GIS and RS Applications in Water Resources Management in Consumption with Crop Assessment

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Abstract Raigad is the district in Maharashtra located in range of Sahyadri Mountain. Most part of district contains hilly terrains. Its land covers with thick forest. Crop estimation in hilly terrain is quite difficult because of its uneven surface undulating topography. Crop acreage estimation in hilly region is challenging for remote sensing. The reflection of vegetation and crop features is seen similarly in FCC images, so it becomes hard to differentiate. Remote sensing technique is economical, faster and gives accurate result because of its higher temporal frequency and spatial resolution. Present study utilizes satellite images of Sentinel 2 satellites. The objective of this study is to identify measure, map the standing crops in Rabbi season, year 2021, in Raigad district and map taluka level area of standing crop. The objective is achieved with 67% crop accuracy, as the study area is in hilly terrain and having thick forest; hence, it is difficult to achieve reasonable accuracy. Although ground truth is difficult in hilly terrain, 150 training sets were taken during ground truth. Sentinel 2 satellite images having higher resolution 10 m are used for this study, but for achieving more accuracy in hilly terrain containing thick forest, 1–2 m higher spatial resolution images are essential with temporal resolution of 5–10 days.

Keywords Remote sensing · Erdas imagine · Satellite image · Sentinel 2 · Raigad

1 Introduction

Raigad is the district in Maharashtra, located on bank of Arabian Sea. Garden of areca nuts, cashew nuts and coconut increases its beauty. Paddy is the predominant crop in Kharip season, and production of finger millets and small millets is also taken during Kharip season in the district. Cow pea, red gram, green gram, horse gram and beans are the major crops in Rabbi season; Remote sensing technique gives higher accuracy due to repetitive coverage of area. Hence in this study, remote sensing

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technique is used to carry out standing crop mapping in Rabbi season, year 2021, in Raigad district. For such study purpose, satellite images of Sentinel 2A and Sentinel 2B are used for analysis.

As Raigad district situated in Sahyadri mountain region, it is having hilly terrain and thick forest. Due to this, achieving reasonable accuracy for such district becomes difficult. For this study purpose, images of Sentinel 2A and Sentinel 2B satellites of European Space Agency (ESA) are utilized. This data is free downloadable and having higher resolution of 10 m. On these images, crop land and forest land reflection are seen similarly, so for this study subset of crop land is subtracted from full scene image and then classification is performed. For achieving accuracy, 150 training sets were taken during ground truth. The point, line or polygon features of every class are collected during the visit.

2 Study Area and Data Source

For standing crop assessment, Raigad district is considered. Fifteen talukas from Raigad district are covered in this study. It is located in the Konkan Region. This district comes between 18° 51′ 58″ N latitudes and 73° 18′ 22″ E longitudes. Geographical area of Raigad district is 7152 km^2. The main rivers in Raigad district are Kalu, Patalganga, Amba, Kundalika, Ghod, Ulhas, Bhogawati and Savitri. Kal and Morabe are the major dams in district while Rajanalla, Hetavane and Savatri are the medium dam (Source: Government of Maharashtra official website) (Fig. 1).

2.1 Data Used

2.2 Field Data

Crop cycle of Rabbi and summer season of Raigad district (District Agricultural Dept). List of major and medium reservoirs in the Raigad district. (Website-Mahawrd). Toposheets of Raigad district. (SOI, Survey of India official website). List of villages in Raigad district. (MRSAC, Maharashtra Remote Sensing Application Center, village maps).

2.3 Satellite Data

Sentinel satellite images are used for present study. The details of the satellite data selected for study are shown in Table 1.

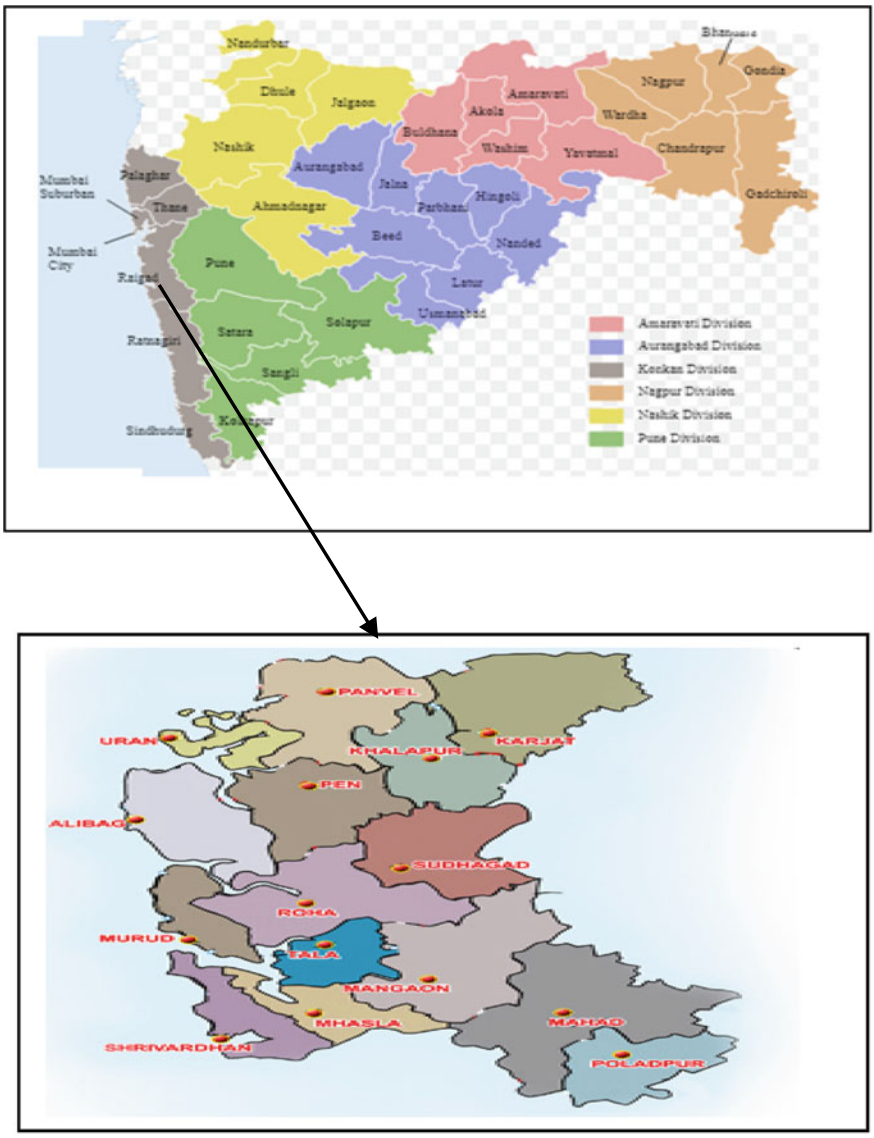

Fig. 1 Index map of Raigad district

2.4 Mosaic of Satellite Image

To cover all geographical area of Raigad district, six satellite images are required. Then by using above images, a mosaic image is prepared, which covers the whole 15 tahasil of Raigad district.

Table 1 Dates of pass for satellite data

Satellite	Sensor	Tile no	Date of pass for pre-monsoon	Remark
Sentinel 2	2A,2B	T 43 QBA	17/01/2021	First image
		T 43 QBA	22/01/2021	
		T 43 QCA	24/01/2021	
		T 43 QCB	16/05/2019	
		T43QCVV	24/01/2021	
		T 43 QCB	24/01/2021	Second image
		T 43 QCV	08/02/2021	
		T 43 QBA	08/02/2021	
		T 43 QBB	11/02/2021	
		T43QCBB	21/02/2021	
		T 43 QCA	21/02/2021	

2.5 Digital Village Maps from MRSAC (Maharashtra Remote Sensing Application Centre)

The digital village maps in vector form have been used for village-wise statistics generation.

2.6 Methods

The methodology adopted for analysis is described as fallows. Subset of Raigad district is taken out from the full scene of mosaic satellite image. Six satellite images are required for covering geographical area of such district. Subset is shown in Fig. 3 (Fig. 2).

2.7 Supervised Classification

Classification is done by using supervised classification technique in ERDAS IMAGINE software. The classes represented by pixel may be water bodies, forest, barren land, crop, vegetation urban or other land cover types.

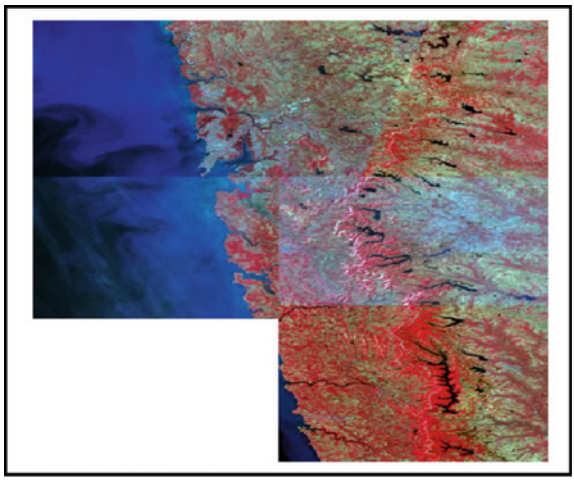

Fig. 2 Mosaic image

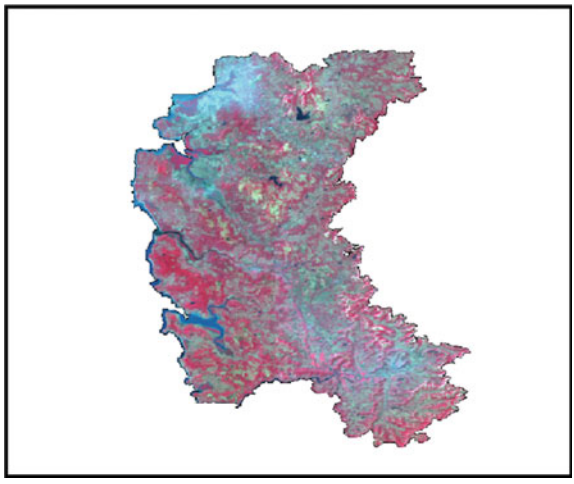

Fig. 3 Subset of Raigad district

2.8 Field Visit for Ground Truth Data Collection

For crop mapping, ground truth is very important. In ground truthing, various signature samples like, barren land, forest land, crop land, fallow land and vegetation are collected. Maximum signature samples give more accurate results. The field visit carried out from 27 to 29th January 2021 and collected signature sets are used for classification of image of Raigad district. The collected features are overlaid on the subset of satellite image as shown in Fig. 4, and supervised analysis of images is done.

Ground Truth photo 1

Ground Truth photo 2

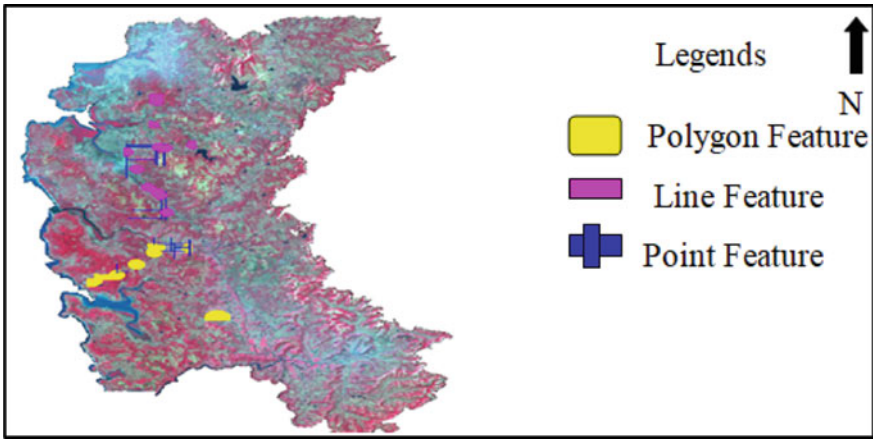

Fig. 4 Collected ground truth features

2.9 Conglomeration of Two Date Supervised Classified Images

From collection of ground truth samples, following shades are identified for the earth features in the area of interest: shades of pink-crop, cyan-barren, reddish brown-forest, gray-Fallow, mix pixel-urban, reddish pink-vegetation, blue-water in lakes and river. Then supervised classification is performed. First and second supervised classified image for standing crop is shown in Figs. 5 and 6, respectively.

MATRIX image is generated from two supervised classified images. Such image has 168 (14 $\times$ 12) probable unification of classes. Various class combinations are recoded and reduced to following seven classes. Class 1-Forest, 2-Crop, 3-Fallow, 4-Barren, 5-Water, 6-Vegetation, 7-Urban. Matrix image is shown in Fig. 7. Final recoded image of taluka-wise standing crop for Rabbi season, year 2021 is shown in Fig. 8.

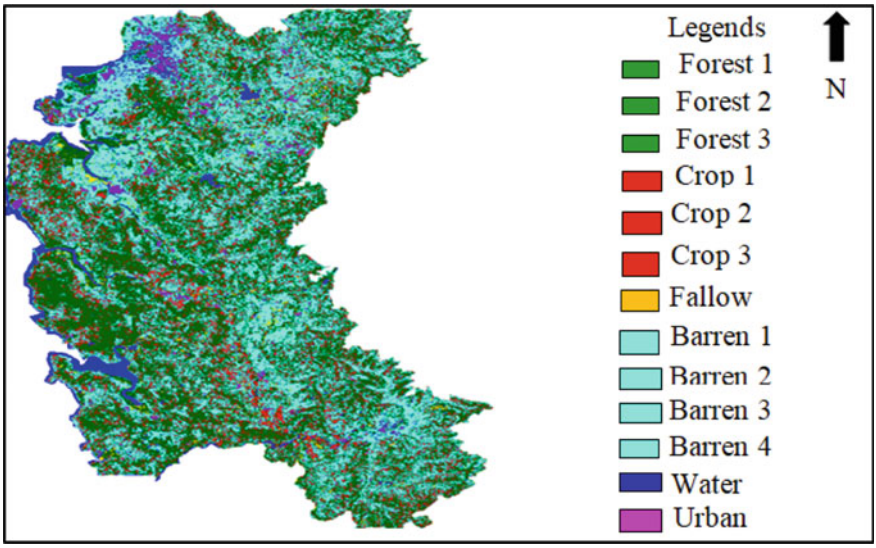

Fig. 5 First supervised classified image of Raigad district

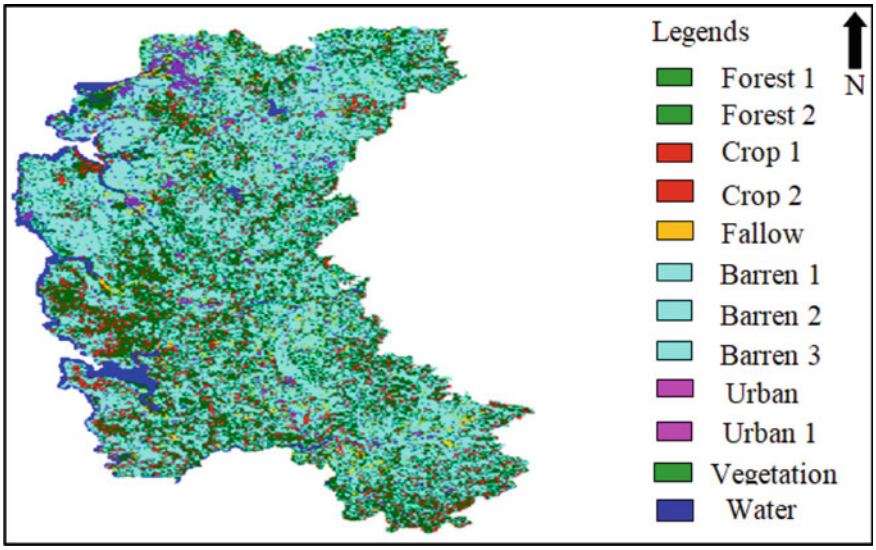

Fig. 6 Second supervised classified image of Raigad district

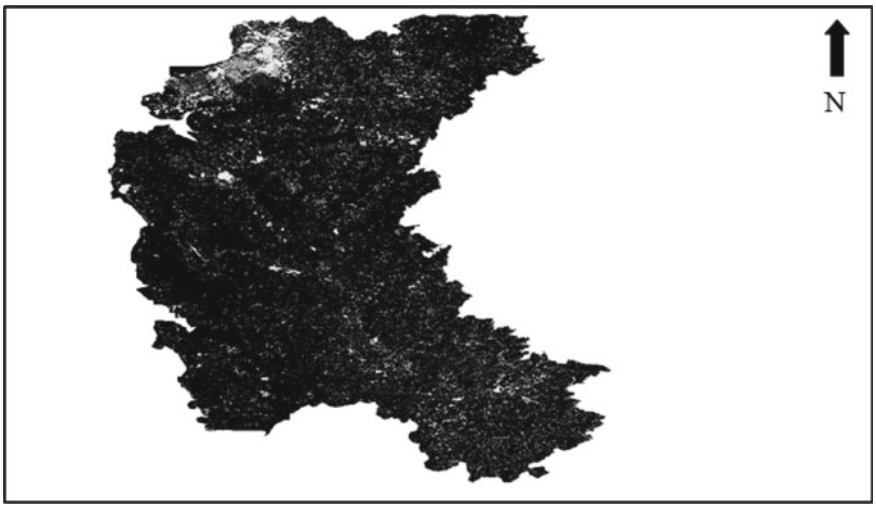

Fig. 7 Matrix image

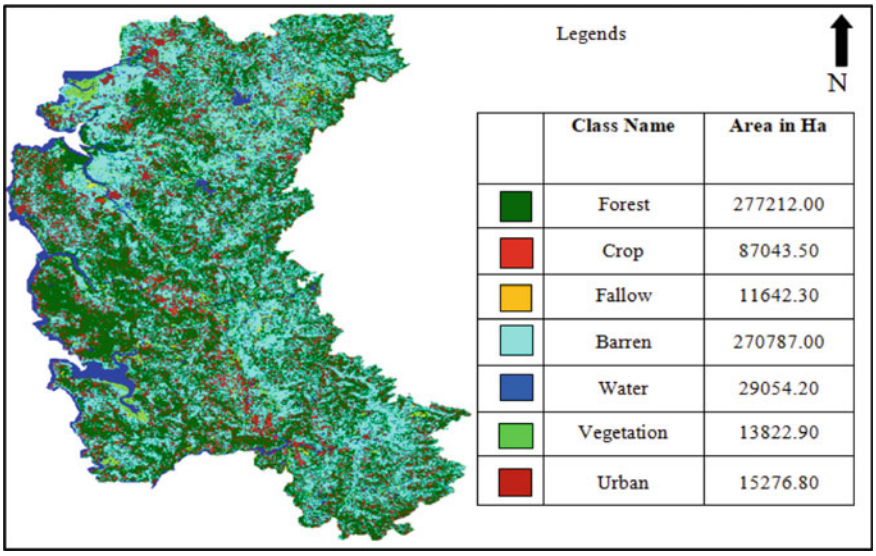

Fig. 8 Final recoded images

2.10 Creation of Area Statistics

After preparing recoded image, digital village map in vector form is superimposed on image. Taluka-wise standing crop area statistics is generated by using Summary

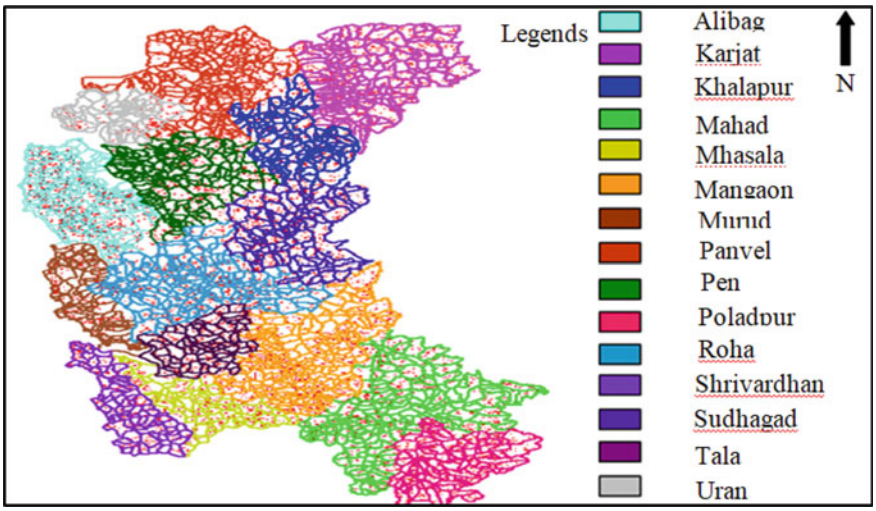

Fig. 9 Distribution of taluka-wise standing crop in Rabbi season, year 2021 of Raigad district

module in ERDAS Imagine 2010 classification software. Such distribution of Raigad district is shown in Fig. 9.

2.11 Accuracy Assessment

In order to assess the accuracy of the classification of final recode image, a following confusion matrix is generated and hence the accuracy of identification and measurement of crop in Rabbi season year 2021 for Raigad district is 67% and the overall accuracy of the supervised classification is 91.24%, which is shown in Table 2

$$\text{Total no. of samples} = 137$$
$$\text{Correct classified samples} = 125$$

$$\text{Overall Accuracy} = \frac{\text{Correct classified samples}}{\text{Total no. of samples}} = \frac{125}{137} = 91.24\%$$

Table 2 Confusion matrix ground truth reference data

Class	Crop	Fallow	Barren	Urban	Forest	Water	Vegetation	Total of row	Accuracy (%)
Crop	24	4	2	0	4	0	2	36	67
Fallow	0	13	0	0	0	0	0	13	100
Barren	0	0	31	0	0	0	0	31	100
Urban	0	0	0	10	0	0	0	10	100
Forest	0	0	0	0	10	0	0	10	100
Water	0	0	0	0	0	27	0	27	100
Vegetation	0	0	0	0	0	0	10	10	100
Total of column	24	17	33	10	14	27	12	137	91.24

3 Results and Discussion

By using remote sensing technique with sentinel satellite, two scene images, most accurate results of standing crop in Raigad district, are generated shown in tabular and graphical form in Table 3, Fig. 10, respectively.

Table 3 Abstract

S. No	Name of district	Name of taluka	No. of villages in taluka	Area of taluka in Raigad district (Ha)	Total standing crop area (Ha)	Percentage of standing crop
1		Alibaug	280	52,676.46	8416.93	15.98
2		Karjat	198	65,392.92	7937.03	12.14
3		Khalapur	146	40,826.74	4856.21	11.89
4		Mahad	187	81,665.97	9942.15	12.17
5		Mhasala	86	32,047.96	3697.4	11.54
6		Mangaon	187	68,502.23	10,130.3	14.79
7		Murud	90	26,282.17	3165.32	12.04
8		Panvel	200	60,455.38	5698.84	9.43
9		Pen	209	50,702.56	4971.51	9.81
10		Poladpur	89	36,580.76	4611.60	12.61
11		Roha	183	63,512.49	8238.07	12.97
12		Shrivardhan	79	26,092.45	3683.30	14.12
13		Sudhagad	105	46,582.32	6113.40	13.12
14		Tala	77	24,949.13	3421.08	13.71
15		Uran	73	20,794.30	1659.50	7.98
		Total	2189	697,063.84	86,542.64	12.42

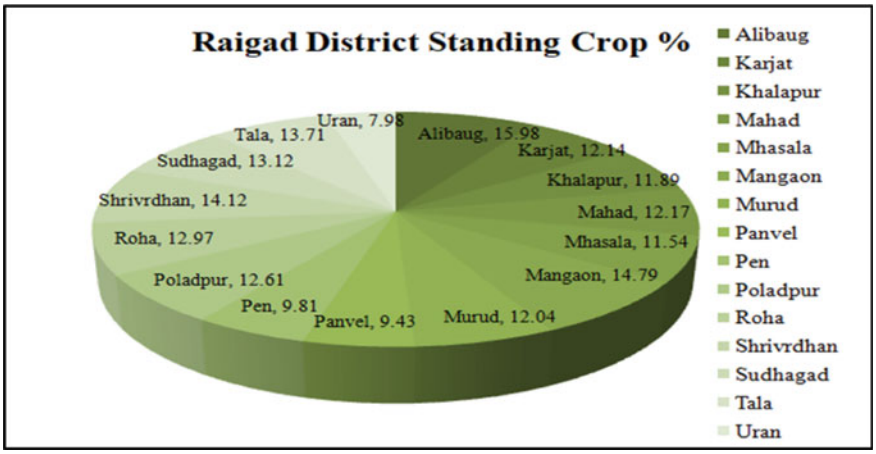

Fig. 10 Pie chart showing percentage of taluka-wise standing crop in Rabbi season, year 2021 of Raigad district

4 Conclusions

- The objective of the study is to identify measure, map the standing crops in Rabbi season, year 2021 in Raigad district and map taluka level area of standing crop. This objective has been achieved with 67% accuracy.
- The accuracy of particular study is affected due to extremely hilly area, uneven terrain and maximum forest, vegetation cover.
- It is to conclude that 12.42% of total geographical area of Raigad district is covered under standing crop for Rabbi season, year 2021.
- The creation of accurate and detailed crop maps requires high-quality ground truth and high-quality multi-temporal satellite data [1].
- The methodology adopted using the remote sensing technique with two scene images of Sentinel 2A are used to give fairly accurate results at village level [2] standing crop which has been confirmed in the field visit validation survey (Ground Truth). The village level database like area of barren land, area of fallow land, area of forest land, area of crop land and area of water can be used for periodical monitoring of land use activity.
- Remote sensing and geographic information system is the best tool for crop assessment. It is economical, cost-effective and less laborious. Remote sensing technique for assessment of standing crop in hilly area with forest cover gives reasonable accuracy; however, it is not possible to achieve accuracy around 95% due to extremely hilly terrain.

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