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NDVI prediction using Machine learning after Geofencing on satellite data of Sugarcane crop

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Abstract: - The manual fencing of the crop is too tedious and time-consuming for the farmers. The farmers have to physically see that they are not crossing the boundaries and usually, farmers fight related to the plots. In this paper focus is on the satellite data imagery of Satara district and if geofencing is done for sugarcane crops then monitoring the crop is comparatively easy and analysis can be further done related to sugarcane plots. Geofencing helps then to have the precise data of the farmer and boundaries can be detected to avoid hassles. The Cane plots that have been geofenced can then be labeled according to the plots of the farmers, thus streamlining th classification process. The digitization of the farmer plots is used in this paper and converted into shape files by using GIS which helps to do the further analysis of the crop. Further after doing the pre-processing by using GIS, the Normalized Difference Vegetation Index (NDVI) is predicted prior using Machine learning technique in python. The NDVI actual and predicted for one life cycle of sugarcane is shown in the paper. The NDVI predicted values can be helpful for sustainable agriculture of sugarcane crop in terms of disease detection, cane classification and prediction also. The Machine learning algorithms can be applied further and the geofencing can be done district wise in future scope along with the vegetation indices.

Keywords: GIS, Geofencing, NDVI, Machine learning

I. INTRODUCTION

Even though smart agriculture has been implemented in all of the world's developing nations, not all farmers can increase their crop yields and crop diversity because of issues with land parameters like soil quality, water contaminants, and nutrition. Some farmer's land may be suitable for growing more plants than their neighbors, which could cause a serious agricultural crisis. Scientists were conducting additional studies, but they had not yet determined whether or not the soil was suitable for growing all types of vegetables and plants. Although many techniques were used by small-scale farmers, progress was slower than hoped for, particularly in vegetable cultivation. Geofencing can help to find the farmer plots individually and sort out their problems related to nutrients and soil health. To address complex issues in GIS and remote sensing, Esri has created tools and workflows that leverage recent advances in deep learning. In the realm of computer vision, deep learning techniques have been gradually replacing more conventional machine learning algorithms. Image categorization,

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object recognition, semantic segmentation, and instance segmentation are all possible with the help of Esri's tools. The term "geographic information system" (GIS) refers to a collection of databases and software used to manage, analyse, and display geographically-based information. The system also includes the people who use it and the people who help them, the procedures and workflows they employ, the body of knowledge on relevant concepts and methods, and the underlying institutional structures. Geographic information systems (sometimes abbreviated GIS) is the most frequent word for the field and sector that deals with these technologies.

It is a subset of the greater geospatial discipline that encompasses global positioning system (GPS) technology, remote sensing, and other similar tools. Numerous tools, procedures, and strategies make use of geographic information systems. They are a part of many processes and programs used in fields like engineering, planning, management, transportation/logistics, insurance, IT, and business As a result, location-enabled services, which depend on geographic analysis and visualization, rely heavily on GIS and location intelligence applications. The "key index variable" in a GIS is location, which allows for the linking of data that wouldn't otherwise seem connected. Any reference to a location or area on Earth should be able to be mapped to some other location or area on Earth, and eventually to some "real" physical location or area. This essential feature of GIS has started to pave the way for new lines of research and study in the scientific community. Geofencing is virtual boundaries created through GIS which help the farmers in resolving the issues related to their plots of the farmers. The cane monitoring and classification after geofencing helps farmers in sustainable agriculture.

A. LITERATURE SURVEY

To maximize productivity, cost, convenience, and environmental protection, agriculture is and has always been an industry that quickly adopts cutting-edge technologies.

Types of Geofencing:

1) **Circular and Radius geofence**: The administrator or programmer can enter the geofencing software, select the area they wish to draw the border around, and then specify the radius or diameter of the geofence in feet. The sole potential drawback of radius geofence is that they may inadvertently include places outside of the target area rather than just the target area itself. Most structures, for instance, are not shaped like a circle. For this reason, it's not a good idea to construct a geofence with a circular radius around a building with a square footprint.

2) Polygonal Geofencing:

One can place 12–15 points around a defined region with a polygonal geofence; its precision is superior to that of a geofence based on a radius. The first step in creating a geofence is deciding where you want it to be located, and then selecting individual points inside that area. The polygonal geofences have the same drawback—an expected capture variance of around 5 feet along all of the geofence's boundaries.

3) **Latitude and longitude Geofencing**:

The final method of geofencing, this one based more on squares. The latitude and longitude of the spot you want to hit are usually required. Then, will construct a square around that location, with a radius of anywhere from 10 feet to 500 feet. The major problem with this strategy is that it might be difficult to determine the exact location, increasing the likelihood that you would accidentally record a road or parking lot. The researchers in literature survey had trackthe where and when of cattle activities, this research suggests setting up a geographical paddock. To find cattle that wander away from typical corrals, farmers with traditional livestock tracking systems have to put in a lot of hard work. The proposed technique helps farmers define a safe area for their cattle with minimal effort. When cattle attempt to leave the designated area, the system will alert the farmers [2]

This research study presents a geofencing-based user movement detection and risk assessment system for disaster information. The server gathers risk data from multiple sources, while the client keeps tabs on the user to alert them when necessary; together, they comprise a client-server architecture. Based on the risk information saved on the server, the client sets up a geofence around the potentially hazardous location and tracks the user's entry and exit through the fence. This allows the system to send timely alerts and recommendations to individual users who may be at risk [4].Mobile users can access services, such as data or features, via geo-fencing apps whenever they are inside predefined geographic boundaries. Recent advancements in geo-fencing technologies make it possible for several service providers to serve distinct geo-fenced areas. For this concept to work, a service router is needed to direct customers' requests to their preferred service providers based on their actual locations. In this paper, we introduce a service router-based mechanism for forwarding requests based on their physical location [3] .This study compares and contrasts two approaches for identifying breaches in geofence boundaries. The first approach is called "Ray Casting," and it involves repeatedly checking each edge of the geofence to see if the target location is inside In the second method, called Triangle Weight Characterization (TWC), the geofence domain is partitioned into a finite number of triangles, and each triangle is iteratively examined to determine whether or not the target location is contained within the geofence by way of classifying objects, detecting semantic relationships, and segmenting [1].This study explores the issue of limited UAV control in geofencing scenarios. In this study, we offer a limited control technique for guiding a UAV to a target location in a way that always satisfies imposed restrictions [10].In many instances , farmers persistently dispute the boundaries of their lands. Landmarks are included but not precise GPS coordinates, which are missing from the documentation. This makes it challenging to clearly define the lines in practice. The system reads the documents and locates the landmarks on a map. The farmer then decides what they should plant depending on their knowledge, the state of the market, and other variables. Soil health cards and the 7/12 document will be used by this system to advise farmers on what crops should be planted on their land for optimal profit. From boundary marking to yield forecasting, this technology is a boon to farmers everywhere [11].To prevent agricultural damage caused by unauthorized visitors like wild animals, the author suggested installing an Internet of Things (IoT) and geofencing-based intrusion notification system. The system consists of an ultrasonic sensor, LTE network connectivity, geofencing technology, a mobile application that sends messages to farmers in real time, and a server system that stores the data. The prototype was built and tested in the lab to examine how well the hardware module and the mobile app responded to the notification in terms of response time. If this system is put into place, there will be no crop losses in agricultural fields [12].Drones in industrialized nations are used to assess the soil quality and nutritional status of farmers, thereby mitigating this issue. Drone data is used to map the damaged areas and assess the soil fertility of agricultural sectors. Applications and software on smartphones and tablets can reveal the number of nutrients and fertilizers applied to a plot of land. Geo-Fencing is a technique proposed in this study for using drone photos to determine the soil's quality and nutritional value. With the help of application software, farmers will receive reminders at preset intervals to use the results of the analytics. To grow the fruits and vegetables that are predicted to be harvested during each season, this study also enhances the land quality by fertilizing it [9].In particular, the platform's geofence protection system needs to make the right course corrections when obstacles are identified, and it also needs to choose the right landing surface in the event of an emergency [6].In the context of a location-based service (LBS), a user's entry or exit from a predetermined area (a "geofence") triggers the generation of a location event. The most important requirement for spotting location events is background monitoring, which keeps tabs on a user's whereabouts in real-time. This article gives an introduction to geofencing and background tracking and explains how they operate for location-based recommender systems after discussing the recent rise of LBSs [8]. In this research, we provide a comprehensive evaluation of Flying Ad-hoc Network (FANET) routing protocols, describing in detail the various approaches and methods used by these protocols. Finally, the mobility models and agriculture-specific needs are analyzed theoretically to determine the appropriate routing protocol for each application. [14].This study suggests an information system that makes use of geofencing technology to track users' locations and alert authorities whenever they're in danger. The system is client-server based, with the server gathering risk data from multiple sources and the client keeping tabs on the user to alert them as necessary. Using risk data stored on the server, the client sets up a geofence around the potentially hazardous location and tracks when the user enters and leaves the fence. This allows the system to send timely alerts and recommendations to individual users who may be at risk [5].

B. METHODOLOGY AND IMPLEMENTATION

It offers the specifics about the technique that was employed as well as the details about the implementation of the hands-on work that was done. This section serves as a guide that walks us through each step of the process of implementing Geofencing on a specified dataset.

Polygon mapping:

This part involves the conversion of gpx (GPS exchange format) files into shp (shape) files. This involved the use of Quantum Geographic Information System (QGIS) software. The steps included were as follows:

Load the gpx file into the workspace using the GPS data tool.

Plot the lines and polygons to fit the shape of the gpx file using the Lines and Polygon tool.

Export the obtained polygon in the shp format with its 5 supporting files

Repeat for the remaining files in the same manner.

ArcGIS Pro is the name of the most recent desktop GIS application that ESRI has released. Exploration, visualization, and analysis of data are all possible with ArcGIS Pro. The application in question makes use of remotely sensed data from EarthExplorer and Copernicus for the region of some villages in Satara. To analyze vegetation, the satellite data for May 2023 from Earth Explorer and Copernicus have been acquired. The methodology entails the gathering of information from satellite data, the determination of the best time for the selection of satellite data, the preprocessing techniques, and the selection of methods for agricultural vegetation.

These shape files were then merged into single shape files per device for Budh village in Satara district. This was done using the geoprocessing toolbox of the ArcGIS Pro software.

After merging the shapefiles, these are then opened in Google Earth Pro to edit all the polygons in such a way that every individual shape perfectly aligns with each field in that area.

The gpx files from the satellite imagery need to be converted to shape files and so preprocessing is done with the following steps:

Step 1Get the QGIS software from https://www.qgis.org/en/site/.

Step 2: Open QGIS as shown in Fig1

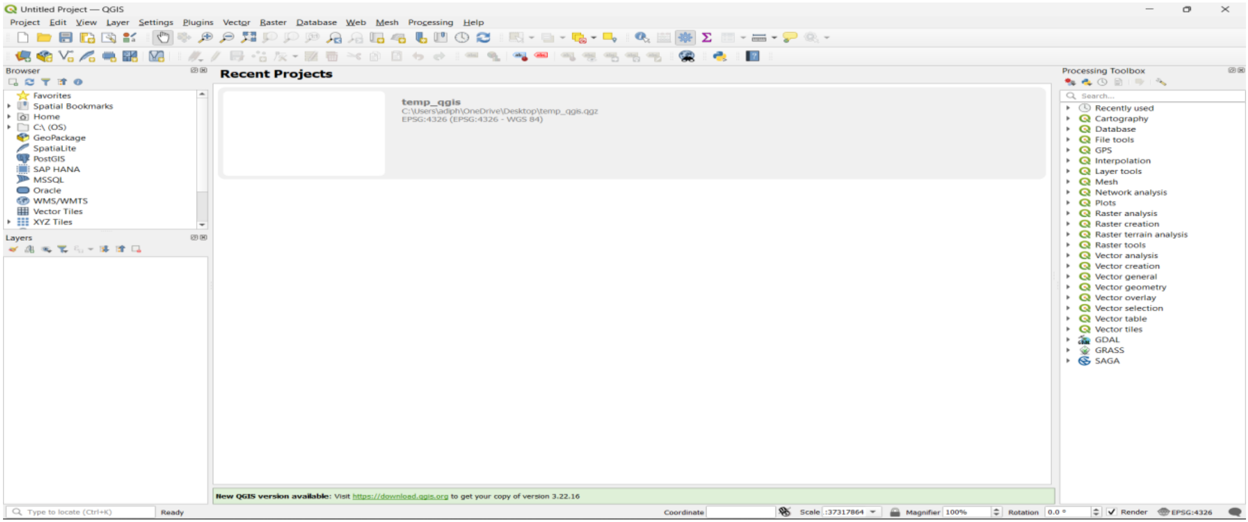

Fig.1. GPX file loaded in QGIS

Step 3: In the Processing Toolbox on the right-hand side, search for gps. A function called Convert GPS data will be displayed. Click on it.

Step 4: Select the input .gpx file by navigating to the appropriate folder .Select the file and click on Open.

Step 5: Select Format as GPX XML .Step 6: Select Feature type as Tracks

Step 7: Click on Run. After running click on Close. Some border like figure will be displayed on the screen as shown in Fig 2.

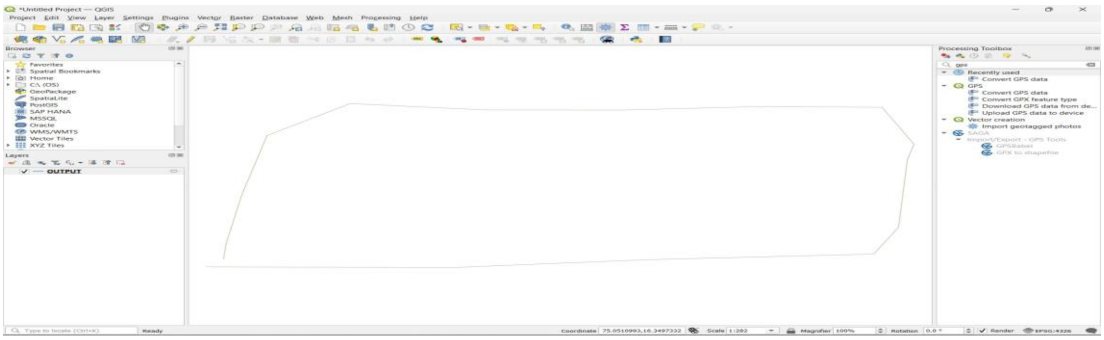

Fig.2. Converted file in QGIS

Step 8: In the Processing Toolbox on the right-hand side, search for lines. A function called Lines to polygon will be visible .Click on it.

Step 9: Click on Run. Then click on Close. The bordered figure will now be filled with a solid color as shown in Fig 3.

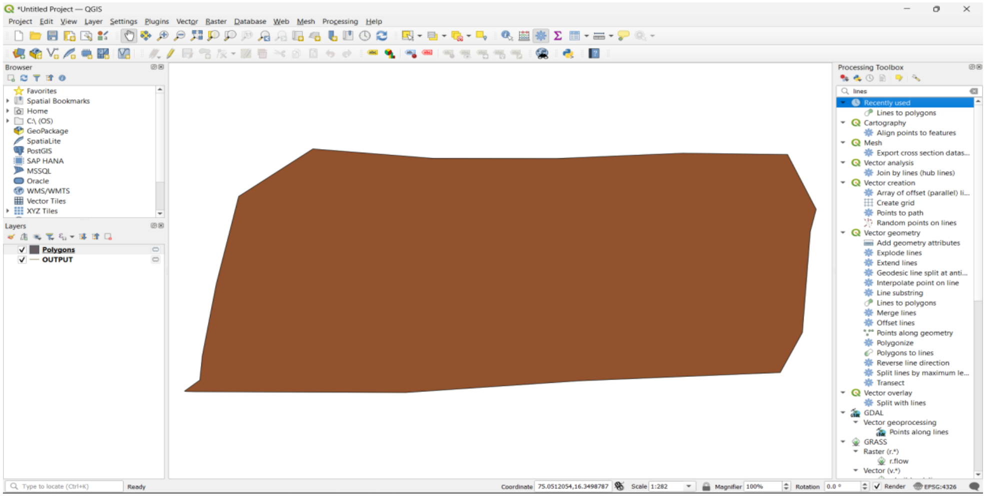

Fig. 3. Filling color in QGIS

Step 10: In the Layers panel on the bottom left, right click on the Polygons file. Then click on Export and Save Feature .Also format MUST be ESRI shapefile . Choose your desired destination folder and give a file name. Rest all options stay default. Click on OK.

Step 11: The file has been successfully converted into .shp file with 5 other support files. DO NOT DELETE THE OTHER FILES AS THEY ARE DEPENDENCIES FOR THE .SHP FILE.

Step 12: In the Layer panel, select all the layers, right click and click on Remove Layer. This will clear the canvas as shown in Fig 4.

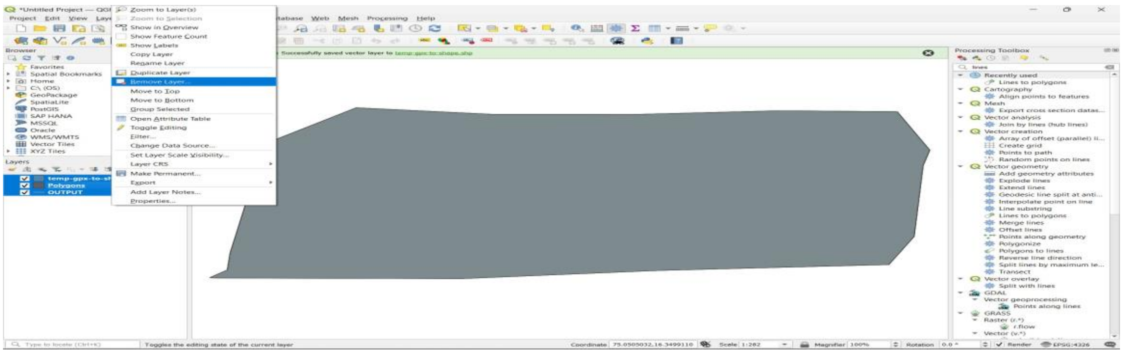

Fig.4. Clearing the canvas in QGIS

Merging multiple shape files into one using ArcGIS Pro:

Step 1: Open ArcGIS Pro. Open the Geoprocessing Toolbox. Search for merge (Data Management Tools) and open it.

Step 2: Select the input dataset. Navigate to the folder where all the shape files (with other 5 files for each shape file) are stored and select all the shape.

Step 3: Select the output dataset folder and give a name for the output file and save as shown in Fig 5.

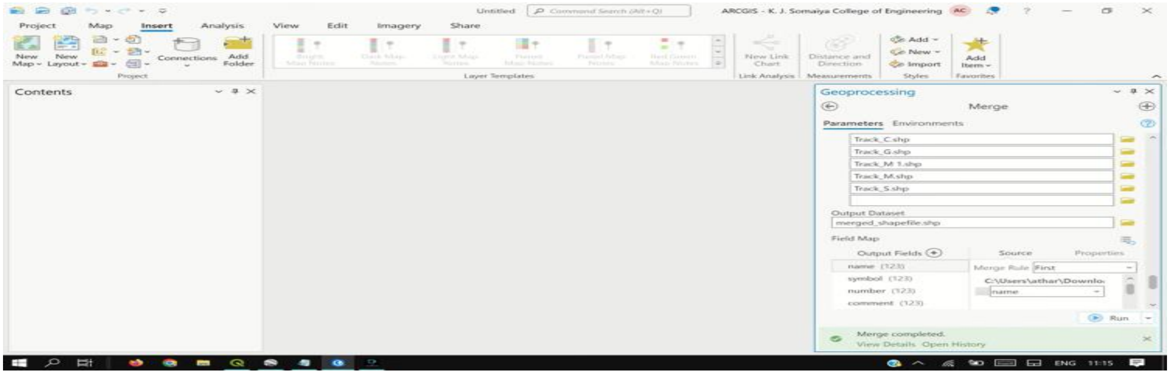

Fig.5. Save output file in ArcGIS

Step 4: Click on Run.

This will complete the Merge process The Merged shape file to .kml steps are as follows:

Step 1: Download and Install Google Earth Pro from Earth Versions – Google Earth.

Step 2: Open Google Earth Pro.

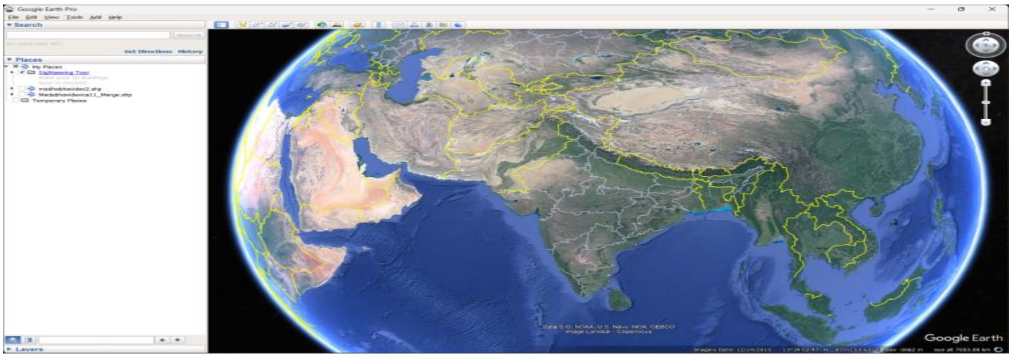

Fig.6. Google Earth Pro Image

Step 3: Click on File -> Open the area of Budh, Satara district and latitude is 17.759858 and longitude is 74.321403. Select the merged shape file and Open. File type ESRI shape(*.shp) as shown in Fig 6.

Fig.7. ESRI area in Google Earth Pro

Step 4: There will be a popup “Do you want to apply a style template to the features you ingested?” Click On ‘No’.

Step 5: Tick the box on the left side of the shapefile under temporary places.

Step 6: In the left pane, right click on the shapefile you are working on in the temporary places folder. Click on Properties

Step 7: Now zoom into one of the field outlines and will see that the outline is mostly crooked and not perfectly surrounding the field as shown in Fig 8

Fig.8. Outline of the plots to be repaired in Google Earth Pro

Step 8: We need to repair all of such outlines and make it more precise. This will involve manual editing. To edit the outlines, Right click on the shape -> Move the popup window aside. Now the connecting points that form the shape are visible. Use these connecting points to edit the shape of the field. Right click to delete a connecting point, left click to add one and press and drag to resize/move. The output should look like this as shown in Fig 9

.

Fig.9. Geofenced Output Image

Step 9: Repeat the above step for each shape individually until all the shapes are properly aligned with the fields.

Step 10: After editing all the shapes, Right click on the shape file in the temporary places folder. Click on Save Place As Select file type Kml(*.kml).Rename the file and Save. This process is repeated for all the merged shapefiles. This completes the entire process of gpx -> shp -> merging shp -> editing shp -> kml.

Testing of Geofencing:

The creation of a Geofence on a map does not necessitate the construction of any real-world infrastructure. The task is completed online. The polygon on your map should be the same size as the actual piece of land around which the geofence is centered.

The person working remotely should be able to create the geofence with the same shape, size and with the exact same area of farmer plot. After the geofencing is done then actual NDVI is calculated using the formula (NIR-R)/(NIR +R).The Python script is used for calculating the Normalized Difference Vegetation Index (NDVI) from a satellite or aerial image and then further analyzing the NDVI values to calculate average NDVI for geofenced farms.

Further Linear regression is applied using python and the predicted NDVI for further months are retrieved .The NDVI mean values over the year 2023 for geofenced plot of Satara are shown in Table 1. The linear regression does the predictions well using the dependent and independent variables. The actual and predicted values of NDVI after applying linear regression are shown in Table 2. Y=co +c1x where co is the intercept and c1 is the slope whereas x is independent variable and y is dependent variable

Table 1: Actual NDVI for sugarcane

NDVI	Month
0.320140	January
0.290269	February
0.280040	March
0.257417	April
0.242471	May
0.466981	July
0.017659	August
0.168053	September
0.409017	October
0.247569	November
0.364741	December

Table 2: Predicted NDVI for sugarcane crop

ACTUAL	PREDICTED	MONTH
0.242471	0.28678455	May

0.247569	0.28678455	November
0.280040	0.28678455	March

The actual and predicted values after linear regression shows that if geofencing is done accurately then NDVI prediction shown in Table 2 help the farmer for the harvest and monthly monitoring of satellite imagery data with vegetation indices can improve remote results on dense and sparse canopy, reducing dust and atmospheric effects on farms.

CONCLUSION

The system uses geofencing using QGIS and ArcGIS for implementing on the individual plots of the farmers so that disputes are resolved. Further it can lead to sugarcane classification and monitoring of the crops if geofencing is done prior .The farmer plots of matured and standing in field cane provided with vector file data can be used and digitized plots are combined in one shape file and use this file for NDVI prediction which can further lead to cane area classification. In order to ensure that the sugarcane cutting time corresponds with the satellite data indications, ground truth data must also be gathered. Because there is cloud cover in June and July, atmospheric correction will improve the NDVI and aid in the computation of canopy. The future work on geofencing can be automated further using Artificial intelligence for the entire district along with prediction of vegetation indices precisely.

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Data Availability Statement

All data in support of the findings of this paper are available within the manuscript.

Conflict of interest

The authors declare that they have no competing interests

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