops. A multiple cropping system is followed on 1,10,500 ha area. A total of 8.73 per cent area of the district is under forest. The climate of the district is hot and dry, on whole extremely genial and is characterized by a hot summer and general dryness during major part of the year except during south-west monsoon season. Ahmednagar district receives average 566 mm. rainfall. The major rainfall received during month of June to September. The average temperature ranges between 9 0c (during Dec.) to 41 0C (during April and May). The soil types of the district are broadly divided into four categories namely coarse shallow soil; medium black soil; deep black soil and reddish soil occupying about 38, 41, 13 and 8 percent of the cultivated area respectively. In the first two categories, soil moisture is the predominant limiting factor affecting productivity of crops particularly under rainfed condition. Godavari and Bhima are the major rivers in the district. Godavari river flows through the northern border of Ahmednagar district. Major Kharif crops grown in the district are Cotton, Maize, Bajra, Sugarcane, and Soybean and during Rabi season are Jowar, Wheat, Soybean and Pulses. The study region is illustrated in Figure 1.

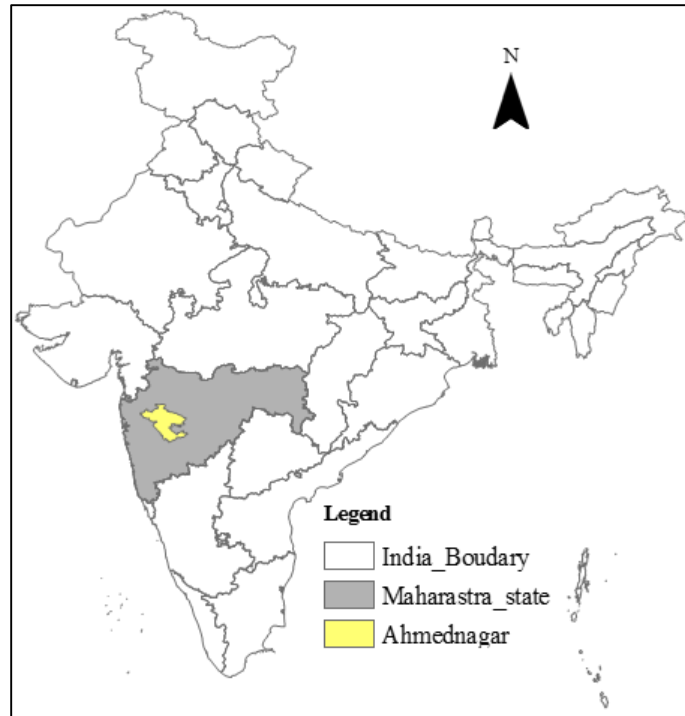


Figure 1. Study area Ahmednagar

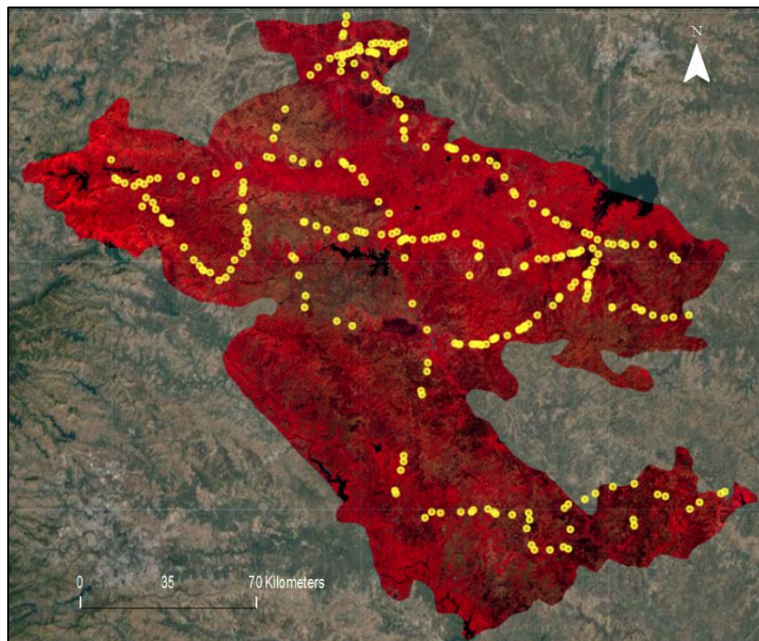


Figure 2. Spatial distribution of ground survey data in the study area.

**Key deliverables and uses:**

1. Land use / land cover map including specific crop type
2. Ground survey data

**Data and Methods**

## Satellite Images

Sentinel-2 images were provided in top of atmosphere (TOA) reflectance values with radiometric and geometric corrections applied (Level-1C data) are freely available. Sentinel-2 multi-temporal images with a cloud cover lower than 5% over the study area were collected from the Google Earth Engine platform. These images were recorded from June-October 2018 for Kharif season and October, 2018 to January 2019. Each image consist of 13 spectral bands covering the visible, near-infrared, and short-wave-infrared spectral regions.

Land use land cover map including specific crop type mapping is prepared using time series spectral indices extracted from the optical images during crop growing period. The indices are adopted in this study are the Normalized Difference Vegetation Index (NDVI) (Rouse et al., 1973), and the Modified Normalized Differentiation Water Index (MNDWI). These indices are calculated as:

$$NDVI = \frac{NIR-RED}{NIR+RED} \text{-----(1)}$$

$$MNDWI = \frac{GREEN-SWIR}{GREEN+SWIR} \text{-----(2)}$$

## Bands

Satellite	Scale	Resolution	Wavelength (nm)	Description
Sentinel-2 June-October 2018	0.0001	10 meters	496.6nm	Blue
	0.0001	10 meters	560nm (S2A) / 559nm (S2B)	Green
	0.0001	10 meters	664.5nm (S2A) / 665nm (S2B)	Red
	0.0001	10 meters	835.1nm (S2A) / 833nm (S2B)	NIR
	0.0001	20 meters	1613.7nm (S2A) / 1610.4nm (S2B)	SWIR 1
	0.0001	20 meters	2202.4nm (S2A) / 2185.7nm (S2B)	SWIR 2

The process of labeling class identification was done based on spectral matching techniques (SMTs) (Gumma et al. 2018; Gumma et al. 2016; Gumma et al. 2015). Initially, 60 classes from the unsupervised classification were grouped based on spectral similarity or closeness of class signatures. Each group of classes was matched with ideal spectral signatures and ground survey data, and assigned class names. Classes with similar time series and land cover were merged into a single class, and classes showing significant mixing, e.g., homogeneous irrigated areas and forest, were masked and reclassified using the same ISOCCLASS algorithm. Some continuous irrigated areas mixed with forests in the Western Ghats were separated using a 90 m digital elevation model (Papademetriou) from the Shuttle Radar Topography Mission (SRTM) and an elevation threshold of 630 m, sentinel-2 imagery and ground survey data through spatial modeling techniques such as overlay, matrix, recode and proximity analysis. This resulted in 5 classes of LULC. While class aggregation could have been performed statistically using a Euclidean or other distance measure, we employed a user-intensive method that incorporates both ground survey data and high resolution imagery in order to avoid lumping classes that might be spectrally similar but

have distinct land cover. The signatures of some classes differed in only one or two months, which would have caused the classes to be merged if an automated similarity index were used.

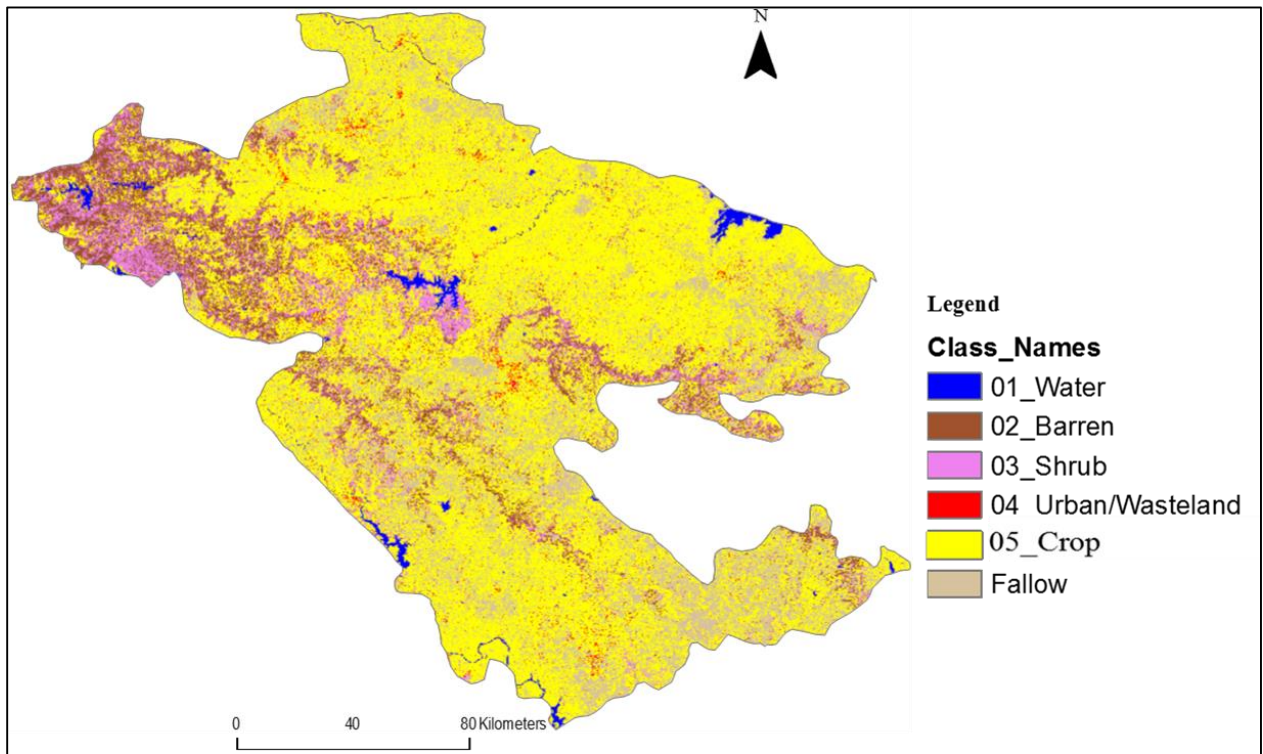


Figure 3. Spatial distribution of Land use land cover map in the study area.

### Spatial Distribution of crop type mapping:

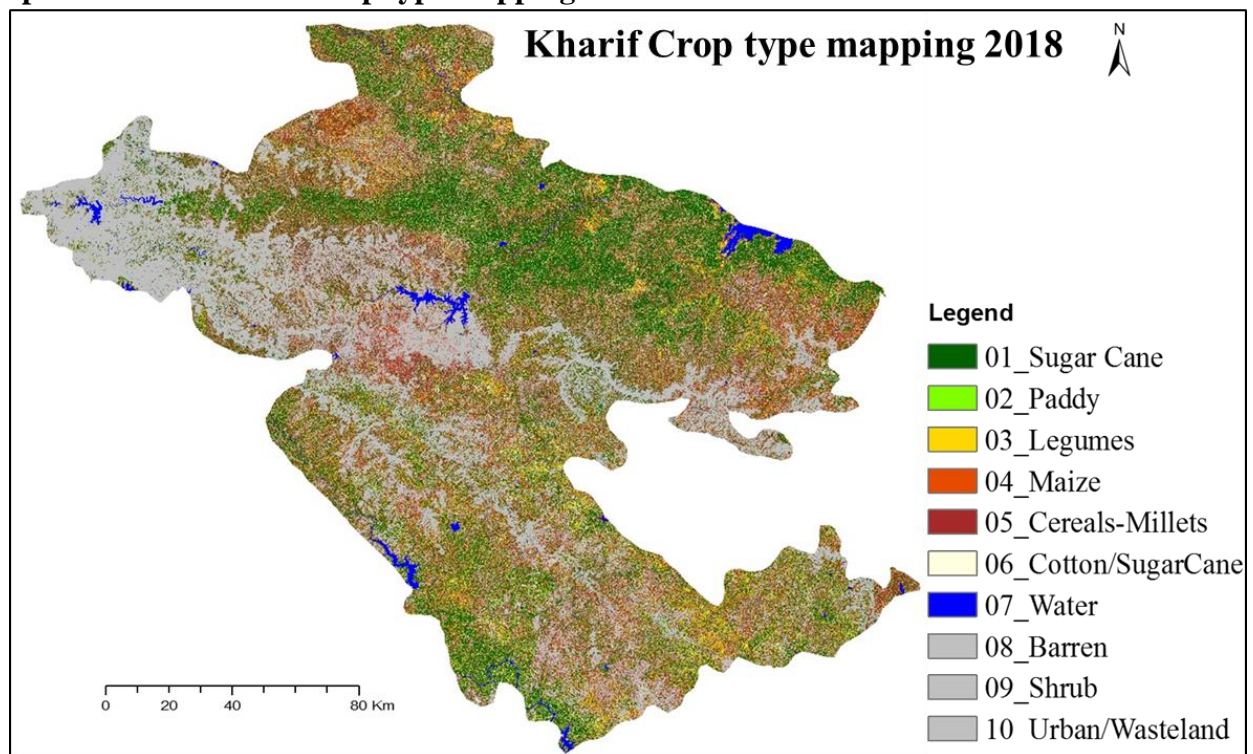




Figure 4a. Kharif season spatial distribution of specific crop type map for Ahmednagar region (2018)

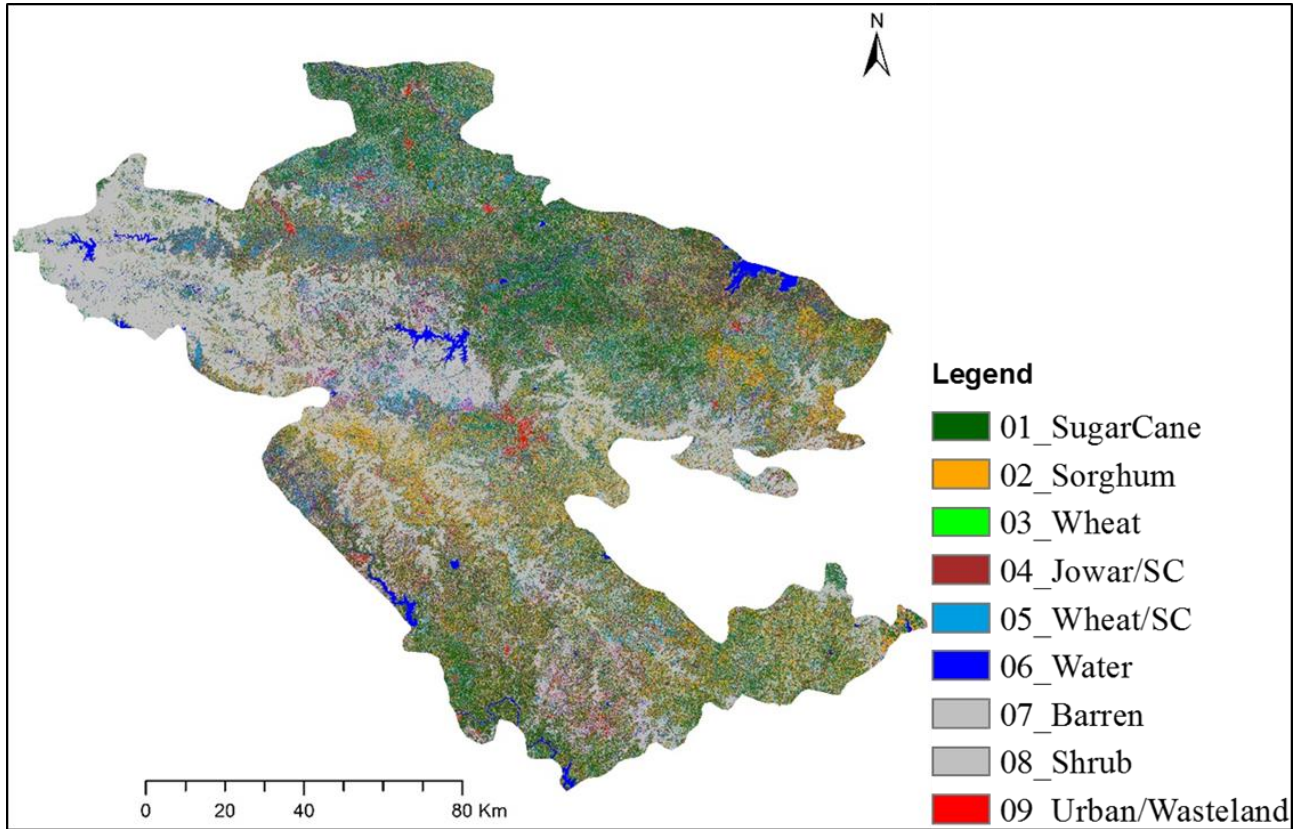


Figure 4b. Rabi season spatial distribution of specific crop type map for Ahmednagar region (2018-2019)

Table1: Accuracy Report of Kharif Specific Crop type mapping

Reference Data							
Classified Data	Sugar Cane	Paddy	Legumes	Maize	Cereals	Cotton/Sug	Row Total
Sugar Cane	70	2	7	4	2	0	85
Paddy	1	1	0	0	0	0	2
Legumes	4	0	10	3	1	2	20
Maize	1	0	0	5	1	1	8
Cereals	3	0	0	0	23	1	27
Cotton/Sugar Cane	0	0	0	0	1	8	9
Column Total	79	3	17	12	28	12	151
----- End of Error Matrix -----							

<b>Accuracy Total</b>					
Class Name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
-----	-----	-----	-----	-----	-----
	0	0	0	---	---
Sugar Cane	79	85	70	88.61%	82.35%
Paddy	3	2	1	33.33%	50.00%
Legumes	17	20	10	58.82%	50.00%
Maize	12	8	5	41.67%	62.50%
Cereals	28	27	23	82.14%	85.19%
Cotton/Sugarcane	12	9	8	66.67%	88.89%
Totals	151	151	117		
<b>Overall Classification Accuracy = 77.48%</b>					
<b>KAPPA (K<sup>^</sup>) STATISTICS</b>					
<b>Overall Kappa Statistics = 0.6526</b>					
Conditional Kappa for each Category.					
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Class Name	Kappa				
-----	-----				
Sugar Cane	0.6299				
Paddy	0.4899				
Legumes	0.4366				
Maize	0.5926				
Cereals	0.8181				
Cotton/Sugarcane	0.8793				
----- End of Kappa Statistics -----					

Table2: Accuracy Report of Rabi Specific Crop type mapping

<b>Reference Data</b>						
Classified Data	Sugar Cane	Sorghum	Wheat	Jowar/SC	Wheat/SC	Row Total
-----	-----	-----	-----	-----	-----	-----
Sugarcane	79	7	4	0	0	90
Sorghum	11	35	1	0	0	47
Wheat	5	1	9	0	0	15
Jowar/SC	2	1	0	7	0	10
Wheat/SC	0	1	0	0	13	14
Column Total	97	45	14	7	13	176
----- End of Error Matrix -----						

ACCURACY TOTALS					
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Class	Reference	Classified	Number	Producers	Users
Name	Totals	Totals	Correct	Accuracy	Accuracy
-----	-----	-----	-----	-----	-----
	0	0	0	---	---
Sugarcane	97	90	79	81.44%	87.78%
Sorghum	45	47	35	77.78%	74.47%
Wheat	14	15	9	64.29%	60.00%
Jowar/SC	7	10	7	100.00%	70.00%
Wheat/SC	13	14	13	100.00%	92.86%
Totals	176	176	143		
<b>Overall Classification Accuracy = 81.25%</b>					
KAPPA (K <sup>^</sup> ) STATISTICS					
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<b>Overall Kappa Statistics = 0.7047</b>					
Conditional Kappa for each Category.					
Class Name	Kappa				
Sugarcane	0.7277				
Sorghum	0.657				
Wheat	0.5654				
Jowar/SC	0.6876				
Wheat/SC	0.9229				
----- End of Kappa Statistics -----					

#### References:

- Gumma, M.K., Thenkabail, P.S., Deevi, K.C., Mohammed, I.A., Teluguntla, P., Oliphant, A., Xiong, J., Aye, T., & Whitbread, A.M. (2018). Mapping cropland fallow areas in myanmar to scale up sustainable intensification of pulse crops in the farming system. *GIScience & Remote Sensing*, 55, 926-949
- Gumma, M.K., Thenkabail, P.S., Teluguntla, P., Rao, M.N., Mohammed, I.A., & Whitbread, A.M. (2016). Mapping rice-fallow cropland areas for short-season grain legumes intensification in South Asia using MODIS 250 m time-series data. *International Journal of Digital Earth*, 9, 981-1003
- Gumma, M.K., Uppala, D., Mohammed, I.A., Whitbread, A.M., & Mohammed, I.R. (2015). Mapping Direct Seeded Rice in Raichur District of Karnataka, India. *Photogrammetric Engineering & Remote Sensing*, 81, 873-880
- Papademetriou, M.K. (2000). Rice production in the Asia-Pacific region: Issues and perspectives. In M.K. Papademetriou, F.J. Dent, & E.M. Herath (Eds.), *Bridging the Rice Yield Gap in the Asia-Pacific Region* (p. 220). Bangkok Food and Agriculture Organization of the United Nations