INDIAN JOURNAL OF GEOGRAPHY & ENVIRONMENT 20 (2023-24)
Indian Journal of Geography 20 (2023-24) 1-14
Vidyasagar University, West Bengal, India
(http://vidyasagar.ac.in/journal) ISSN: 0972-7388

VIDYASAGAR UNIVERSITY
Department of Geography

Multi-temporal Analysis of Sentinel 2B Satellite Images for Identification of Paddy Crop in South Gujarat, India

Tathagata Ghosh[1], Sukanta Kumar Saha[2], Rolee Kanchan[2@]

[1] Department of Arts, School of Liberal Arts and Sciences, Mody University of Science and Technology, Lakshmangarh, Sikar, Rajasthan
[2] Department of Geography, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, India
[@] Email of corresponding author: roleekanchan@gmail.com
Mob: +91-9426315022

Article History:
Received 11 February 2022
Received in revised form 24 November 2022
Accepted 27 November 2022

1. Abstract:

Agriculture as a primitive economic activity has changed its nature to great extent over the time period. Increasing needs as well as variability of need are the some of the major cause behind such change. To keep pace with this kind of dynamic scenario, it is essential to closely monitor the agricultural activity. Looking at the vastness of the agriculture-based country like India, timely generation of agricultural data is a matter of great concern for further necessary action and plans. Appropriate application geospatial technology combined with field observation can significantly assist to attain the objective. In the present work, Valsad district of south Gujarat is taken into consideration for the evaluation. The main objective of the paper is to identify the paddy crop through geospatial technique in association with the traditional field observation. For the extraction of paddy crop multi-temporal Sentinel 2B satellite images were used. Normalised Differential Vegetation Index (NDVI) helped in the process to extract the paddy crops in the study area with 77.42% accuracy level.

Keywords:
NDVI, Sentinel 2B, Paddy crop, Geospatial.

2. Introduction:

Timely availability of information related to crop lands and specific crops has become crucial as it has a direct relationship with need of increasing population all over the world. With increasing mechanization in the agriculture, there is a massive shift in this sector of economy. Like any other fields of economy, management is a necessary aspect to the agriculture also as it has become more complex in the recent era. The spatial extent and increasing varieties in agriculture, laid a challenge on the traditional way of collection of information for the purpose of management. Hence, application of geospatial technology is becoming popular throughout the world. Other than estimation of cultivated area, there are many applications of geospatial techniques in agriculture. Bharatkumar and Mohammed-Aslam (2015) worked on the cropping pattern of Tumukur taluka of Karnataka. Crop suitability map was created for a number of crops in the study area using NDVI. In the study, it is also found that crop suitability mapping using NDVI can clearly depict the less water consuming crops. Mondal et al. (2014) focused on the depiction of seasonal cropping pattern using multitemporal vegetation index in Muzaffar District of Bihar. In the study, the authors have incorporated vegetation indices like NDVI, EVI2 and NDSBVI to depict a comparative analysis. The result shows that NDVI has the highest accuracy level in extracting the cropping pattern among these three indices. Sarkar and Parihar (2014) worked on the similar manner of mapping of cropping pattern of parts of Kolkata assisted by composite NDVI. The main objective of the work was to find out any significant changes in the cropping pattern from 2002 to 2010. The work concluded with the fact that the adopted technique shows increase in double cropping and horticulture region and decrease in waterlogging wetlands. Horticulture fruit crops mapping is taken into consideration by Singh et al. 2017. High resolution CARTOSAT-1 was used in the study to extract horticulture fruit crops using geoinformatics. In the study, it is concluded that high resolution satellite images associated with field survey can produce results with high accuracy. Lunetta et al. (2009) worked on cropping pattern of Laurentian Great Lakes basin region using MODIS NDVI data. In the study, crop rotational change of 2005-06 and 2006-07 were analyzed. The result showed that there is rotations of corn-corn, soybean-corn and wheat-corn repetition in the concerned time period. Crop phenology mapping was attempted by Pan et al. (2014) using HJ-A/B data in part of China. In the research, NDVI time series was used and TIMESAT program was employed. The results showed that, HJ-1 A/B NDVI derived crop phenology is capable of deriving the crop season and it is comparable with agro-meteorological observations. Hasim and Bhar (2000) worked in the Bankura district of West Bengal using LISS-III satellite image based NDVI for depicting the cropping pattern of Rabi season. The results showed that in the recent years there is increasing potato cultivation over rice. Similar kind of work was also undertaken by Rahman and Saha (2009) in Bogra district of Bangladesh. In this study, temporal change of crop land and cropping pattern over sixteen years was analyzed. The result showed that during summer the area was mostly under mono crop but during winter season, the crop cultivation was changed drastically. Aduvukha et al. (2021) focused on the agro-natural heterogeneous landscape using high resolution satellite images. The study concluded that using geospatial technology, small scale farming landscapes can be accurately extracted. Further the study also suggested that, the method is applicable to similar agro-ecological regions.

In the present study, an attempt has been made to depict the paddy crop from satellite images based on the geospatial technique and assisted by field verification.

3. Data and Methods:

In the present study, multitemporal satellite images were used to depict paddy crop. Sentinel 2B satellite images were taken in to consideration in this context. The images were downloaded from https://scihub.copernicus.eu/dhus/#/home (accessed on 9/5/2021). Sentinel 2B is a Copernicus program and belongs to earth observation mission. The satellite captures

 DOI: http://dx.doi.org/10.62424/IJGE.2024.20.00.01

images with high resolution ranging from 10m to 60m. In association with high resolution, as a Synthetic Aperture Radar (SAR), the backscattering is highly sensitive to the geometric property of the target. The satellite images were downloaded for the entire study area for the agricultural calendar year 2019-20. The details of the images are given in the Table 1a and Table 1b.

Table 1a. Area Covered: Umbergaon. Padri, Valsad and part of Kaprada Talukas

Sl. No.	Image Acquisition Date	Platform	Tile Number
1	09-03-2019	Sentinel-2B	T43QBC
2	19-03-2019	Sentinel-2B	T43QBC
3	29-03-2019	Sentinel-2B	T43QBC
4	08-04-2019	Sentinel-2B	T43QBC
5	18-04-2019	Sentinel-2B	T43QBC
6	28-04-2019	Sentinel-2B	T43QBC
7	18-05-2019	Sentinel-2B	T43QBC
8	24-11-2019	Sentinel-2B	T43QBC
9	24-12-2019	Sentinel-2B	T43QBC
10	03-01-2020	Sentinel-2B	T43QBC
11	23-01-2020	Sentinel-2B	T43QBC
12	02-02-2020	Sentinel-2B	T43QBC
13	03-03-2020	Sentinel-2B	T43QBC

Source: https://scihub.copernicus.eu/dhus/#/home

(accessed on 9/5/2021)

Table 1b. Area Covered: Dhrampur and part of Kaprada Talukas

Sl. No.	Image Acquisition Date	Platform	Tile Number
1	09-03-2019	Sentinel-2B	T43QCC
2	19-03-2019	Sentinel-2B	T43QCC
3	29-03-2019	Sentinel-2B	T43QCC
4	08-04-2019	Sentinel-2B	T43QCC
5	28-04-2019	Sentinel-2B	T43QCC
6	08-05-2019	Sentinel-2B	T43QCC
7	18-05-2019	Sentinel-2B	T43QCC

8	23-01-2020	Sentinel-2B	T43QCC
9	22-02-2020	Sentinel-2B	T43QCC
10	03-03-2020	Sentinel-2B	T43QCC
11	12-04-2020	Sentinel-2B	T43QCC

Source: https://scihub.copernicus.eu/dhus/#/home

(accessed on 9/5/2021)

Spackle noise in the SAR images is a common aspect; hence prior to any other operations (Kaplan and Avdan, 2018) spackle noise is removed with 7X7 kernel size using SNAP software. Once noise is removed, near infrared band (Band 8) and red band (Band 4) were used for depicting Normalized Differential Vegetation Index (NDVI). NDVI is the ratio between the Near Infrared (NIR) band and red band. It is widely accepted index in terms of vegetation strength. Following expression (Rouse et al. 1973) is used for depiction of NDVI-

$$\text{NDVI} = \frac{(\beta nir - \beta red)}{(\beta nir + \beta red)} \qquad (1)$$

NDVI= Normalised Differential Vegetation Index
βnir = Reflectance of Near Infrared Band
βred = Reflectance of Red Band

The same expression (1) is applied for all the satellite images. 59 ground control points for paddy crop fields were selected on random sampling basis for ground verification. The GCPs were marked on GPS (Garmin GPS Model GPS MAP 78 S) and during field visit, field photographs were also taken. Among these 59 sampling points, 70% of the data i.e. 41 locations were considered as training data set and 30% of the data (18) were used as testing data. Other than these, 59 paddy crop field locations, 59 ground verification points of other crops fields were also taken that consists of vegetables, fruits and sugarcane fields. Thus, 59 paddy fields and 59 other crop field GCPs, altogether 118 GCPs were incorporated in the study. 59 paddy field GCPs were superimposed on the temporal NDVI to extract the temporal NDVI pixel values for paddy crop. Similarly, 59 other crop field GCPs were also added on the temporal NDVI for extracting temporal NDVI pixel values. Signatures obtained from both the groups, i.e. paddy crop and other crop fields were tabulated. The non-crop lands were manually digitized with the help of Sentinel 2B images and verified with Google earth images. Once the non-crop lands were identified, then the crop land of the entire study area was taken into considerations. From NDVI vegetation composite, threshold value of paddy was extracted by supervised classification through number

 DOI: http://dx.doi.org/10.62424/IJGE.2024.20.00.01

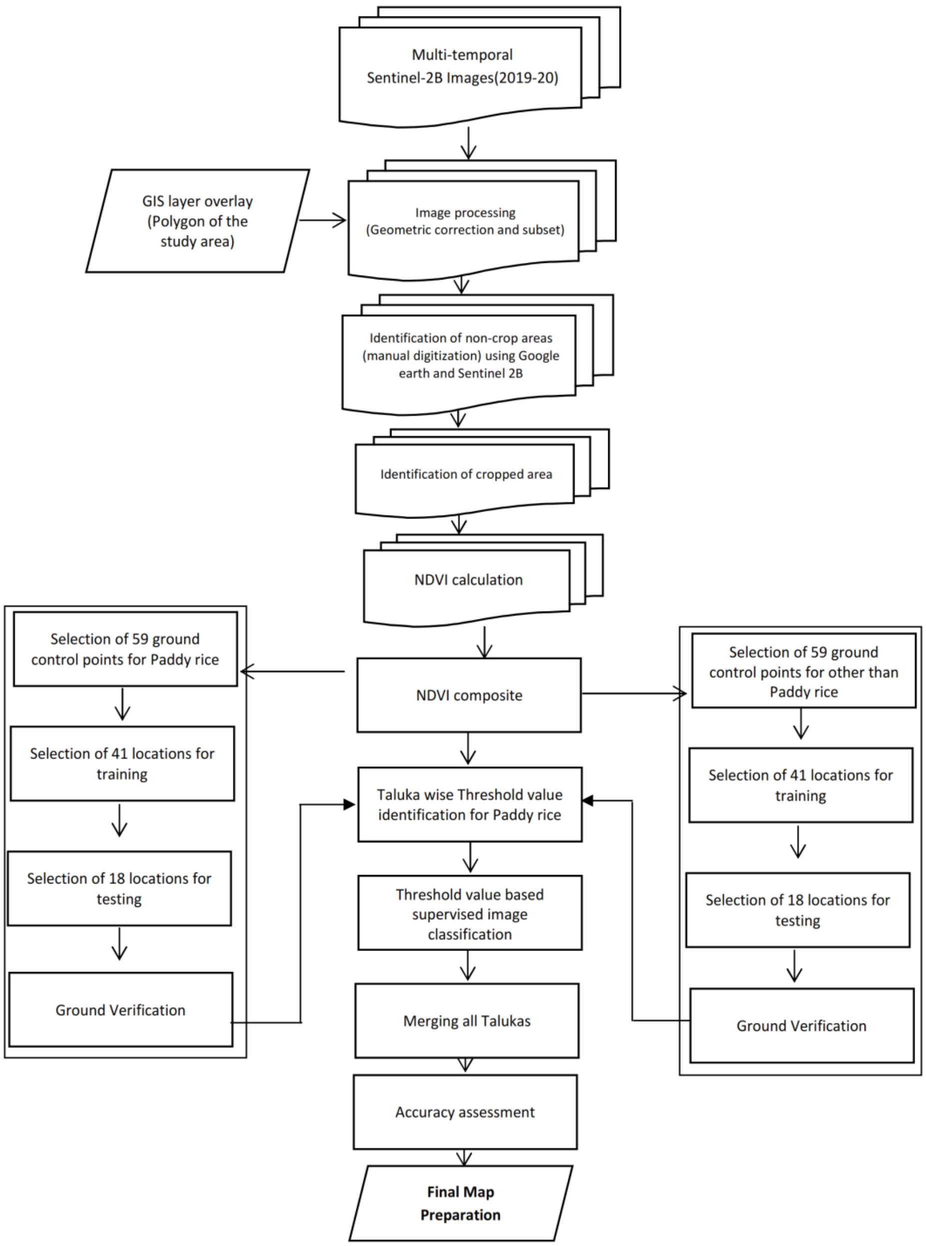


Fig.1 Workflow

of iterations. The best possible threshold range for the extraction of paddy crop are tabulated in table 4. As all the NDVI vegetation composite of different scenes exhibited different signature for paddy crop. Hence different threshold range is produced for different scenes of the entire study area that best depicted the paddy signature. Finally, all the scenes are merged with each other to depict final result for paddy for the entire study area (Fig.1).

4. **Study area:**

The present research area encompasses the entire district of Valsad and located in the southern segment of Gujarat, India (20°07' to 20°45' North latitude and 72°43' to73°29' East longitude) comprising an area of 2953.96 km^2 (Digitized from District Census Handbook, Valsad, 2011) (Fig.2).

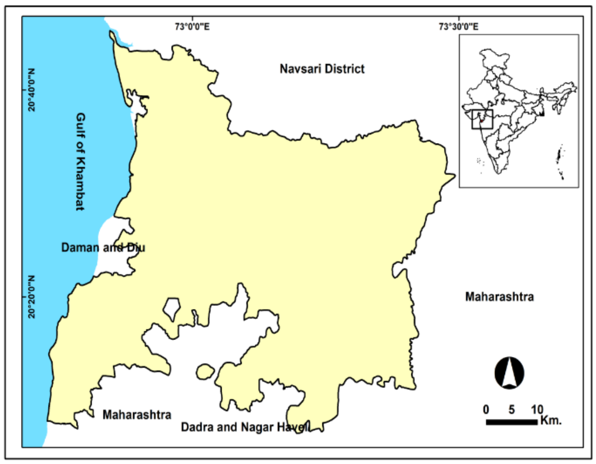


Fig.2. Location map of the study area

It comes under sub-tropical climate. Rainfall varies between moderate to high as the region receives rainfall from south west monsoon and falls under South Gujarat (Heavy Rain Area) Agro Climatic Zone (Dairying in Gujarat. Statistical Profile, 2013). The maximum temperature varies between 32.2°C to 41.2°C while minimum temperature ranges between 9.9°C to 23.3°C. The regional slope of the study area is from west to the east. Eastern segment marks the elevation as high as 600 m while the western portion merges with the coastal plain (Fig.3).

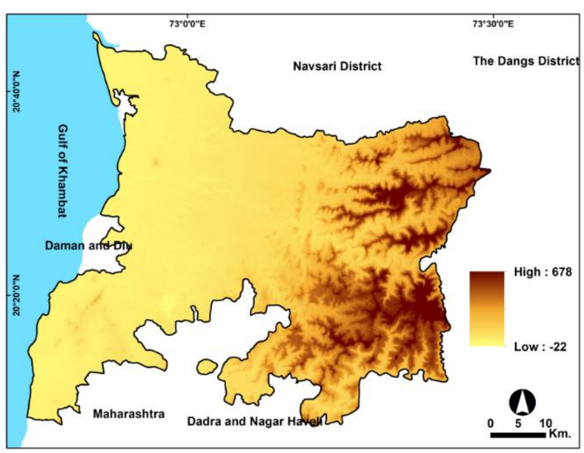


Fig.3. Elevation map the study area

 DOI: http://dx.doi.org/10.62424/IJGE.2024.20.00.01

Auranga, Par and Daman Ganga are the major rivers draining the region. All the rivers originated from the eastern hilly terrain and traverse through the central portion and pour in to the Arabian Sea in the west (Fig.4).

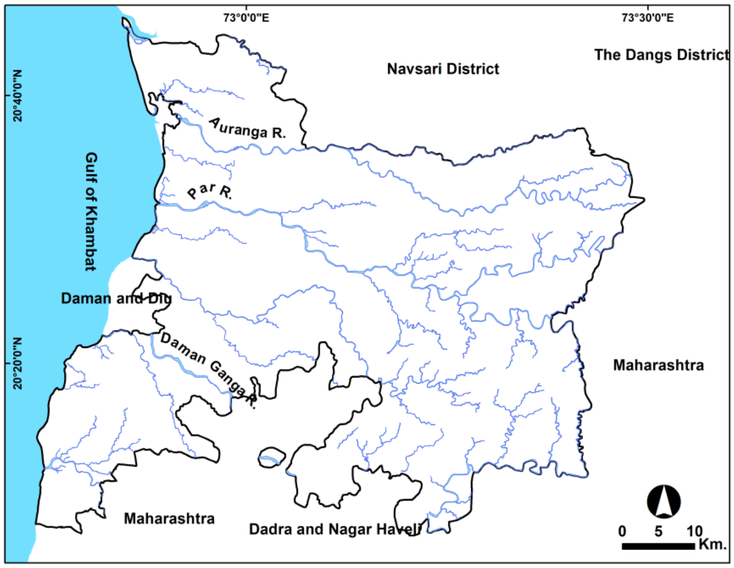


Fig. 4 Drainage map of the study area

Table 2: Taluka wise area and population density of Valsad district

Sr. No.	Taluka	Area (km^2)	Population Density (Persons per km^2)
1	Valsad	494.45	813
2	Pardi	419.61	1219
3	Umbergaon	370.92	817
4	Dharampur	723.15	303
5	Kaprada	945.84	278
	Total	**2953.96**	**567**

Source: Area- Computed from digitized map, District Census Handbook, Valsad, 2011, Population density- District Census Handbook, Valsad, 2011

Physiographic units consists of narrow coastal strip of intertidal saline wet lands and adjoining plains in the west while intermediate rocky table associated with high relief in the east comprise the entire area. The eastern segment of the study area is mostly under the dissected plateau region while the western part is under the pediment-pediplain complex (Bhukosh, Geological Survey of India) (Fig.5) (https://guj-nwrws.gujarat.gov.in/showpage.aspx?contentid=1518&lang=english accessed on 12/12/2021). There are mainly four major types of soils found in the entire region. Eastern segment, related to hilly terrain is associated with the Bilimora, belongs to Bedmal series.

Beldha of Vandawania series Encompasses the central zones while Ene of Jalpur series is found in the western coastal region. A small patch of Onjal of Dandi series of observed in the North-western portion of the study area (Fig.6). Demographically Pardi showed the highest density (1219 persons/km^2) while Kaparda had the least population density (278 persons/km^2) (Table 2).

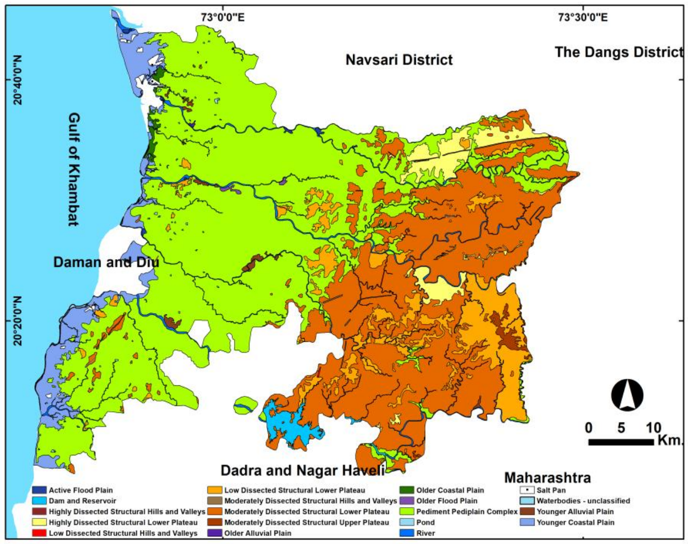


Fig.5 Physiographic map of the study area

(Source: Bhukosh, Geological Survey of India)

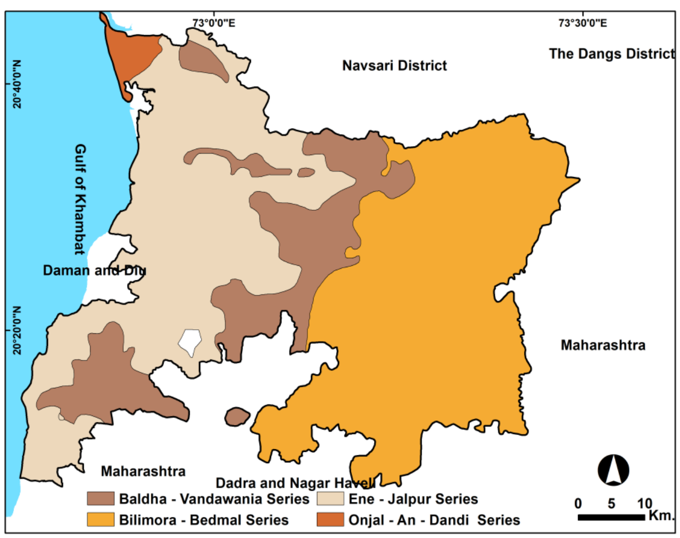
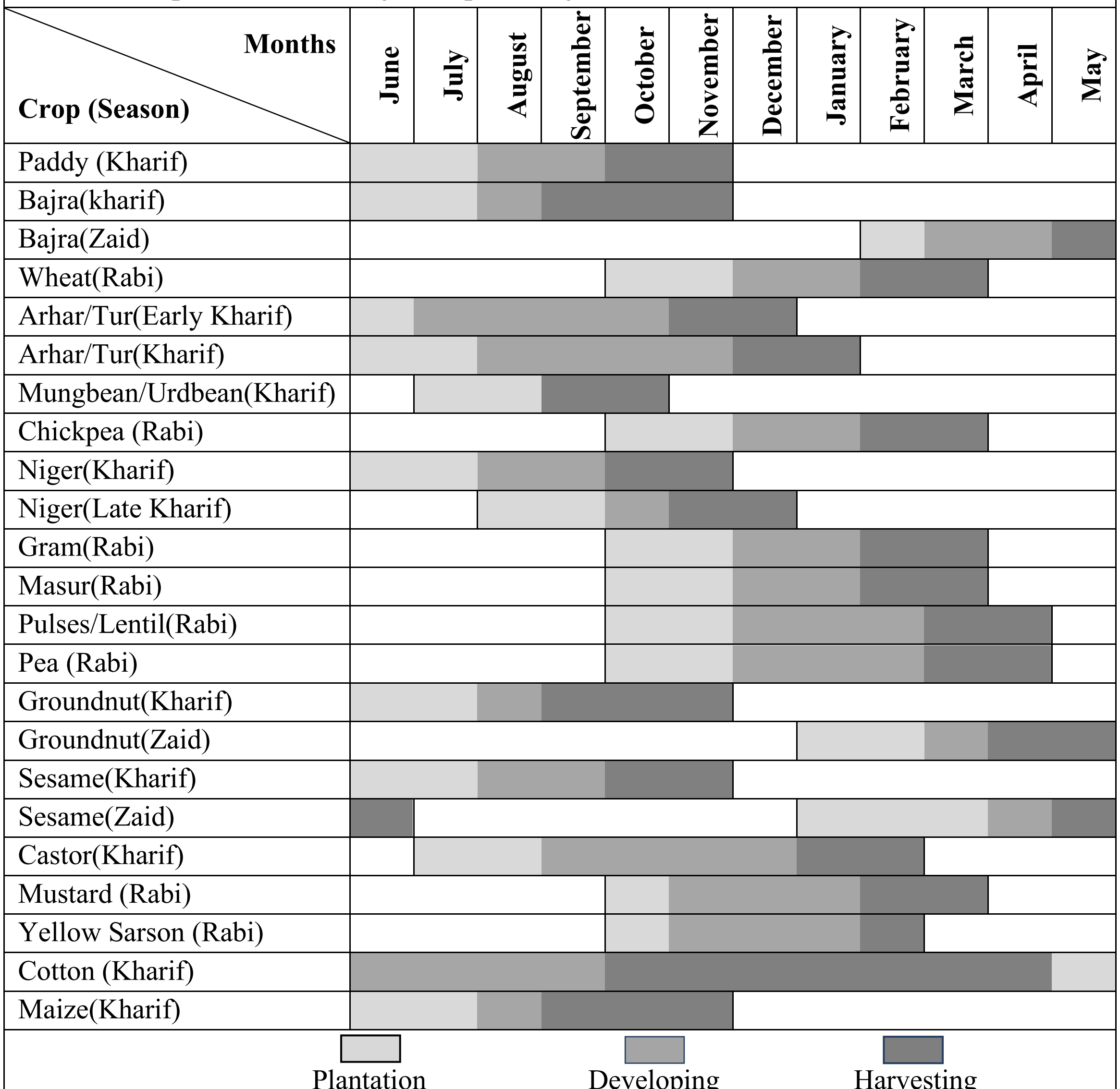


Fig.6 Soil map of the study area

(Source: https://guj-nwrws.gujarat.gov.in/showpage.aspx?contentid=1518&lang=english)

 DOI: http://dx.doi.org/10.62424/IJGE.2024.20.00.01

Table 3: Crop Calendar of major crops of Gujarat



Source: Indian Council of Agricultural Research (Crop Science Division)

Table 3 elucidates the crop calendar of major crops of Gujarat. It can be observed that majority of crops belong to Kharif and Rabi seasons while a very few belongs to Zaid season. In the present paper, Paddy crop is taken into consideration and it can be seen that the plantation period of paddy crop is from early June to late July while from early August to Late September it the growing season. From early October to late November, it is the harvesting season for the Paddy crop.

5. Results and Discussion:

During classification of image from the Sentinel-2B images it was found that the spectral reflectance of paddy crop was similar to other crops in different regions as they have the same growing period. Geospatial technique assisted multitemporal spectral reflectance along with the ground verification helped in this scenario to depict paddy crop region with considerable accuracy. In this context, NDVI supports the system to a great extent. As different tiles of images were associated with different spectral signature for the same crop of same time, the analysis was done talukawise. Once non-cropped area was identified using manual digitization, the threshold value of paddy crop was identified. For the identification of paddy rice, number of iterations was done to depict the maximum accuracy. The following expression was used in the operation for depiction of the pixels corresponding to the paddy rice in different talukas-

Dhrampur:

Con((NDVI_1.img>=0.14&NDVI_1.img<=0.268,1,Con((NDVI.img>=0.279&<=0.475,2))))

Kaprada:

Con((NDVI_1.img =>0.359& NDVI_1.img<=0.453,1,Con((NDVI_2.img>=0.13&<=0.332,2))))

Pardi

Con((NDVI_1.img>=0.24&NDVI_1.img<=0.30,1,Con((NDVI_2.img>=0.402&<=0.43,1,Con((NDVI_3.img>=0.12&<=0.202,1,2))))))

Valsad

Con(NDVI.img>=0.10&<=0.22,1,Con(NDVI.img>=0.22 &NDVI.img<=0.60),2)

Umbergaon

Con(NDVI.img>=0.103&<=0.14,1,Con(NDVI.img>=0.185&<=0.359,2))

Table 4: Taluka wise range of NDVI value for Paddy rice

Sr. No.	Taluka	Threshold values for Paddy rice (Extracted from NDVI)	
		Minimum	Maximum
1	Dharampur	0.140	0.268
2	Kaparda (Both satellite images)	0.359	0.453
3	Pardi (Satellite image 1)	0.240	0.300
	Pardi (Satellite image 2)	0.402	0.430
	Pardi (Satellite image 3)	0.120	0.202
4	Valsad	0.100	0.220
5	Umbergaon	0.103	0.140

Source: Computed by the authors

DOI: http://dx.doi.org/10.62424/IJGE.2024.20.00.01

Expressions and the Table 4 depicted the range of the threshold value for the paddy crop and other crops in the study area. The depicted thresholds are considered to be the best possible range though number of iterations. It is found that in Dharampur taluka the threshold ranges from 0.140 to 0.268 while for the other crops the range of threshold is from 0.279 to 0.475. On the other hand in Kaparda, the range of threshold value that depicted paddy rice ranges from 0.359 to 0.453 and its common for both the satellite images that covers entire taluka of Kaparda. In the analysis, it is found that NDVI pixel values ranges between 0.13 and 0.332 showed other than paddy crops. Pardi taluka on the other hand, comprised of three satellite images and for all the three images, three different ranges of thresholds for both paddy and other than paddy crops were depicted. In case of Valsad taluka, the range of threshold for paddy crop is from 0.100 to 0.220 while in case of Umbergaon taluka, the range is between 0.103 to 0.140.

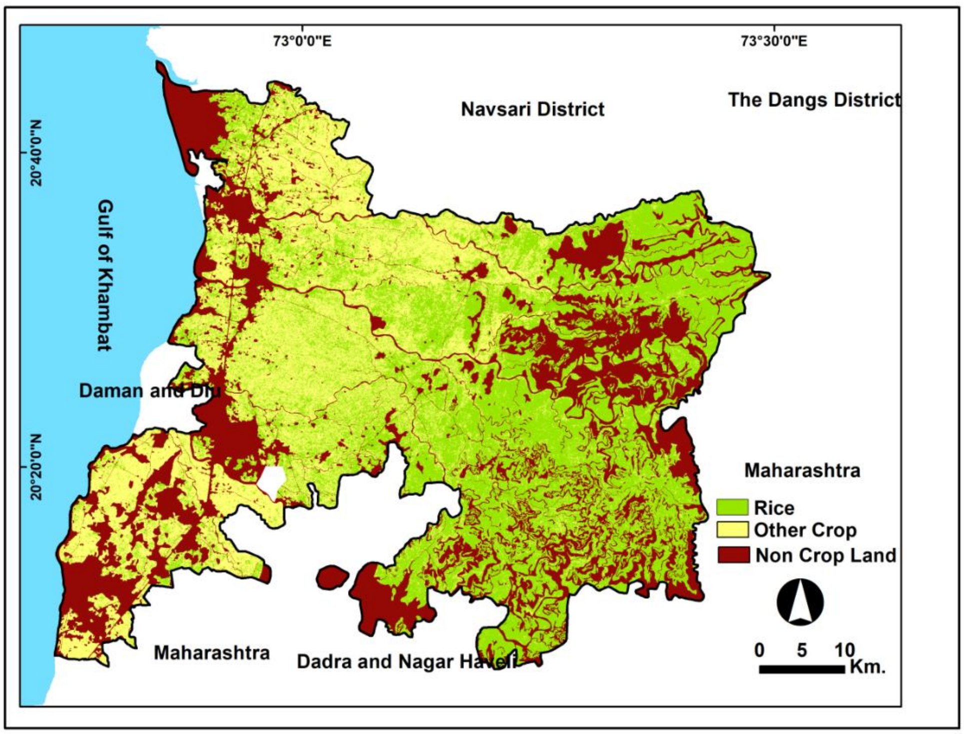
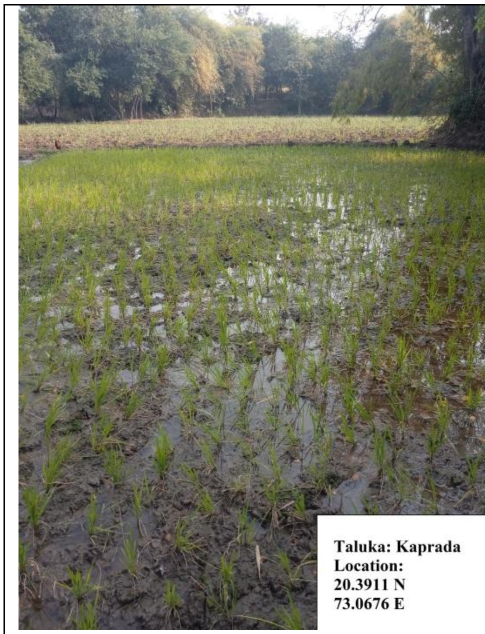
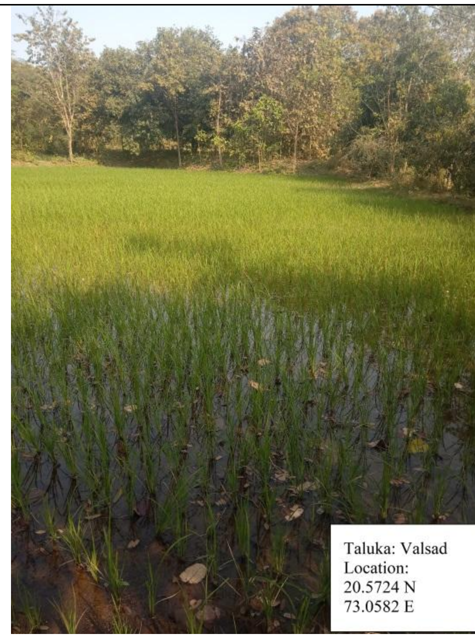


Fig.7. Paddy rice, other crops and non-crop area of Valsad district

Based on the depicted results, accuracy assessment is done on the data set. Total 118 locations were used (59samples for locations of paddy rice and 59 samples for other than paddy crop locations) for the accuracy assessment and the entire operation was performed in ERDAS imagine software (ERDAS imagine 2014). The result depicted that with 77.42% of accuracy the paddy rice fields were classified and the Kappa Coefficient is 0.8230. From the depicted results, it is found that the taluka located in the eastern segment like Dharampur and Kaparda were associated with relatively more area under paddy while the talukas situated in the western portion like Valsad, Pardi and Umbergaon had relatively lesser area under paddy rice (Fig.7). Fig.8a, Fig.8b and Fig.8c shows the photographs of the paddy crops, taken during the field survey of the study area.



(8a)



(8b)

(8c)

Field Photographs

DOI: http://dx.doi.org/10.62424/IJGE.2024.20.00.01

6. Conclusion:

The present study executed a relatively faster method for the identification of Paddy crop using NDVI extracted from multitemporal high resolution satellite images. In the present study, it is found that NDVI successfully depicted the paddy crop as well as the regions other than paddy crop areas. As the area of the study is considerably larger (2953.96 km^2), 77.42% accuracy with Kappa coefficient of 0.8230 is acceptable. It is also found that the geospatial technology along with traditional field observation can depict the specific crop with considerable accuracy.

7. Acknowledgement:

Prof. Rolee Kanchan (Project Investigator) and Dr. Tathagata Ghosh (Co-project Investigator) are thankful to Indian Council of Social Science Research (ICSSR), New Delhi, India, for funding the Major Research Project (IMPRESS/P680/279/2018-19/ICSSR).

8. References:

Aduvukha, G. R., Abdel-Rahman, E. M., Sichangi, A. W., Makokha, G. O., Landmann, T., Mudereri, B. T., ... & Dubois, T. (2021). Cropping Pattern Mapping in an Agro-Natural Heterogeneous Landscape Using Sentinel-2 and Sentinel-1 Satellite Datasets. Agriculture, 11(6), 530.

Bharathkumar, L., & Mohammed-Aslam, M. A. (2015). Crop pattern mapping of tumkur taluk using NDVI technique: a remote sensing and GIS approach. Aquatic Procedia, 4, 1397-1404.

Bhukosh, Geological survey of India (https://bhukosh.gsi.gov.in/Bhukosh/Public accessed on 28/10/2021)

Dairying in Gujarat. Statistical Profile; 2013. Available from: https://www.nddb.coop/sites/default/files/pdfs/Dairying-in-Gujarat-04-04-14-low.pdf. (Last accessed on 9/5/2021).

District Census Handbook (2011) Valsad, Village and Town wise Primary Census Abstract (PCA), Directorate of Census Operations, Gujarat

Hasim, S., &Bhar, K. K. (2020). Seasonal Cropping Pattern Extraction Using NDVI from IRS LISS-III Image of Kangsabati Commanded Area. Procedia Computer Science, 167, 900-906.

https://scihub.copernicus.eu/dhus/#/home (accessed on 9/5/2021)

Kaplan, G., & Avdan, U. (2018). Monthly analysis of wetlands dynamics using remote sensing data. ISPRS International Journal of Geo-Information, 7(10), 411.

Lunetta, R. S., Shao, Y., Ediriwickrema, J., & Lyon, J. G. (2010). Monitoring agricultural cropping patterns across the Laurentian Great Lakes Basin using MODIS-NDVI data. International Journal of Applied Earth Observation and Geoinformation, 12(2), 81-88.

Mondal, S., Jeganathan, C., Sinha, N. K., Rajan, H., Roy, T., & Kumar, P. (2014). Extracting seasonal cropping patterns using multi-temporal vegetation indices from IRS LISS-III data in Muzaffarpur District of Bihar, India. The Egyptian Journal of Remote Sensing and Space Science, 17(2), 123-134.

Pan, Z., Huang, J., Zhou, Q., Wang, L., Cheng, Y., Zhang, H., ... & Liu, J. (2015). Mapping crop phenology using NDVI time-series derived from HJ-1 A/B data. International Journal of Applied Earth Observation and Geoinformation, 34, 188-197.

Rahman, M., &Saha, S. (2009). Spatial dynamics of cropland and cropping pattern change analysis using Landsat TM and IRS P6 LISS III satellite images with GIS. Geo-spatial information science, 12(2), 123-134.

Sarkar, S., & Parihar, S. M. (2014). Mapping of cropping pattern of East Kolkata Wetland Area using multi-temporal satellite data. Journal of Geomatics, 8(1).

Singh, V., Patel, A. N., Dalwadi, A., Kathota, J., Suthar, J., &Kalubarme, M. H. (2017). Horticultural Fruit Crop Plantations Mapping using Geo-informatics Technology in Gujarat State India. International Journal of Advanced Remote Sensing and GIS, 6(2), 2033-2049.

https://guj-nwrws.gujarat.gov.in/showpage.aspx?contentid=1518&lang=english accessed on 12/12/2021.

 DOI: http://dx.doi.org/10.62424/IJGE.2024.20.00.01