MONITORING OF IRRIGATED AREAS IN GUJARAT STATE USING GEE CLOUD BASED ALGORITHM

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IN

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CERTIFICATE

This is to certify that the project work entitled "***MONITORING OF IRRIGATED AREAS IN GUJART STATE USING GEE CLOUD BASED ALGORITHM***" has been successfully completed by **Ms. TATA VINEELA (Roll No: 18031D3216).** During the academic year 2018-2020 as a partial fulfillment of the academic requirement of the Master's Degree in Spatial Information Technology of Center for Spatial Information and Technology (CSIT) from Institute of Science and Technology, Jawaharlal Nehru Technological University Hyderabad.

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CERTIFICATE

This is to certify that the dissertation entitled "***MONITORING OF IRRIGATED AREAS IN GUJART STATE USING GEE CLOUD BASED ALGORITHM***" has been carried out by **Ms. TATA VINEELA** in partial fulfillment for the award of M.Tech, Spatial Information Technology, is a record of work carried out by her under my guidance and supervision.

The results embedded in this report have not been submitted to any other university or institute for the award of any degree or diploma.

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I hereby declare that the dissertation entitled "***MONITORING OF IRRIGATED AREAS IN GUJART STATE USING GEE CLOUD BASED ALGORITHM*****"** is submitted by me in partial fulfillment of the requirements for the award of **Master of Technology in Spatial Information Technology** from **Jawaharlal Nehru Technological University Hyderabad,** and is a record of bonafide work carried out by me at ICRISAT as a student of **Centre for Spatial Information Technology, IST, JNTU Hyderabad** under the guidance of **Sri. B. Harish** and **Dr. Murali Krishna Gumma, Senior Scientist, Head- RS&GIS Lab, ISD, ICRISAT, Patancheru.** The results embodied in this project work have not been submitted to any other University/Institution for the award of any degree or diploma.

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ABSTRACT

The main aim of this study to identify the irrigated areas in Gujarat state using GEE using Sentinel-2 satellite imagery for crop year 2018-19. Traditionally, the classification is carried by downloading satellite images from available websites and processing of images in available software like Erdas, ArcGIS etc. The freely available high spatial resolution satellite datasets like Landsat-8, Sentinel -1 and Sentinel-2 consumes large amount of storage and also requires high end computers for processing and analyzing. In order to overcome some of the difficulties, Google Earth Engine (GEE), the most advanced cloud-based geospatial processing platform is being used. The download of satellite imagery, image processing and image classification etc. will be carried out in GEE with the help of Random Forest Algorithm. The results include LULC map, Rice crop extent map, Identification of rice crop extent The above maps will be validated using independent samples. These results help Government agencies and policy makers for quick decision making and implementation of their programme.

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CHAPTER-1

INTRODUCTION

1.1 General

Agriculture

Agriculture is of huge economic significance across the globe. Today, real-time, reliable information on crop development is essential to support the transition towards maximizing efficiency and sustainable production. Satellite imagery provides valuable insights into crop growth and development. Radar monitoring enables weather-proof analysis during high cloud cover, while optical sensors differentiate crop type, health, and maturity.

The major rural items can be comprehensively gathered into nourishments, filaments, fills and rawmaterials classesinclude cereals (grains), vegetables, fruits, oils, meat, milk, fungi and eggs. More than 33% of the world's specialists are utilized in farming, second just to the administration area, despite the fact that the quantity of rural laborers in created nations has diminished altogether throughout the long term.

Types of Agricultural Water Use

Irrigation vs. Rain-Fed Agriculture
There are two main ways that farmers and ranchers use agricultural water to cultivate crops:

- Rain-fed farming
- Irrigation

Rain-fed farming is the natural application of water to the soil through direct rainfall Teluguntla (2016). Relying on rainfall is less likely to result in contamination of food products but is open to water shortages when rainfall is reduced. On the other hand, artificial applications of water increase the risk of contamination. (Gumma, 2016)

Irrigation:

- Irrigation is the artificial application of water to the soil or agricultural field. It is the replacement or supplementation of rainwater with another source of water (Thenkabail, 2016). It is used in dry areas and during periods of inadequate rainfall.

- The main idea behind irrigation systems is to assist in the growth of agricultural crops and plants by maintaining with the minimum amount of water required, suppressing weed growth in grain fields, preventing soil consolidation etc (Whitbread, A. M. 2016).

Guide to irrigation methods helpful for Indian farmers

- India has about 140 million hectares of net cultivated area, out of which merely 45% is irrigated. Currently, 9 million hectare is under micro-irrigation, in which drip irrigated area is 4 million hectare.

- For the plant growth (Gumma, 2016) adequate supply of water is extremely important. Irrigation is the only way our farmers can continue to store and use water appropriately. Not only this, with proper irrigation facilities our farmers would be able to spend less time on the fields and more time in learning new skills, personal development, and in on agricultural forums

The primary points that need to be considered while planning for irrigation are:

1. Land suitability
2. Effective rainfall
3. Decide when to irrigate (this depends on the soil, crop, and climatic condition)
4. How much water is required by the crop
5. Select the most suitable method to irrigate
6. Quality of the irrigated water

Five highly effective methods of irrigation:

1. Sprinkler irrigation
2. Drip irrigation
3. Surface irrigation
4. Basin irrigation
5. Furrow irrigation

1. Sprinkler irrigation

- Sprinkler irrigation is similar to rainfall.
- In this type, water is pumped using a pipe system and then sprayed through sprinkler heads.
- With Sprinkler Irrigation field areas irrespective of their sizes can be covered efficiently.
- This irrigation method can be applied to all the types of soils since sprinklers with different discharge and outlet capacities are available on the market.

2. Drip irrigation

- Drip irrigation can be defined as the method in which water drips slowly via a pipe system to the roots of the plants either from above or below the soil surface.
- It is also known as micro-irrigation by which both water and soil nutrients can be saved.
- A set up of valves, tubes, pipes, and emitters is used for drip irrigation.
- The best part about drip irrigation is that valves and pumps can be operated both manually and automatically with the help of a controller.

3. Surface Irrigation

- Surface irrigation has been practiced and followed for many years now.
- It can be defined as a group of techniques where water is distributed over the surface of the soil gravity.
- In this type of irrigation, either the field is flooded (this is known as Basin Irrigation) or the water is fed into small channels (this is known as furrow irrigation).

4. Basin Irrigation

- Basin Irrigation method is primarily used for crops that stand in water for more extended periods, flat lands where rice is grown or in terraces on hillsides.
- In Basin Irrigation flat areas of land are surrounded by low bunds. These bunds block the water and prevent it from entering the adjacent fields.
- Trees can also be grown using basin irrigation method.
- Basin irrigation is suitable pastures, citrus, banana and to some extent tobacco.

- This method cannot be used for crops that cannot stand waterlogged like potatoes, beetroot and carrots
- The type of crop grown determines the soil suitable for basin irrigation
- Basin irrigation can be constructed on a flat surface, the easier it is to build basins, sloping land.
- Level basins, called terraces, can be constructed on steps of a staircase.

5. Furrow irrigation

- The application in which small channels carry water in between the crop rows and down the slope is known as Furrow irrigation.
- Furrow irrigation is preferable to row crops and the ones that cannot thrive water logging.
- Only maize, sunflower, sugarcane, and soyabean can be irrigated via furrow irrigation.
- While Tomatoes, Potatoes, Beans, Citrus and Grape would be damages if grown with Furrow Irrigation.
- In this particular method of irrigation water flows from the field channel into the furrows by opening up the bank of the channel or by siphons or spiles.
- Furrows must determine the slope, type of soil, size of the stream, irrigation depth, and field length.
- It should be done on flat or gentle slopes; if done on undulating land, furrow irrigation should follow the land contouring method.
- The farmers should be acquainted with the type of soil moisture, quality of irrigation water, frequency of irrigation for the proper implementation of irrigation systems.

Types of crops

The most important crops grown in India. It is the second-largest producer of wheat and rice. In fact, Agriculture has always been the backbone of our country's economy. Ever since the Green Revolution, we have started cultivating a variety of crops.

Crops Definition

A crop is a plant that is cultivated or grown on a large scale. In general, crops are grown so they can be commercially traded. In other words, a crop is any plant that is grown and harvested extensively for-profit purposes.

Kharif Crops

The word "Kharif" is Arabic for autumn since the season coincides with the beginning of autumn or winter. As cultivation of these crops happens in the monsoon season, another name for Kharif crop is monsoon crop. The Kharif season differs in every state of the country but is generally from June to September. We sow the crop (Gumma, 2016) at the beginning of the monsoon season around June and harvest by September or October. Rice, maize, bajra, ragi, soybean, groundnut, cotton are all Kharif crops. Let us take a detailed look at few of these,

Rabi Crops

Rice (Thenkabail, 2016) prominently grows in high rainfall areas. It requires average temperatures of 25°c and a minimum of 100 cms of rainfall. It's traditionally grown in waterlogged rice paddy fields. Northeast plains and coastal areas are the major rice-producing areas of the country.

Rice

As mentioned before, India is the second-largest producer of rice in the world after China. India accounts for approximately 20% of the world's rice production. It is arguably (Gumma, 2016) the most important agricultural crop that grows in the country. Rice is a staple food pan India, and its cultivation is also widespread across the country. Rice prominently grows in high rainfall areas. It requires average temperatures of 25°c and a minimum of 100 cms of rainfall. It's traditionally grown in waterlogged rice paddy fields. Northeast plains and coastal areas are the major rice-producing areas of the country.

Western Region

This region comprises of Gujarat, Maharashtra and Rajasthan. Rice is largely grown under rain fed condition during June-August to October - December.

There are three seasons for growing rice in India viz.- autumn, winter and summer. These three seasons are named according to the season of harvest of the crop. Autumn rice is known as pre-kharif rice. The sowing of pre-kharif rice is taken up during May to August. However, the time of sowing slightly differs from state to state according to weather condition and rainfall pattern. It is harvested in September-October.

Figure 1.1 Optical rice field photographs

The main rice growing season in the country is the 'Kharif'. It is known as winter rice as per the harvesting time. The sowing time (Thenkabail, 2016) of winter (kharif) rice is June-July and it is harvested in November-December About 84% of the country's rice crop is grown in this season and generally, medium to long duration varieties are grown in this season. Summer rice is called as Rabi rice. The sowing time of summer rice is November to February and harvesting time is March to June. The area (Gumma, 2016) under summer rice is only 9% and early maturing varieties are mostly grown in this season. The **normalized difference vegetation index** (**NDVI**) is a simple graphical indicator (Teluguntla et al. 2017; Gumma et al. 2014; Thenkabail et al. 2007b) that can be used to analyze remote sensing measurements, often from a space platform, assessing whether or not the target being observed contains live green vegetation.

Role of remote sensing in the field of agriculture:

Using remote sensing by spectral signatures, we can identify the type of crop and we can also monitor growth and yield capacity and changes in land cover of land use in agricultural land and the Irrigation and crop health monitoring (Gumma, 2016) can also be analyzed. Using pixel-based supervised random forest classification, which is a machine learning algorithm running on the GEE cloud computing platform, derived the rice rotation map In India using IRS WiFS data with 188 m spatial resolution and 5-day revisit capability, (Nguyen et al. 2012) mapped the Mekong Delta rice cropping patterns using 10-day SPOT VGT NDVI 1 km spatial resolution imagery

Advantages of remote sensing technology:

Large area coverage:

- Very Large spatial areas data extraction also possible very easily and regional level of the data can also be identified easily.
- The remote sensing technology covers the large space very easily compared to the surveying process in the area of water, agricultural fields and much more
- Remote sensing allows for straightforward collection of knowledge over a spread of scales and resolutions.
- An image captured by remote sensing is often analyzed and interpreted for use in various applications and purposes. There is no limitation on the amount of data that will be collected from a remotely detected image.
- Remotely sensed data can easily be processed and analysed fast employing a computer and therefore the data utilized for various purposes.
- Remote Sensing plays a very important role in the passive sensors with reference to electromagnetic energy reflection of any particular object. This means that passive remote sensing doesn't disturb the thing or the world of interest. Data collected through remote sensing is analysed at the laboratory which minimizes the work that needs to be done on the field.
- Remote sensing allows for map revision at little to medium scale which makes it a touch cheaper and faster.
- Colour composites are often obtained or produced from three separate band images which ensure that the details of the world are much more defined than when a single band image or aerial photograph is reproduced.

- It’s easier to locate floods or fire that has covered an outsized region which makes it easier to plan a rescue mission easily and fast.
- Remote sensing can be a constructive and relatively inexpensive way to reconstruct a base map in the absence of detailed land survey methods.

Disadvantages of remote sensing:

- Remote sensing may be a fairly expensive method of study especially when measuring or analysing smaller areas.
- Remote sensing requires special training to analyze images. It is therefore costly by the end of the day to use remote sensing technology as additional training needs to be granted to users of the technology.
- It is expensive to analyse repetitive photographs if there is need to analyse different aspects of the photography features.
- It is humans who select which sensor should be used to collecting the information, specify the resolution of the information and the calibration of the sensor, select the platform that will carry the sensor, and determine when the information will be collected. Because of this, it is easier to introduce human error during this analysis.
- Powerful active remote sensing systems like radars that emit their own electromagnetic wave are often intrusive and affect the phenomenon being investigated.
- The tools used in remote sensing can sometimes be out of calibration, which can cause out of calibrated remote sensing data. Sometimes the different phenomena analyzed may appear the same during measurement, which can lead to classification errors
- The image being analysed may sometimes be interfered by other phenomena that are not being measured and this should also be accounted for during analysis.

Remote sensing technology was generally oversold with the aim that it seems that it is a panacea that can provide all the solution and knowledge for the realization of physical, biological or research projects. The knowledge provided by remote sensing data may not be complete and should be temporary.

Sometimes large scale engineering maps can't be prepared from satellite data which makes remote sensing data collection incomplete.

1.2 Google Earth Engine

The Google Earth Engine platform may be a3 cloud computing platform for geographical data Analysis. It gives access to a full complete catalog of remote sensing products alongside the potential to process these products quickly online through massive parallelization. The GEE data catalog includes data from Land sat 4, 5, 7 and eight processed by the us Geological Survey(USGS), several MODIS products, including global composites, recently imagery from

Sentinel 1, 2 and three satellites, and lots of more. The processing, Georeferencing are prepared for the direct use, user data in raster or vector formats are often uploaded (ingested using GEE terminology) and processed within the GEE. We took advantage of this feature for doing image classification u used as ground truth in our experiments.

In this work, all required sentinel2 images were retrieved from the (COPERNICUS/S2_SR) Image Collection available within the GEE. In Google Earth Engine(GEE)the availability of the Cloud Computing Platform , which helps in the easy process of the huge volume of Multi temporal satellite data of very high spatial resolution data for example such as Landsat and Sentinel sensors (Gorelick et al., 2017). These images contains top of atmosphere (TOA) reflectance (calibration coefficients are included in metadata). These products also include two additional bands: the standard assessment band (BQA) and therefore the FMask cloud mask. We use the cloud flag included within the BQA nominal product to assess if previous images over each test site location are cloud free or not, which allows us to simply and automatically retrieve cloud-free images from the whole archive. To overcome to errors of the cloud free images we use advanced cloud identification and composting algorithms which were associated with clouds and cloud shadows (Xiong et al., 2017b).Additionally download of satellite imagery; image processing and image classification are going to be done using Sentinel-2 satellite imagery for crop year 2018-19. With the assistance of Random Forest Algorithm.

The GEE computation engine offers both JavaScript and Python application programming interfaces (API), which permit to simply develop algorithms that employment in parallel on the Google data computer facilities. The programming model is object oriented and supported the Map Reduce paradigm. The GEE engine is also accessioned from web-based integrated development environment (IDE) using the JavaScript API. The web-based IDE allows the user to see images, results, tables and charts which will be easily exported. On the opposite hand, the Python.

However, we chose the JavaScript API to develop our image classifications because it's easier to integrate with long running tasks, which are essential to run the complete validation study in an automatic manner.

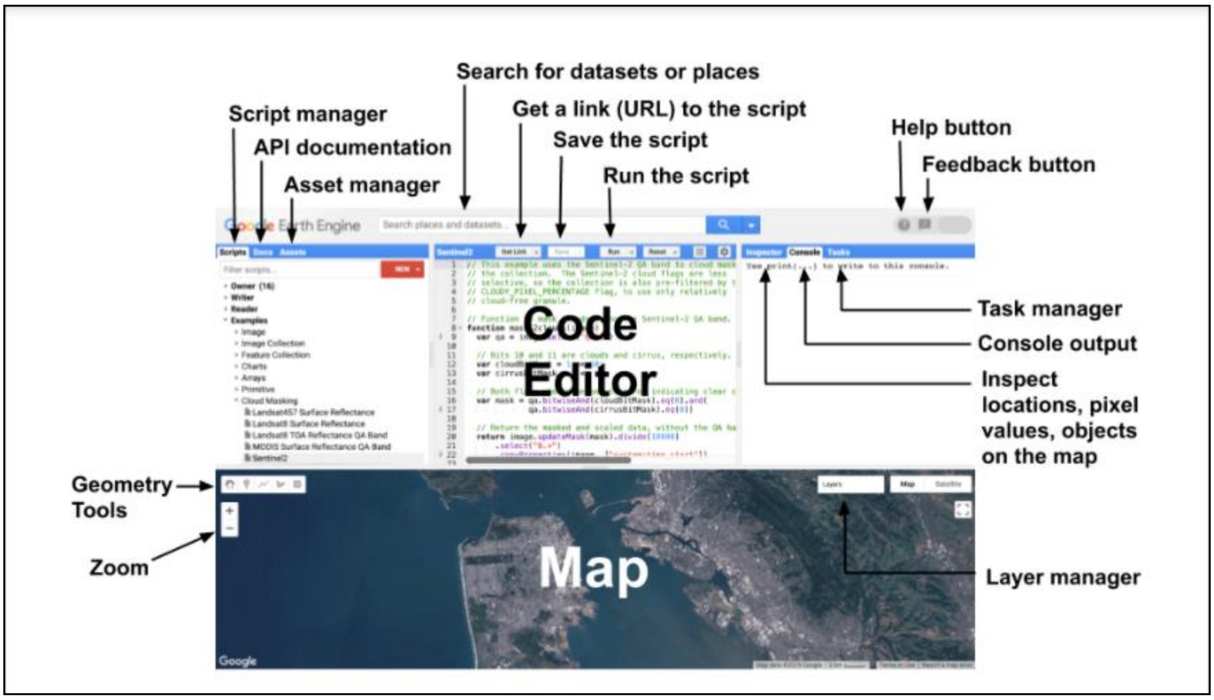

Figure 1.2 Diagram of components of the Earth Engine Code (sources :- https://code.earthengine.google.com/d84a378043dc3df53666b285d2b53bb8**)**

Google Earth Engine Interface

- **JavaScript code editor**

  In code editor where we write our codes using java scripts API

- **Git-based Script Manager (Scripts tab)**

  In the left side you have scripts tab, where you save scripts/codes

- **API reference documentation (Docs tab)**

  In the left side you have doc tab, doc tab also known as API tab. It has complete JavaScript API documentation.

- **Asset Manager (Assets tab)**

  In the left we have assets tab, assets tab is used to upload and manage your own images and shape files in earth engine.

- **Inspector tab**

  In the right side of code editor we have inspector tab it gives details of the map.

- **Console tab**

  In the right side of code editor we have console tab it display the results of code editor.

- **Tasks tab**

  In the right of the code editor we have task tab. it shows the processing of our uploads, allows to download data (images).

- **Search for datasets**

  Above the code editor panel we have search option. Where you can search for GEE datasets.

- **Get link**

  Get link option gives link for code, it also can be shared with others.

- **Save script**

  After creating and editing the scripts we can save by clicking the save script option.

- **Run script**

  Run option allows you to run your scripts to get the output.

- **reset**

  Reset option will clear our scripts like map, console and inspector tabs.

- **Map visualize**

  Below code editor we have map visualize. We can see the results of what we have done in code editor part like classifications. It also has tools like layer manager, geometry tools, and zoom tools.

- **Geometry tools**

  The geometry tools have stop drawing, draw a line, add a marker, draw a polygon (shape), and draw a rectangle. Where we can digitize the required part with required tools.

- **Zoom**

  We can increase or decrease the map visualize.

- **Layer manger**

It shows the class-cart and layers weather it loading are not. It also have map and satellite image options. We can choose According to your option.

Google earth engine Applications:-

• **Agriculture**: -	Crop modeling
	Crop mapping
• **Urban planning**: -	4D urban modeling
	Urban expansion
• **Land cover**: -	Automatic land cover mapping
	Detection of general land cover changes
• **Atmosphere and climate**: -	Climate change
	Carbon cycle,
• **Pedosphere**: -	soil mapping
	Mining surface
• **Image processing**: -	data preparation
	Cloud masking
	Data enhancement
• **Natural disaster**: -	disaster monitoring
	Forest fire
• **Hydrology**: -	glacier studies
	Surface water dynamics
• **Vegetation**: -	vegetation dynamics monitoring

Advantages and limitations in Google earth engine:-

GEE is a valuable tool for analyzing geospatial data that provides researchers with many capabilities. , especially for the RScommunity. However, there are also several limitations that users should be aware of. The key advantages and limitations of GEE are discussed in Table. The advantages and disadvantages of GEE are within the four categories of cloud infrastructure, API, data, and functions.

	Advantages	Limitations
Cloud Infrastructure	• Optimized for spatial data analysis • Data is available online to all users • Shareable codes and scripts • No need for Third-party software installation • Uses image pyramids and tiles to improve processes. • Quickly filter and sort data for research, education, and charitable purposes	• Training machine/deep learning algorithm is limited to only 100MBof data. More feature mean fewer pixels • Writing code requires knowledge in server-side • Translating all techniques to understandable server-side functions is not always easy • Debugging is relatively challenging
API	• Web interface • Uses JavaScript and python • Online IDE to run and debug codes • Similar to existing open access components • Easy access from Google colab Jupiter notebook	• JavaScript and Python code are executed on the client side. • Client-side functions are carried out in the user browser.
Data	• large catalog of data sets • Capability of uploading data by users • Automatically handles data projection • Most of the data has already been pre-processed and corrected • Several derivative products are already available	• Limited to 250GBs of users data upload • Downloading data depends on users internet quality and data volume Data is mainly not private
Functions	• Large set of callable functions, • Expanding the library of methods and packages • Parallel-in-nature algorithms • Contains machine learining,image processing ,vector processing, geometrical analysis, visualization algorithms • Availability of tutorials and documentations for algorithms	• Only hosts some selected data mining models • Image analysis is restricted to existing tools • Developing new tools is not easy • There are not enough atmospheric correction algorithms

Table 1.2 Advantages and limitations in Google Earth Engine

1.4 Objectives of the study:

The project mapped the Irrigated Cropland and Rain fed Croplands in the Gujarat. These are the below objectives are performed using Google earth engine (GEE) for getting the final outcomes.

- Mapping LULC of Gujarat state
- Mapping Kharif and Rabi Croplands
- Identification of rice crop

CHAPTER 2

LITERATURE REVIEW

Gumma,M.K(2011) mapped rice area for six South Asian countries using Modis time series data for the period 2000 to 2001.In Gujarat there has been an uncontrolled rate of population increase and as a result there is demand for rice but unfortunately rice production is less. It needs to be grown more Therefore, an accurate and timely assessment of where and how rice is grown is important for developing food security and poverty reduction strategies. Satellite data with a spatial resolution of 500 m and a temporal resolution of 8 days from the MODIS sensor for mapping the rice and identifying the characteristics such as the intensity growth of the culture and the growth of the moth culture for a certain period of time. In this article, they took for the years 2000 and 2001 using spectral signature matching methods, they derived the decision tresses that are good and unhealthy and for the identification and classification of rice over a large spatial surface they used temporal profiles of the rapid identification and classification. . There the correlation between national statistics and maps for the very large area was defamed

Gumma,M.K(2014) This article explains the approach towards precision and separation for the quantification of crops in the area of the Krishna river basin. Using the IRS-P6 satellite data and MODIS satellite data with a spatial resolution varing from 23.6m and 250m for the year of 2005. The temporal variations of the NDVI (Normalized Difference Vegetation Index) model obtained in the crop dominance classes allow a demarcation between long-term crops and short-term crops.When compared to the short-term crops in long-term policemen, the value of NDVI is more consistent .This is due to the water supply that is provided, the surface water resources that were available and other factors are the water supply of the canals.Due to these factors there will be an growth ina less time which directly shows the effect n the NDVI reflectance pattern. Through the collected soil data with reference to the state-level census data using these two data as a reference, an identification of the plant classes was carried out, which was done in parallel in both the test and verification processes. From these output results we can conclude that technological methods are close to creating data sets using algorithms for the study area and the idea of a precise mapping of paddy rice for a very large area and also extracting the statistical figures for the entire area study. This study found that the combination of the IRS-P6 23.6 m and the MODIS 250 m was really very useful for the identification of the crop, and the source of irrigation water as well as the water resources of the crop. surface for irrigation and also the mode of applicationThe study concluded that there should be taxes in both areas irrigated with surface and ground water and proof of basic information for the proper use of water resources in the basin scale area.

Pardhasaradhi Teluguntla (2016) they found the standard crop land production for a long period of the time for each individual year.

They used two Novel Methods:

i.) Quantitative spectral coincidence techniques (QSMT) applied at the continental level.

ii.) (ii) A rule-based automated farmland classification algorithm (ACCA).

This way they can get past and present data and also estimate future predictions. Australia was chosen for the study because of its extensive farmland, rich agricultural history, and yet non-extensive annually generated routine agriculture and yet non-existent routine annually generated farmland products using multi-temporal remote sensing. Explained produced three separate cropland products using MODIS 250m NDVI for a 16-day time series for a 16-year period: 2000 to 2015. These are list of products which are present, I.) Crop land extent/ it are area versus and crop fallow land. ii.) Data on irrigated versus rain fed crops iii.) Intensity of single, double and continuous crops .We need to train the exact database on the field knowledge for the development of the ACCA algorithms that were later applied to the MODIS satellite data for the years 2000 to 2015.

Gumma M.K (2016) usedMODIS 250 m times series data identified the Rain fed and irrigated rice fellow cropland areas across South Asia. In which, the agricultural system can be intensified by including a short-season crop during the fallow period. 250 m NDVI with 16-day time series for one year from June 2010 to May 2011 of imaging data with moderate resolution radiometry using spectral matching (SMT) techniques and extensive knowledge of the field. The accuracy of the maps was assessed on the basis of the independent fundamental truth data and compared with available statistics at the sub-national level.

Gumma, M.K (2018) worked on Land sat has 8 bands (blue, green, red, NIR, SWIR1, SWIR2, TIR1 and NDVI) and 16-day OLI (Operational Land Imager) data for the years 2013–2015. Using pixel-based supervised random forest classification, which is a machine learning algorithm running on the GEE cloud computing platform, each band was temporally composed for the 4-6 time periods per year, with the median for different Agro ecological Zones was used for the nations of Australia and China. It resulted in a 32-48 layer mega cube of data for each of the AES. Validation and baseline training data were collected from (a) field visits, (b) very high spatial resolution imaging (VHRI) data of sub mi meter at 5 m, and (c) auxiliary sources such as those of the National Offices of Agriculture The knowledge base of cropland versus non-agricultural land for RF algorithm training was derived from MFDC using 958 reference training samples for Australia and 2,130 reference training samples for China. Product accuracy was assessed using independent validation samples from 900p our Australia and for china it was1972. The Australian product of the cultivated land area of 30 m showed an overall accuracy of 97.6% with a producer's accuracy of 98.8% (errors or omissions=1.2%), and user's accuracy of 79 %(errors of commissions=21%) for the cropland class. For China, overall accuracies were 94% with a producer's accuracy of 80 %(errors or omissions=20%), and user's accuracy of 84.2% (errors of commissions=15.8%) for cropland class. Total cropland areas of Australia were estimated as 35.1 million hectares and 165.2 million hectares for China.

Yaotong Cai (2019) Mainly used Object based Random forest method for Paddy rice Mapping. Used sentinel 1 and 2 data. RASTFM is the Robust Adaptive Spatial Temporal Fusion Model it will not blend to the MODIS and Sentinel-2 data for obtaining the MSS Multi temporal sentinel 2 data Subsequently, Then, the Savitzky-Golay (S-G) filter was applied to smooth the NDVI data from the Sentinel-2 time series. The phenological parameters were derived from the NDVI-filtered tie series using the threshold method. On the Ideas of the Sentinel 2 MSI Satellite image paddy mapping was done by the optimized featured. In series Sentinel-2 NDVI, phonology data and time series Sentinel-1 SAR backscattering images by using the distance. By the optimum feature combination Random forest classification that was object-based and used to extract the paddy rice. When compare with the Original Sentinel 2 satellite image RASTFM has high correction compared to the fused Sentinel-2 NDVI data

CHAPTER 3

STUDY AREA

3.1 Study Area

Gujarat state is considered for case study located between 20º 0’0’’ to 24º 40’00’’ N Latitude and 68º 40’0’’ to 74º 40’00’’ E Longitude (Fig.1). In the region, the temperatures average between 12ºC to 27ºC during winters while in summers, temperature averages between 25ºC to 43ºC though sometimes it reaches as high as 48ºC. The annual rainfall ranges from 682 mm to 1006 mm within the study area. The area's soil is sandy loamy and shallow to medium clay soil of black cotton clay, deep in places Gujarat is that the main producer of tobacco, cotton, and groundnuts in India .Some of the main crops are jowar, bajra, maize, tur rice, gram, and wheat are other main crops produced. Gujarat has an agricultural economy the entire crop area amounts to quite one-half of the entire acreage.

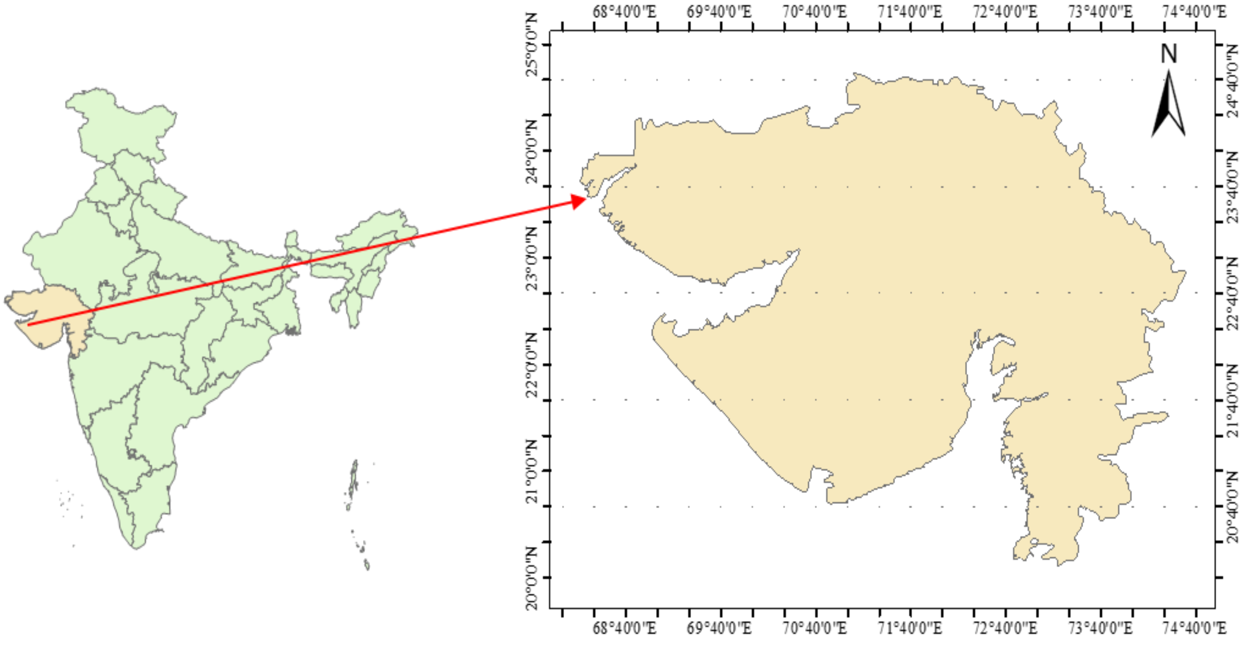

Figure 3.1: Geographical location of Study area

CHAPTER 4

DATABASE AND METHODOLOGY

4.1 General

This chapter deals with satellite data, terrestrial data, software used and methodology carried out for this project.

4.2 Data Used:

- SENTINEL 2(sentinel-2 Multi spectral optical imagery LEVEL-2A)
- Vector Data (India Shape file)
- Ground Data

4.2.1 SENTINEL–2 Data:-

- Sentinel-2 times series from Copernicus Earth Observation program offer a superb potential for fine scale land cover mapping to high spatial and temporal resolutions, with a diametric resolution and five-day repeat time. However, the choice of best available scenes, their download alongside the wants in terms of storage and computing re- sources pose restrictions for large-scale land cover mapping.
- The dataset presented during this paper corresponds to global cloud-free pixel based composite created from the Sentinel-2 data archive (Level L1C) available in Google Earth Engine for the quantity January 2017- December 2018. The methodology used to generate masking clouds, filter a collection of images is described and then metadata related to the ten m resolution dataset are presented.
- it provides free access to Sentinel-2 archives and large-scale analysis capabilities for scientific applications. The dataset presented in this thesis exploits these benefits offered by the GEE platform that enabled the development of a cloud-free pixel based composite created from the Sentinel-2 data archive (Level L1C) available during this platform for the amount January 2017- December 2018
- Sentinel-2 has 13 bands, but only 4 bands are used for classification for NDVI and other land use land cover classifications. They are Red, Green, and Blue and Near Infra-red Bands.
- The Sentinel-2 mission of the European Earth observation program Copernicus became operational in October 2017, providing time series of images with a free,

complete and open access policy with the following characteristics:: 13 spectral bands from 0.44–2.2 μm, high spatial resolution images (between 10 m and 60 m counting on the spectral bands), steady and frequent observations. Observation of the Earth's land surfaces is the properties of the 2A and -2B satellites.

- With a 5-day repeat cycle. They daily generate about 1.6 TB of compressed raw image data. With such characteristics, Sentinel-2 has made acquisitions above every Earth pixel at least every five days since its entry into service in 2017.

4.2.2 The Sentinel-2 mission has the following key characteristics:

- Multi-spectral data with 13 bands within the visible, near infrared, and radio wave infrared a part of the spectrum
- Systematic global coverage of land surfaces from 56° S to 84° N, coastal waters, and every one of the Mediterranean
- Revisit every 10 days Under equivalent viewing angles at high latitudes, the Sentinel-2 interferes with a few areas that will be noticed two or more times every 10 days, albeit with different viewing angles.
- 290 km field of view
- Free and open data policy
- The satellites are phased 180 degrees from one another on an equivalent orbit.
- This allows what would be a 10 day review cycle to be completed in 5 days
- VNIR and SWIR bands having 290km they have 12 detectors that are lined in two offset rows. Swath.
- This civil time was selected as a compromise between minimizing cloudiness and ensuring suitable Sun illumination.
- On It is at the edge of the Land, civil time and corresponds to SPOT, allowing the mixing of Sentinel-2 data with historical images to create long-term statistics.

4.2.3 Spectral Bands and Resolution

Sentinel -2 10m satellite data is used. Sentinel-2 carries the Multispectral Imager (MSI).
It has 13 ranges with spatial resolution from 10 to 60m. The bands of 10m are blue (B2), green (B3), red (B4) and near infrared (B8), and the 20m bands are edge infrared (B5), near

infrared (B6, B7 and B8A) and SWIR. Shortwave infrared (B11 and B12). Bands of 60 M are used for coastal aerosol project and the respective bands are (B1) and cirrus band (B10).

Sentinel-2 Bands	**central wavelength(um)**	**Resolution**
Band1-coastal aerosol	0.443	60
Band2-blue	0.49	10
Band3-green	0.56	10
Band4-red	0.665	10
Band5-Vegetation Red Edge	0.705	20
Band6-Vegetation Red Edge	0.74	20
Band7-Vegetation Red Edge	0.783	20
Band8-NIR	0.842	10
Band8A-Vegetation Red Edge	0.865	20
Band 9- Water vapour	0.945	60
Band10-SWIR-cirrus	1.375	60
Band11-SWIR	1.61	20
Band12-SWIR	2.19	20

Table 4.2.3 Spectral Bands and Resolution

4.2.4 Specifications of Sentinel-2are:

- Orbit: 786km, 14.3revolutionper day node is 10:30(am), sun synchronous, and Orbit inclination: 98.62
- Swath Dimensions:-290km

- Temporal resolution for one satellite is 10 days and for 2 satellites is 5 days.
- Weight: 1200kg (1140) at lunch
- Spatial Resolution: 10m, 20m and 60m
- Design Life: 7.25 years with propellant for 12 years of operations

4.2.5 Vector Data (India Shape file):

Vector data used for classification and preprocessing are Indian States shape files From the India shape file I extracted the study area. (Source: - WWW.DIVA.GIS.ORG)

4.2.6 Ground Data:

Field data was collected by ICRISAT-RS / GIS TEAM from 1000 sampling sites. The information samples from the field survey were based on knowledge of local experts, different types of LULC and preliminary land use classifications. The following information was recorded for each location

- Existing crop type
- Soil type
- GPS Coordinates
- Crop calendar
- Crop density (single, double and triple crops)
- Crop pattern (previous / current including season)
- Irrigation techniques / irrigation methods

These land points are also used for class determination, validation and accuracy assessment.

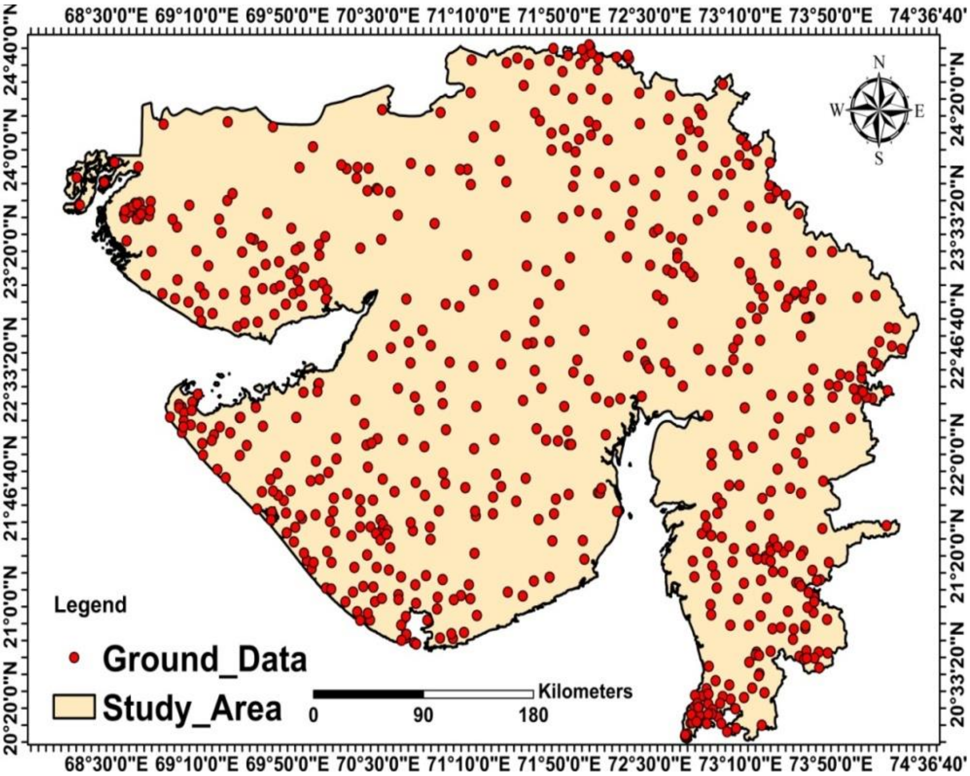

Figure 4.2.6 Field plot data point distributions in the study area.

4.3 Methodology:

4.3.1 Methodology for cropland mapping

The aim of this study was to produce an accurate farmland range product derived from Sentinel-2 (10m) of Gujarat. Random Forest Classification which was a moderated pixel-based classification used in the GEE cloud computing platform to develop Crop Land Range product for Gujarat using Sentinel-2 time series data (10m) for 15 days for the 2018-2019 time period. An overview of the methodology is shown in Fig.4.3.1

In this project I used how to generate random forest classifier in the google earth engine. (Gumma et al., (2019)) And i also used integrating pixel-based &object based algorithms using sentinel-2(.(Gumma et al., (2017))which is useful to find irrigated areas to do cropland classifications.

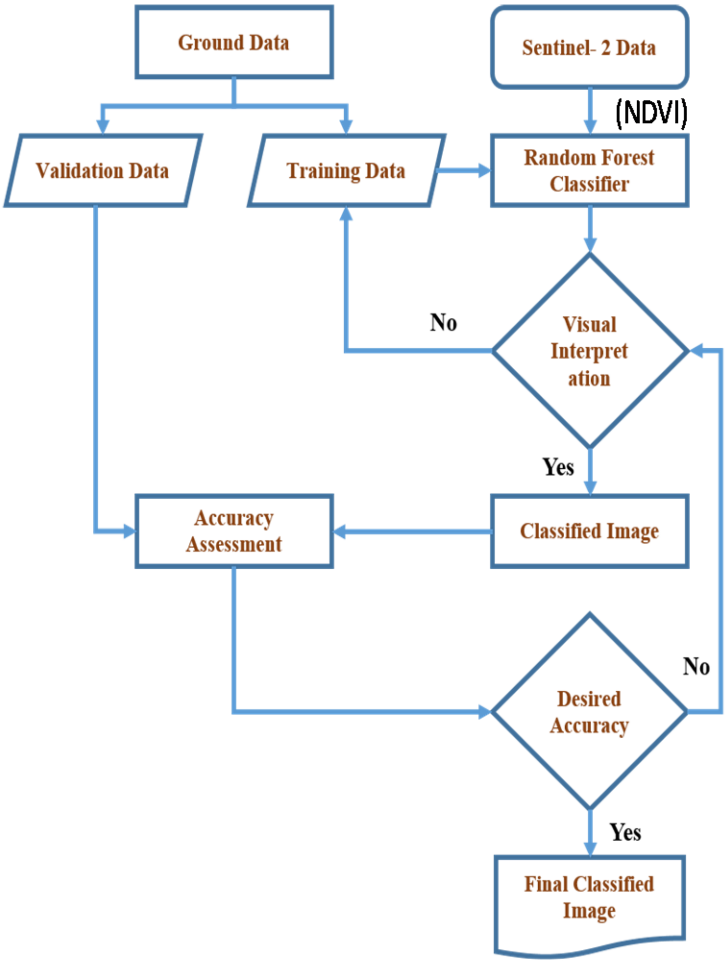

Figure 4.3.1 Flow chart showing methodology

Overview of methodology for the cropland mapping. This study used a pixel-based random forest supervised machine learning algorithm for classification Analysis executed on Google Earth Engine cloud-computing platform.

Application of Random Forest machine learning algorithm on cloud computing platform. These methods consist of pixel-based, object-based, or a combination of both approaches that used either supervised or unsupervised classification techniques. Pixel-based approaches include: a) Random forest algorithm (Tatsumi et al., 2015, Wang et al., 2015, Gislason et al., 2006) (Gumma et al., (2018)).

Here comes flow chart methodology in Google earth engine. [GEE]

- The process starts with taking sentinel- 2Datawith 10m resolution satellite data. It has total 13 bands [b4-red], [b8-nearinfrared]. We generate the NDVI
- Image by applying formula by using two bandsb4, b8.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

- Using NDVI image we will run random forest classification.
- On performing NDVI we download sentinel-2 data.

Training data

Training data is the data which is train by classifier

- Taking training data which we obtain from survey [ground data] by that it creates training samples.
- About 390 points are used for training purpose

Validation data

The independent ground data was collected for validation i.e. about 403 points

The process of assessing the uncertainty of higher levels, the satellite sensors derive products through analytical comparison with reference data. What is the assumption that the truth value of an attribute is the validation?

Both take values at the same time and then classify in the random forest classifier

Random forest classifier

Supervised learning algorithm that randomly creates and merges multiple decision trees in to one forest as a group is Random Forest

- Here random forest classifier is that in such way that by taking the sentinel-2 data (NDVI) and training data pixels values near to NDVI data will from us one tree and form as groups.

Visual image interpretation

Visual interpretation of an Image is a first analysis approach to the Remote Sensing Imagery. Here in this work size shape position of objects as well as the contrast and color saturation is analyzed.

- It checks the wrong data in Google earth engine. if it is wrong it goes to training data and new point.[and process going on]

Accuracy assessment

- Evaluating accuracy assessment is a crucial part of any grading project. It compares the classified image to another data source that is considered to be accurate or ground truth data.
- Accuracy assessment checks the accuracy and processing data for both classified image from NDVI and validation data
- Accuracy assessment done using error matrix method. We compared both classified image and ground data to form matrix.
- Example: - if I give point as crop but in classified image it shows some built up it means wrong pixel. But it shows crop means correct.

Desired accuracy

- Desired accuracy means is how close you are to the true value.
- In desired accuracy assessment correct means it goes to final classified image .if not again it goes to visual interpretation and recheck if any missing.

Final classified image

In final classified image, we get Kharif crop and Rabi crop.

- Kharif [June to November] it depends on rain fed.
- Rabi [December to march] it depend on irrigated.
- Rain fed crops lands were identified by subtracting Rabi crops from Kharif crop lands.

4.3.2 Coding Approaching in Google Earth Engine

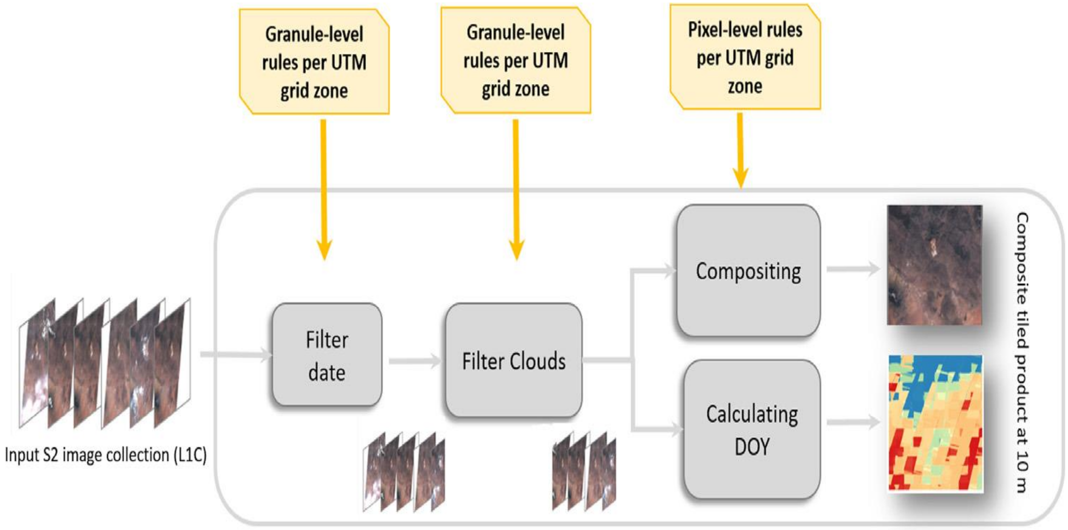

Figure 4.3.2 approaching coding in Google earth engine

- Input to the compositing process are top of atmosphere Sentinel-2 image tiles, from the so-called Level 1C (L1C) product available within the GEE as a picture satellite collection from 23/06/2015 until present. Each Sentinel-2 product may contain multiple granules. The Sentinel- 2 data contain 13 uint16 spectral bands representing TOA reflectance scaled by 10 0 0 0. Additionally, three QA bands are present where one (QA60) may be a bitmask band with cloud mask information. To convert to floating point, the values should be divided by 10 0.

Image Collections:

- A stack or statistics of images are called Image Collections. Each data source available on GEE has its own Image Collection and ID (for example, the COPERNICUS/S2_SR collection. you'll also create image collections from individual images or merge existing collections
- To generate images that cover large spatial areas and to fill in image gaps due to clouds, etc, we can load a full Image Collection but filter the collection to return only the time periods or spatial locations that are of interest. There are shortcut filters for those commonly used (imageCollection.filterDate (), imageCollection.filterBounds ()…), but most filter in the ee.Filter () section of the Docs tab can be used.

Filter an Image Collection:-

Here, we are selecting all imagery in Sentinel-2 MSI: Multispectral Instrument, Level-1C acquired over our classification anytime.

- The identifiers of the image collections are found in the "search" toolbar at the top of the code editor or by searching for the file. Data archive

- The second step, is to pick the smallest amount cloudy Sentinel-2 granules by filtering the image collection acquired within the predefined time-frame on the idea of the share of cloud coverage

Masking clouds:-

- We explicitly define a new function called "mask Clouds" and apply it to each image in the image Collection by using imageCollection.map (). Functions need to explicitly return the final output

Load all sentinel 2 images within polygon boundary

```
Var S2 = ee.ImageCollection ('COPERNICUS/S2')

.filter Bounds (table4)

//.filter (ee.Filter.lt ('CLOUDY_PIXEL_PERCENTAGE', 30));

Var Jun = S2.filterDate ('2019-06-01', '2019-06-15')//.map (maskS2clouds)

Var jun2 = S2.filterDate ('2019-06-15', '2019-07-01')//.map (maskS2clouds);

Var Jul = S2.filterDate ('2019-07-01', '2019-08-15')//.map (maskS2clouds);

Var jul2 = S2.filterDate ('2019-07-15', '2019-08-01')//.map (maskS2clouds);

Var Aug = S2.filterDate ('2019-08-01', '2019-08-15')//.map (maskS2clouds);

Var aug2 = S2.filterDate ('2019-08-15', '2019-09-01')//.map (maskS2clouds);

Var Sep = S2.filterDate ('2019-09-01', '2019-09-15')//.map (maskS2clouds);

Var sep2 = S2.filterDate ('2019-09-15', '2019-10-01')//.map (maskS2clouds);

Var Oct = S2.filterDate ('2019-10-01', '2019-10-15')//.map (maskS2clouds);

Var oct2 = S2.filterDate ('2019-10-15', '2019-10-24')//.map (maskS2clouds);
```

Map.addLayer (table4);

Filter Bounds (geometry):-

Pass elements of the input collection that have geometry that intersects the geometry you are clipping with. If the images in the collection (eg MODIS images), the Bounds () filter will do nothing. Geometry or feature to be clipped**.**

- Returns: Image

CLOUDY_PIXEL_PERCENTAGE:-

- To filter out images with a lot of clouds. Sentinel-2 has the metadata CLOUD_PIXEL_PERCENTAGE, and filter for images less than a certain cloud pixel percentage (say 10-30%)

ee.Filter. Date:-

- Filter images by date by choosing starting to end date.

Map.addLayer:-

- The collections, features, images can be add to the map as a layer

Printing our filtered collection to console tells us how many images are in our filter (665) as well as the band names and properties for the images in our collection

Figure 4.3.2 Printing and filtered collection in gee

Calculating NDVI:-

- Here, we'll use the imageCollection.compositedimage () function by prioritizing the image to use supported one specific band, this method ensures that the values across all bands are taken from an equivalent image. Each pixel is assigned values from the image with the best value of the specified band.
- For our image classification supported the NDVI band we just calculated. The ultimate composite image will retain all bands within the input (unless we were to specify otherwise). Generally, this provides the simplest available snapshot of the landscape.

```
Var junndvi= jun.map (ndvi).max ()
Print (junndvi)
// Map.addLayer (junndvi, {min:-0.5, max: 1},'junndvi');
Var junndvi2= jun2.map (ndvi).max ()
Print (junndvi2)
// Map.addLayer (junndvi2, {min:-0.5, max: 1},'junndvi2');
Var julndvi= jul.map (ndvi).max ()
Print (julndvi)
```

```
// Map.addLayer (julndvi, {min:-0.5, max: 1},'julndvi');

Var julndvi2= jul2.map (ndvi).max ()

Print (julndvi2)

// Map.addLayer (julndvi2, {min:-0.5, max: 1},'julndvi2');

Var augndvi= aug.map (ndvi).max ()

Print (augndvi)

Map.addLayer (augndvi, {min:-0.5, max: 1},'augndvi');

Var augndvi2= aug2.map (ndvi).max ()

Print (augndvi2)

// Map.addLayer (augndvi2, {min:-0.5, max: 1},'augndvi2');

Var sepndvi= sep.map (ndvi).max ()

Print (sepndvi)

// Map.addLayer (sepndvi, {min:-0.5, max: 1},'sepndvi');

Var sepndvi2= sep2.map (ndvi).max ()

Print (sepndvi2)

// Map.addLayer (sepndvi2, {min:-0.5, max: 1},'sepndvi2');

  Var octndvi= oct.map (ndvi).max ()

Print (octndvi)

// Map.addLayer (octndvi, {min:-0.5, max: 1},'octndvi');

Var octndvi2= oct2.map (ndvi).max ()

Print (octndvi2)

// Map.addLayer (octndvi2,{min:-0.5,max:1},'octndvi2');

Var ndvi = function (image) {

 Return image.normalizedDifference (['B8','B4']);

};
```

Var Composited Image = junndvi.addBands (junndvi2).add Bands (julndvi).add Bands (augndvi).add Bands (augndvi2).add Bands (sepndvi).add Bands (sepndvi2).add Bands (octndvi).add Bands (octndvi2)

Var CompositedImage1 = CompositedImage.clip (table4)

// Map.addLayer (CompositedImage1,{},'stack1')

Print (CompositedImage1);

Build classifier:

EE.CLASSIFIER.CART:-

- A classification and regression tree (CART), may be a predictive model, which explains how an outcome variable's values are often predicted supported other values. A CART output may be a decision tree where each fork may be a split during a variable and every end node contains a prediction for the result variable.

Classifier:-

- It classifies a picture.

Varclassifier cart = ee.Classifier.cart ().train (training, 'CODE');

// print (classifier);

//Import vector data from Asset manager

//classify the whole landscape

Varclassified_c_w = dataset. Classify (classifier cart);Map.addLayer(classified_c_w,{min:1, max:6, palette:['green','red','yellow','blue','black','pink']},"class_cart")

Exporting Images:-

- In the JavaScript API, all exports are sent to the ‘Tasks’ tab within the upper right panel. to stop users from inadvertently overwhelming the system with gratuitous, accidental tasks, you would like to explicitly run individual exports from the ‘Tasks’ tab. you'll change filenames and other parameters here if necessary or hard code these into your script.

- When exporting to Google Drive, GEE will find the named folder specified and doesn't need the complete file path. If this folder doesn't yet exist, it'll create it for you in your Drive

```
Export.image.toDrive ({
 Image: CompositedImage1,
 Description:'mncfc_districts_15days_ndvi_max1',
 FileNamePrefix:'gujarat01_15days_ndvimax1',
 Scale: 30,
 MaxPixels: 37100133336
  });
```

Export.image.to drive:-

Creates a task to export an image as a raster to drive.

4.3.3 Approaching of Google earth engine [GEE]

Managing Assets

Geospatial datasets can be upload using asset manager which will be at left side of the code editor [figure1]When the user uploads the datasets from a specific folder by using the assets Manager those assets become the Private assets which only the user can assess and when he shares the Assets then they became shared assets . For Storing the Assets the Space allocated is limited by a quota. The use of the quota depends on the total number and size of the stored asset pouches. for data usage details, click users / username and click the data usage icon

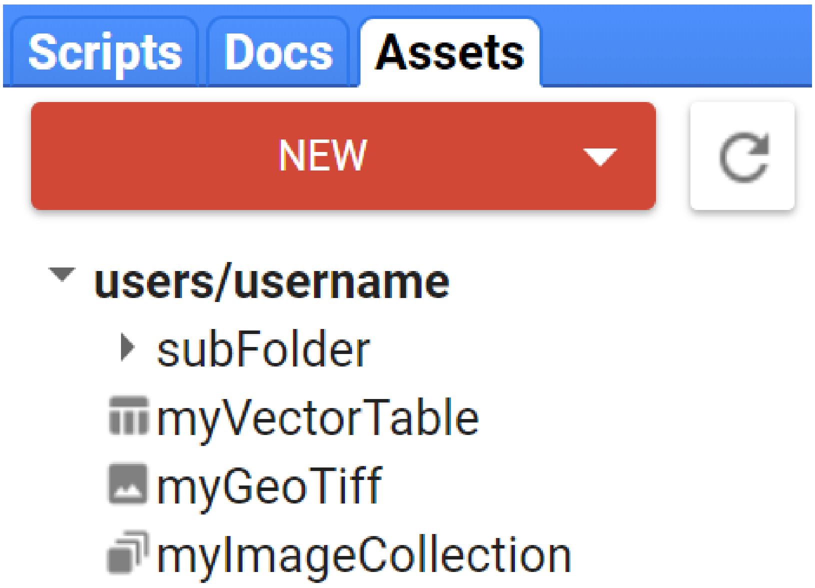

Figure 4.3.3 approaching managing assets

Sharing assets

To configure access to your private assets click the **Share** button. By hovering over the asset and clicking the share icon sharing also done and by using the share button from we can assess to private assets also. The Figure.4 the Sharing Dialog makes user to configure read or write access for individuals, members of a specified Google Group (learn more about Google Groups) and Earth Engine Apps. To make an asset public, check the 'Anyone can read' box.

To allow an Earth Engine application to display an item, select the application name from the drop-down list**.**

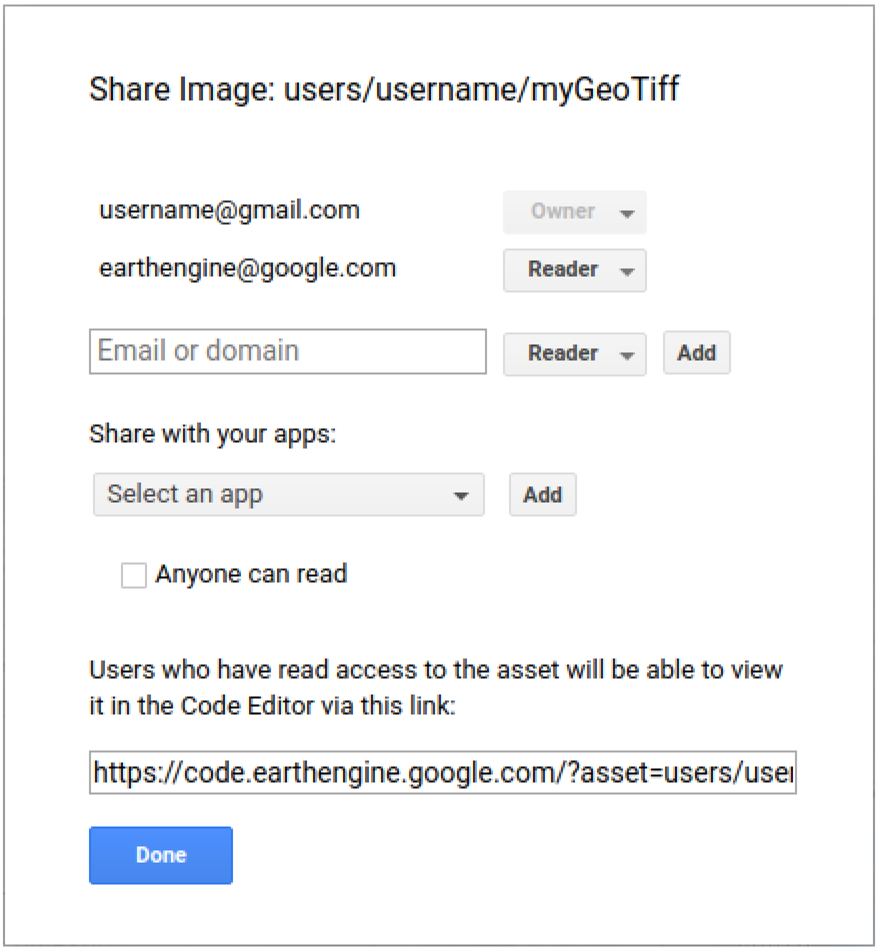

Figure 4.3.3 Approaching sharing assets

Importing Raster Data

Uploading image asset

For uploading the image or other georeferenced raster datasets in GeoTIFF or TFRecordformat. (See Importing Vector Data for details on importing vectors using the Code Editor.) We can use Asset Manager or the command line interface (CLI)

Uploading image assets

GeoTIFF

In the Google Earth Engine there is a limitation of only 10 GB of the TIFF images files. (For larger files, use the command-line upload option.) Up to 10GB data we can upload click the 

button**, then select Image upload for uploading the** GeoTIFF using the Code Editor. Earth Engine presents a loading dialog which should look similar to Figure 1

Click the **SELECT** button and navigate to a GeoTIFF on your local file system. In the specified Users folder, Appropriate Asset ID should be given to the Image. If you want to upload the image to an existing folder or collection, precede the asset ID with the folder or collection ID.

Click **UPLOAD** to start the upload. GeoTIFF

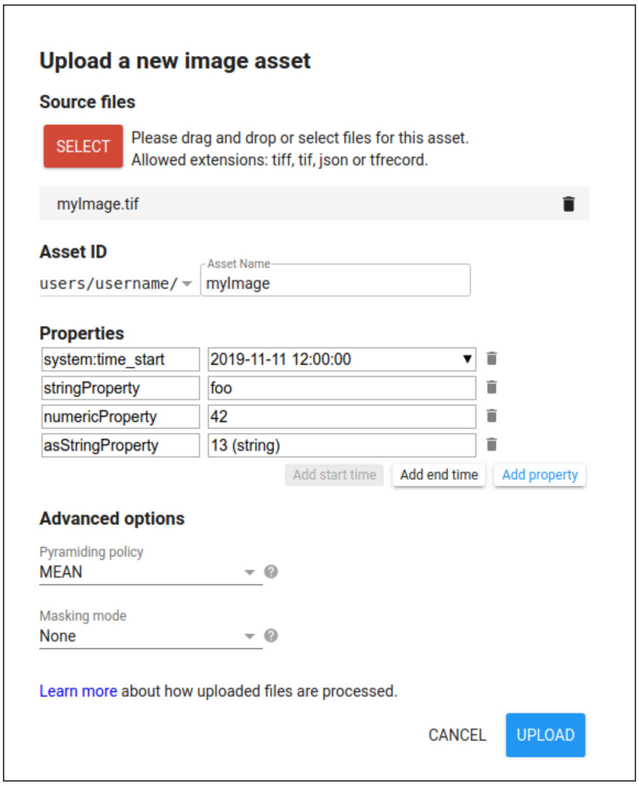

Figure 4.3.3 Uploading image assets geotiff

Importing Table Data

Uploading table assets

For uploading the Shape files and CSU files Asset Manager or command line interface (CLI) is used. And they are private and when we share they become shared assets

Upload a Shape file

For uploading the form files from the Code Editor, click the button 

, then select Shape files under the Table Upload section. Uploading dialogue box appears Figure 1 Click the SELECT button and navigate to a Shape file or Zip archive containing a Shape file on the local storage system. When selecting a .shp file, make sure to select the related .dbf, .shx and

.prj files. The default projection system in GEE is WGS84 coordinate system until we give a specific projection. .

The shape file should contain shp, .dbf, .shx, .prj and all the supporting files and no duplicate filenames.

Confirm filenames don't include additional periods or dots. (Filenames will include one period before the extension.)

Whenever we create a table it should be unique if already existed it won't accept. Click UPLOAD to start out the upload.

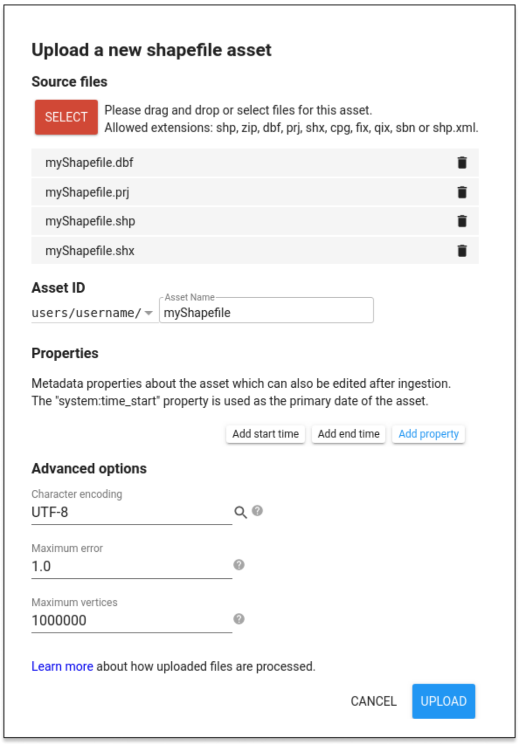

Figure 4.4.3 Upload a Shape file

Upload a CSV file

Activate assets tab for uploading csv file under the Table upload section. Click the SELECT button 

and navigate to a .csv file on your local file system. Table need to be given an Unique one, and asset ID name should be in the table. Click OK to start the upload. An upload dialog similar to Figure 2 will be presents

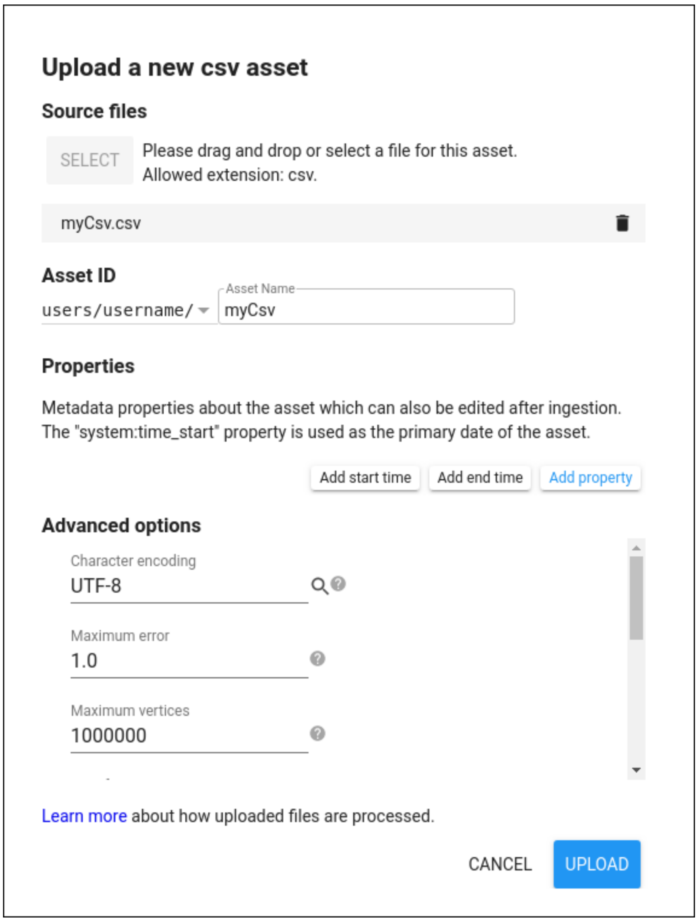

Figure 4.3.3 Upload a CSV file

The CSV file should contain a row for every feature and because the many columns as there are properties or variables for a feature set. If the features are geospatial, they must have a geo location defined by either a geometry string (GeoJSON, WKT) or x and y position properties. If the CSV file is an export from a GIS or geospatial data tool like the GDAL/OGR, a properly formatted and therefore the named geometry column should already been exist. Alternatively, two columns for x and y coordinates representing the point locations can be defined in the spreadsheet application and the exported as CSV format along with any other variables.

Exporting Data

Exporting the Images, Map Tiles, Tables and video from Google Earth Engine. The Exports will directly send to the Associated Google drive o Google Cloud Storage or to a new Earth Engine asset. .To use Google Cloud Storage (a paid service), you need to set up a project, enable billing for the project, and create a storage bucket. See the Cloud Storage quick start page for instructions. Refer to this guide for more information on naming storage compartments. The data exported to the cloud storage container will contain the object's default ACL for the container.

The individual export types are described in detail in the following sections

Exporting images

Exporting of the Images from GEE in geoTIFF or TFRecord format. See Configuration Parameters for the more output options.

To Drive

For exporting an Image to drive account, use export.image.to drive ().for example, to export the portions of the Sentinel-2 Image, define a region to export, then callExport.Image.toDrive ()

GEE Code

```
// Load a sentinel image and select three bands.
Var sentinel = ee.Image (‘ee.ImageCollection ("COPERNICUS/S2_SR")') .select (['B4', 'B3', 'B2']);
// Create a geometry representing an export region.
Var geometry = ee.Geometry.Rectangle ([116.2621, 39.8412, 116.4849, 40.01236]);
// Export the image, specifying scale and region.
Export.image.toDrive ({
  image: sentinel,
  description: 'imageToDriveExample',
  scale: 30,
  region: geometry
});
```

When this code is run, the export tasks will be created within the task as tab of the code editor. click the run buttons next to the task to start it(learn more about the task manger from the code editor section).the images are going to be created in your drive account with the required file format**.**

MaxPixels

The maxPixels parameter is so intended to prevent a very large export from the inadvertently being created. If the default value is just too low for your intended output image, you'll increase the maxPixels. For example:

```
Export.image.toDrive ({
Image: sentinel-2, Export.image.toDrive ({
 description:
'maxPixelsExample',
 scale: 30,
 region: geometry,
maxPixels:1e9
});
```

Sample code:

Program: 1

Classification

- Import Data[sentinel2]
- Filter Dates
- Clipping area of interest[AOI]
- Cloud Masking
- Sampling of training points &build classifier

//--//

Load raster data (sentinel-2).

Load vector data (shape file).

//---//

```
FunctionmaskS2clouds (image) {

Var qa = image. Select ('QA60');

// Bits 10 and 11 are clouds and cirrus, respectively.

Var cloud Bitmask = 1 << 10;

Var cirrus Bitmask = 1 << 11;

 // both flags should be set to zero, indicating clear conditions.

Var mask = qa.bitwise and (cloud Bitmask).eq (0)

.and (qa.bitwise and (cirrus Bitmask).eq (0));

Returnimage.updateMask (mask).divide (10000);

}

// Load the image

Var S2 = ee.ImageCollection ('COPERNICUS/S2')

//Pre-filter to get less cloudy granules.

 .filter Bounds (table4)

Var Jun = S2.filterDate ('2019-06-01', '2019-06-15'))//.map (maskS2clouds);

Var jun2 = S2.filterDate ('2019-06-15', '2019-07-01')//.map (maskS2clouds);

Var Jul = S2.filterDate ('2019-07-01', '2019-08-15')//.map (maskS2clouds);

Var jul2 = S2.filterDate ('2019-07-15', '2019-08-01')//.map (maskS2clouds);

Var Aug = S2.filterDate ('2019-08-01', '2019-08-15')//.map (maskS2clouds);

Var aug2 = S2.filterDate ('2019-08-15', '2019-09-01')//.map (maskS2clouds);

Var Sep = S2.filterDate ('2019-09-01', '2019-09-15')//.map (maskS2clouds);

Var sep2 = S2.filterDate ('2019-09-15', '2019-10-01')//.map (maskS2clouds);

Var Oct = S2.filterDate ('2019-10-01', '2019-10-15')//.map (maskS2clouds);
```

```
Var oct2 = S2.filterDate ('2019-10-15', '2019-10-24')//.map (maskS2clouds);

Map.addLayer (table4);

Var NDVI = function (image) {

Returnimage.normalizedDifference (['B8','B4']);

};

Var junNDVI= jun.map (NDVI).max ()

Print (Jun NDVI)

// Map.addLayer (junNDVI, {min:-0.5, max: 1},'junNDVI');

Var junNDVI2= jun2.map (NDVI).max ()

Print (junNDVI2)

// Map.addLayer (junNDVI2, {min:-0.5, max: 1},'junNDVI2');

Var julNDVI= jul.map (NDVI).max ()

Print (Jul NDVI)

// Map.addLayer (julNDVI, {min:-0.5, max: 1},'julNDVI');

Var julNDVI2= jul2.map (NDVI).max ()

Print (julNDVI2)

// Map.addLayer (julNDVI2, {min:-0.5, max: 1},'julNDVI2');

Var Aug NDVI= aug.map (NDVI).max ()

Print (Aug NDVI)

Map.addLayer (augNDVI, {min:-0.5, max: 1},'augNDVI');

Var augNDVI2= aug2.map (NDVI).max ()

Print (augNDVI2)

// Map.addLayer (augNDVI2, {min:-0.5, max: 1},'augNDVI2');
```

```
Var sepNDVI= sep.map (NDVI).max ()

Print (sepNDVI)

// Map.addLayer (sepNDVI, {min:-0.5, max: 1},'sepNDVI');

Var sepNDVI2= sep2.map (NDVI).max ()

Print (sepNDVI2)

// Map.addLayer (sepNDVI2, {min:-0.5, max: 1},'sepNDVI2');

Var Oct NDVI= oct.map (NDVI).max ()

Print (Oct NDVI)

// Map.addLayer (octNDVI, {min:-0.5, max: 1},'octNDVI');

Var octNDVI2= oct2.map (NDVI).max ()

Print (octNDVI2)

// Map.addLayer (octNDVI2, {min:-0.5, max: 1},'octNDVI2');

VarComposited Image = junNDVI.addBands (junNDVI2).add Bands (julNDVI).add Bands (augNDVI).add Bands (augNDVI2).add Bands (sepNDVI).add Bands (sepNDVI2).add Bands (octNDVI).add Bands (octNDVI2)

// Map.addLayer (Composited Image, {},'stack')

// Map.addLayer (Composited Image, {},'stack')

Var CompositedImage1 = CompositedImage.clip (table4)

// Map.addLayer (CompositedImage1,{},'stack1')

Print (CompositedImage1);

Var dataset =CompositedImage1;

Map.addLayer (table4);

// export image to drive
```

```
Export.image.toDrive ({

Image: CompositedImage1,

Description:'mncfc_districts_15days_NDVI_max1',

FileNamePrefix:'gujarat01_15days_NDVImax1',

Scale: 30,

MaxPixels: 37100133336

 });

// define a broad list of land cover categories.

VarTraining Samples = data;

Print (Training Samples)

Map.addLayer (table4)

Map.addLayer (data)

//Sample training points

Var training = dataset.sampleRegions ({

Collection: Training Samples,

Properties: ['CODE'],

Scale: 30,

TileScale: 16

});

//build classifier

Varclassifier cart = ee.Classifier.cart ().train (training, 'CODE');

// print (classifier);

//Import vector data from Asset manager
```

```
//classify the whole landscape

Varclassified_c_w = dataset. Classify (classifier cart);

Map.addLayer(classified_c_w,{min:1, max:6,
palette:['green','red','yellow','blue','black','pink']},"class_cart")

// Export the classified image to drive

Export.image.toDrive ({

Image: classified_c_w,

Scale: 30,

Region: Table,

MaxPixels: 10e10,

Folder:'gujarat',

Description:'gujarat_3'

  })
```

CHAPTER-5

Role of software

5.1 Software used:

The product utilized for my work is ArcGIS, ERDAS. They assume a crucial function in my venture as without them my work would not have been finished. For every product there is a specific job included.

5.1.1ArcGIS:

ArcGIS is the exclusive framework programming, which means it might be utilized in the event that it is bought by the organization being created. The product is created by ESRI. ESRI Company created everything in ArcGIS programming, including the different apparatuses used to work with geoprocessing work processes. The devices are known as geoprocessing apparatuses and are principally worried about the spatial information. ArcGIS is a geographic engineering data framework for working with guides and GIs information. ArcGIS incorporates work area applications, for example, Arc Map, Arc Reader, Arc Info, Arc Editor, and Arc View. These work area applications are utilized contrastingly for spatial information. Curve Map is the application we use for utilizing devices and overseeing geospatial information there are numerous apparatuses that are available in the arcgis programming utilized in circular segment guide to work with the information. The capacity in this product is as tables. Property tables will be available for each element of this product. The property table contains distinctive data identified with the qualities. The product is a social information base administration framework (RDBMS).

5.1.2 ERDAS Imagine:

ERDAS Imagine could also be an unknown detection application with raster illustration proofreading capabilities provided by ERDAS for geospatial applications. Other examples of use include extracting linear features, generating processing workflows (spatial models in Imagine), importing / exporting knowledge for the right kind of formats, ortho amendment, rule symbolism mosaic, sound system, and programmed extraction of guide information from symbolism Imagine is a remote sensing application with raster graphics editor capabilities designed by ERDAS for geospatial applications. Other examples of use include extracting line features, generating processing workflows (spatial models in Imagine), importing / exporting data for a wide variety of formats, ortho rectification, the mosaicking of imagery, stereo and automatic extraction of cartographic data entities from images.

5.1.3 Google earth pro:-

Google Earth to create KML files and check randomly generated points.

Chapter-6
Results and Discussions

6.1 Land Use Land Cover Mapping

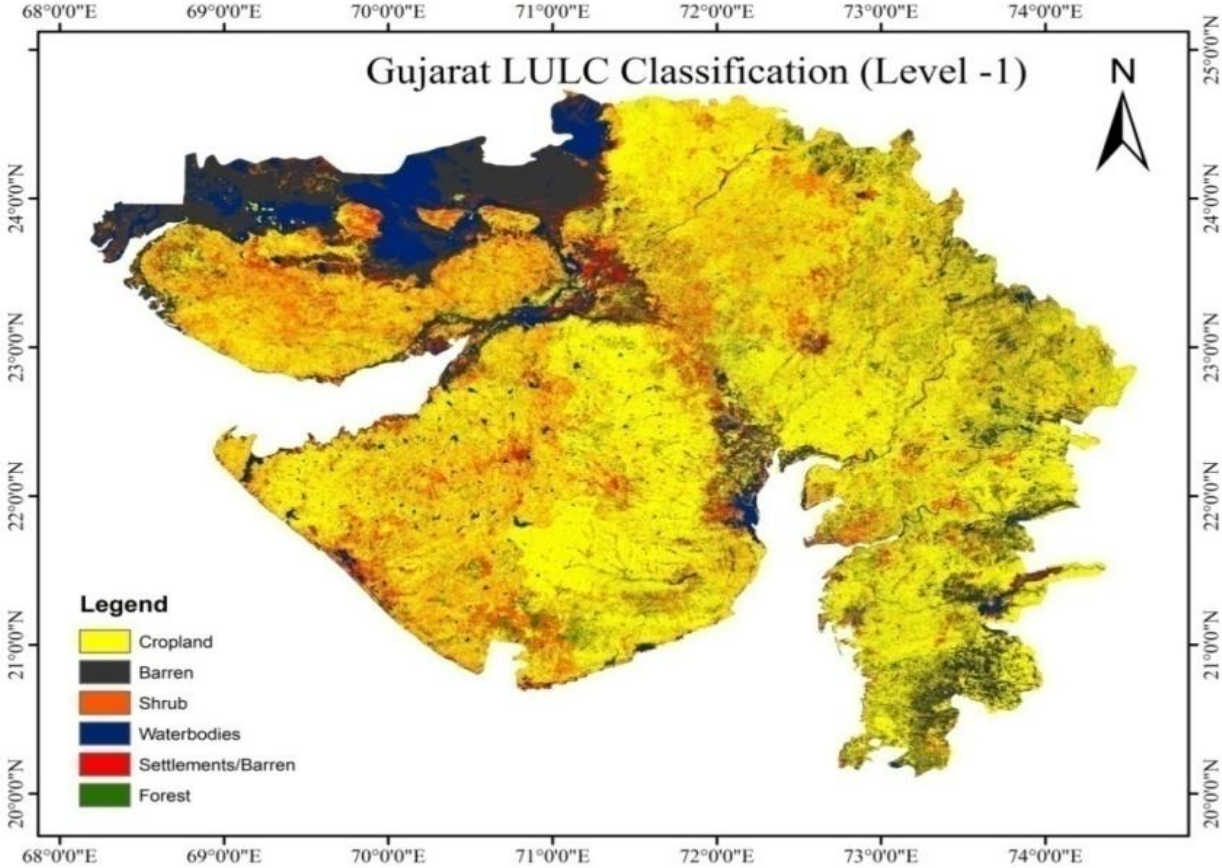

Figure 5.1 Gujarat land use land cover mapping

Gujarat LULC classification(above image) (figure 5.1) was carried out using GEE with the help of ground data. The classified classes are Cropland, Barren, Shrub, Water bodies, Settlements and Forest. Training data was collected within GEE interface by selecting different LULC. The northern part of Gujarat is covered with barren water bodies and the southeastern part contains forest areas**.** contains forest areas**.**

LULC	Area (Ha)
Crop	8628900
Built-up	1777944
Shrub land	3469159
Barren	1181983
Forest	1945309
Water	1742352

Table: 6.1 Land Use Land Cover Mapping table

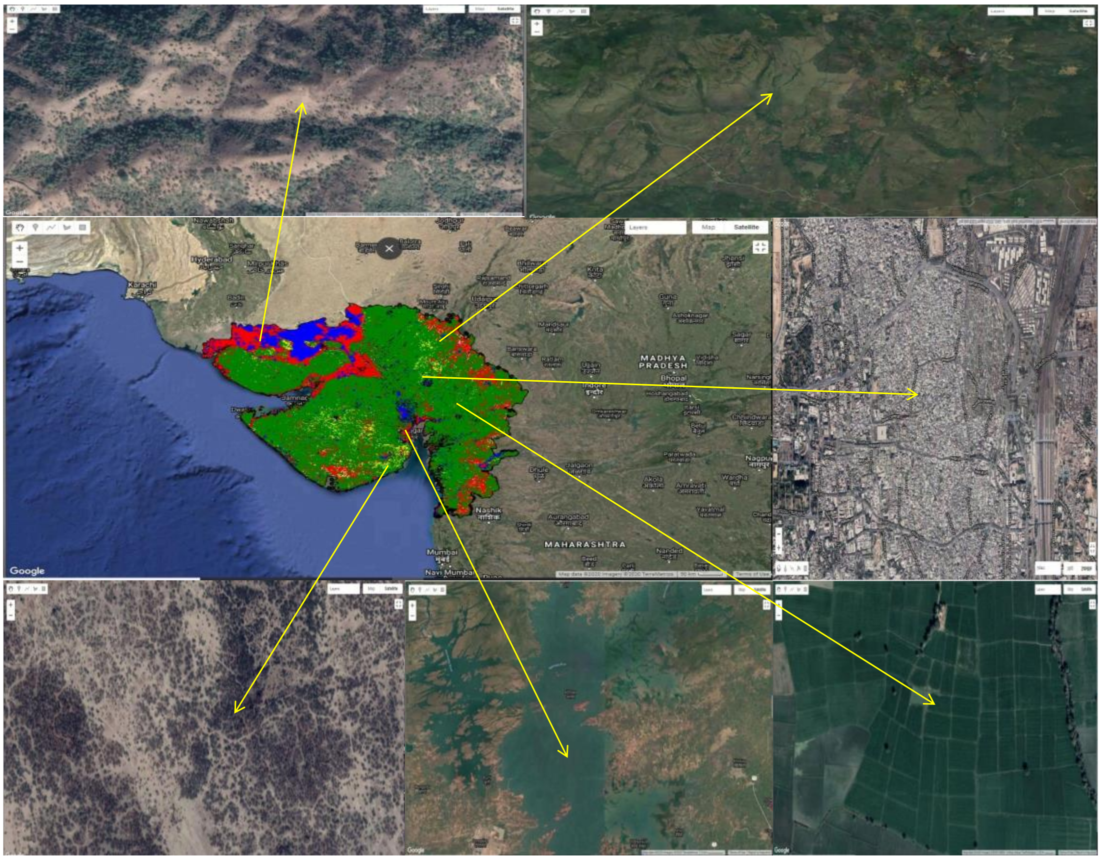

Figure6.1The major LULC areas and related Google Earth high resolution image

The above image (fig 6.1b) shows the major LULC areas and related Google Earth high resolution image. Cropland, water bodies, and barren lands are clearly seen from above image. With the visual interpretation, the LULC map was finalized.

6.2 Kharif and Rabi Season -Cropland Maps

Kharif season crop (Fig) 6.2 was mapped with the help of Random Forest algorithm using ground data collected during that period. Most of the croplands were located in South West region of Gujarat.

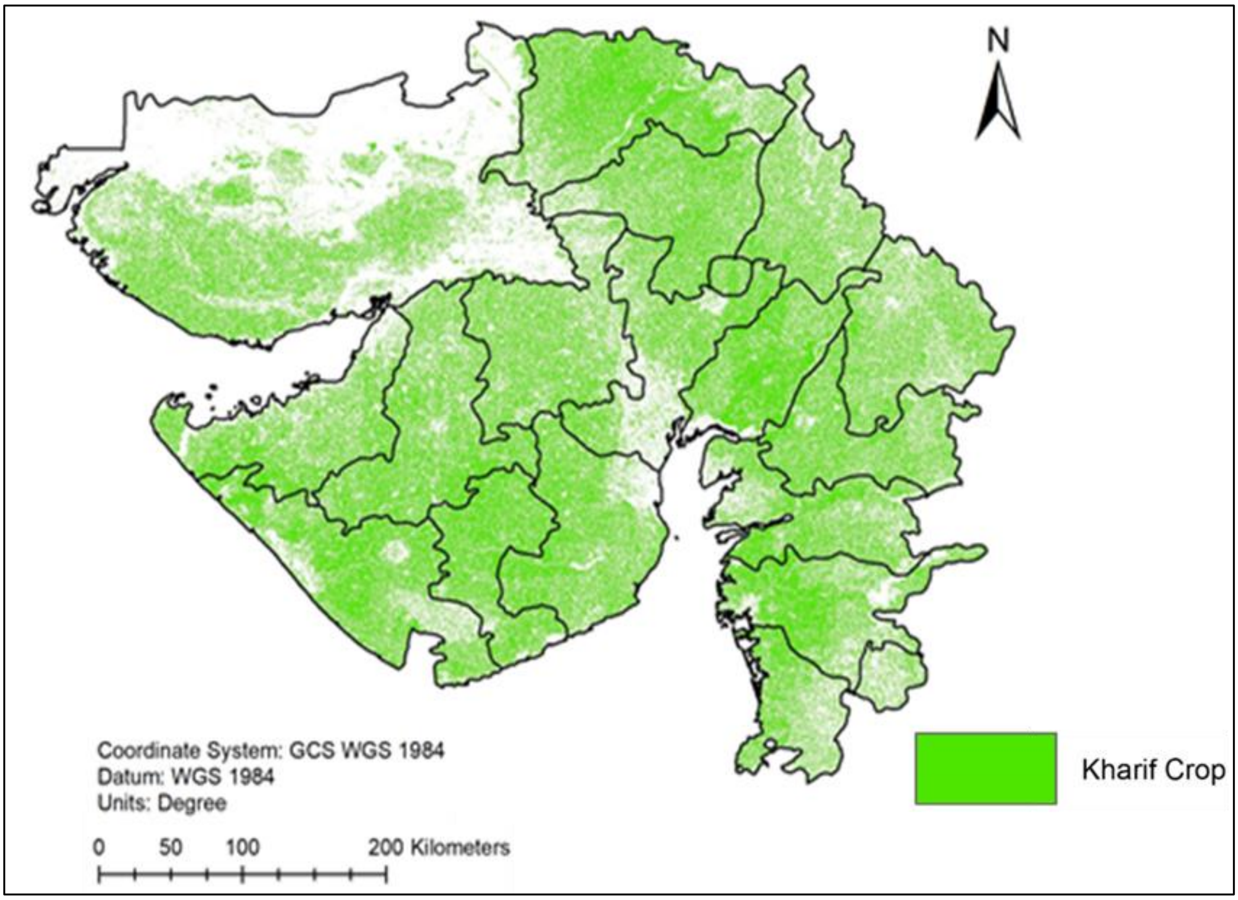

Fig: 6.2 spatial distributions of Kharif croplands

Same Procedure as Kharif croplands was carried out to extract croplands in Rabi season(**Fig)** **6.2**

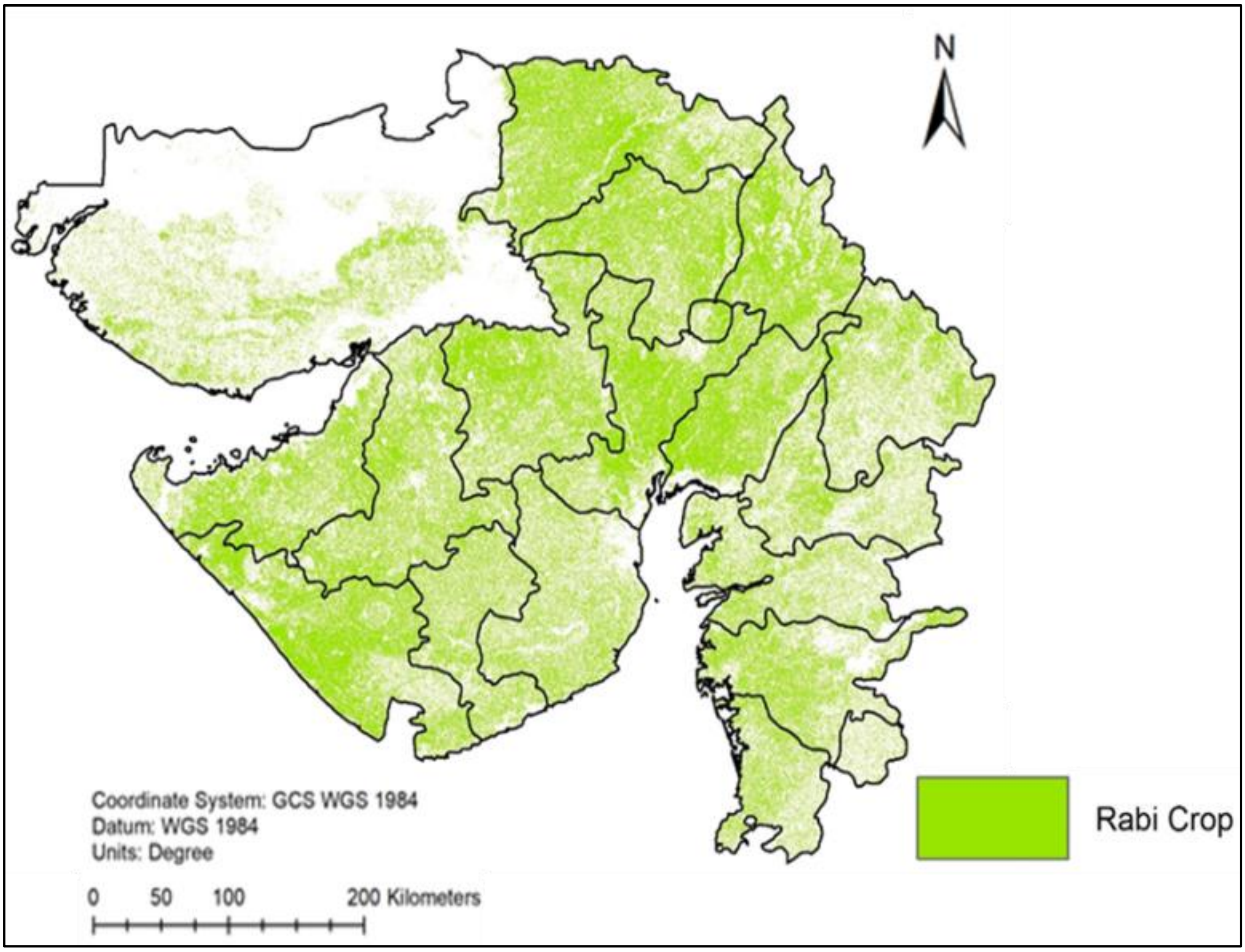

Fig: 6.2 Spatial distribution of Rabi croplands

6.3. Identification of Rice Crop Extent

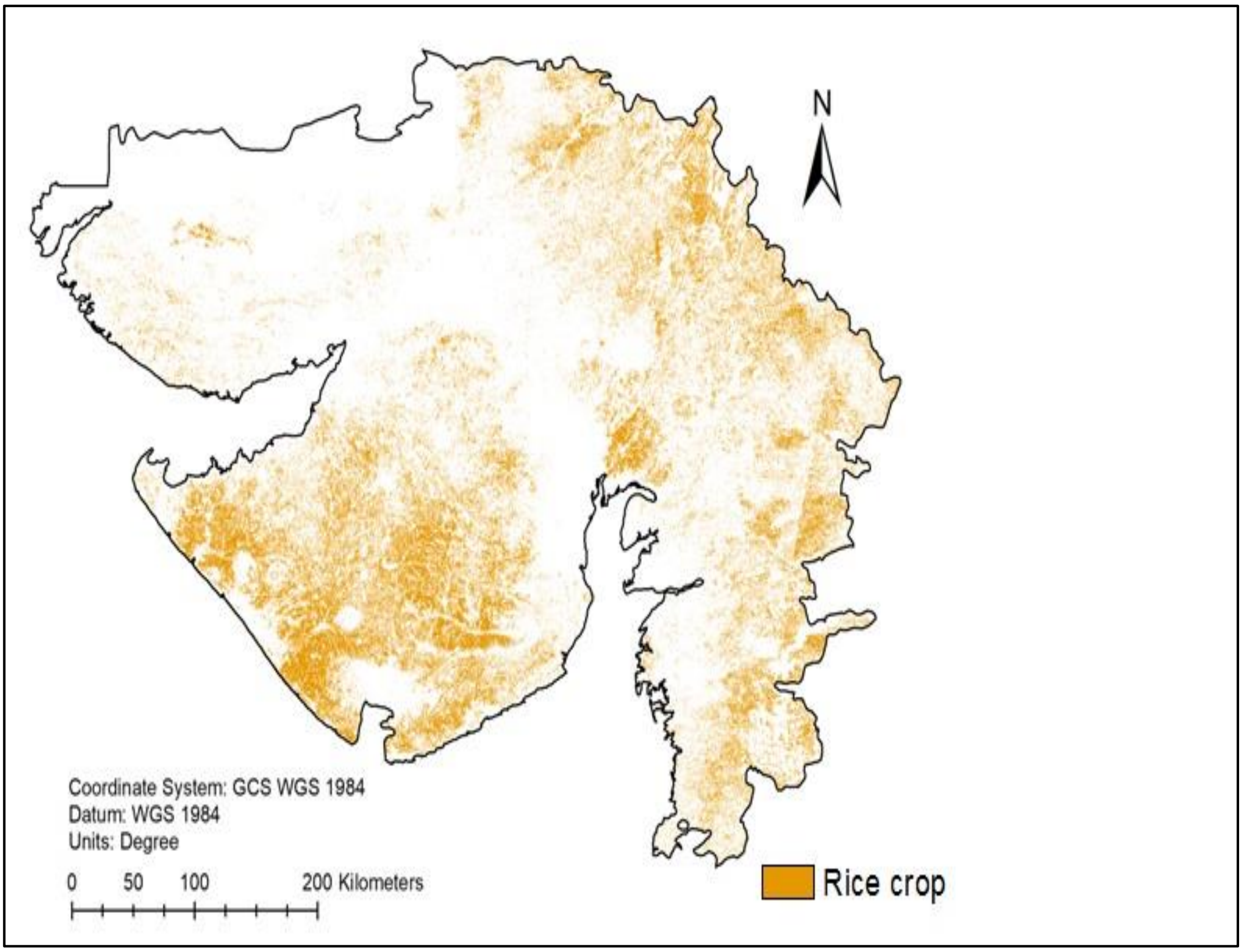

Fig: 6.3 Spatial distribution of rice crop extent

The figure above shows the spatial distribution of the extent of the rice crop for the whole of Gujarat. The identification of rice crop was mainly achieved by using NDVI thresholds with range greater than 0.7 values. Then with the help of ground data contains rice crop was used for validation. Most the Rice crop is in the South West of Gujarat.

6.4Accuracy Assessment for LULC Mapping

Random Forest	Crop	Built-up	Shrub lands	Barren	Forest	Water	Total	Users
Crop	143	3	6	1	4	0	157	0.910
Built-up	3	50	0	1	0	0	54	0.920
Shrub lands	7	1	46	0	6	0	60	0.760
Barren	0	1	1	11	0	0	13	0.840
Forest	10	0	6	0	58	0	74	**0.78**
Water	1	1	0	0	0	43	45	**0.95**
Total	164	56	59	13	68	43	403	
Producers	0.870	0.890	0.770	0.840	0.850	1.000	**Overall**	**0.870**

Table: 6.4 accuracy Assessment for LULC Mapping table

For doing of accuracy assessment we use

1. Ground verification using Global Position System

(Observing the area)

2. Compare the classified image with an assumed correct image (such as an aerial photograph, Google Earth Image)

This regard, images with high spatial resolution from Google earth that are liberal to the general public are an honest source of Imagery including satellite images and air photos. Earth (http://earth.google.com) provided by Google Inc., is a virtual globe programming that maps the world by Superimposition of high resolution satellite images. Since it was released in June 2005, Google Earth has aims to supply viewers with “a more Realistic view of the world”. Beside Google Earth, map data and positional measurement can be obtained using different

Methods such as conventional or modern land survey Methods, Global positional System (GPS) and remote Sensing satellite imagery. Each of these known positional accuracy Google earth high-resolution imagery is important for Assessment of accuracy by comparing the point-by-point basis.

A random set of points is generated for area and then Using Google Earth, the value of each point is identified.

Therefore, this study aimed to analyze the accuracy of the Land Use Land Cover Classification using Google Earth in Gujarat.

- Based on analysis of satellite imagery and monitoring the current state of six major land uses and land cover types were identified within the study area. These include crop, built-up, shrub land, barren, forest, water.

- From **fig 5.1** a random set of points generated for area using Google earth pro. The lulc part is done using Arcgis software.

- From **fig 5.2** with the help of random forest algorithm using ground data collected during Kharif season The output obtained from the gee and by using Arcgis software I have done classified image.

- From **fig 5.3** with the help of random forest algorithm using ground data and training data collected during Rabi season. The output obtained from the gee and using Arcgis software I have done classified image.

- From **fig 5.4** the image is done using ndvi threshold with range greater than 0.7 values with the help of ground data and training data was used. Mosaicking of the rice part was done by using Erdas.

6.5 Land Use Land Cover Classification for 2019-20:-

The land use land cover classification of the area for 2019-20From sentinel-2 satellite image (table 2) showed that the Majority of the study area is covered by **crop land** 8628900hectares (ha). the producer's accuracy and user's accuracy of croplands in fallow were 87%and 91% **Forestland** and cover an aerial size of 1945309 ha the producer's accuracy and user's accuracy of forest 85% and 78% and **shrub land** 3469159 ha respectively, producer's accuracy and user's accuracy is 77% and 76%whereas the aerial coverage of **Rocky/Barren land** and **Settlement land** is1181983 ha the producer's accuracy and user's accuracy is 84% and 84% and 1777944 ha producer's accuracy and user's accuracy is 89% and 92%from the total area of the District. There are also **waters** which covers 1748352 ha. Producer's accuracy and user's accuracy is1%and 95%

By the land use land cover classification he over all accuracy what we obtained is 87% for the study area.

Conclusions:

The study identified LULC, Kharif crop extent, Rabi Crop area extent and Rice crop extent for entire Gujarat using Google earth engine.. As traditional methods require satellite image downloads and the need for high-end computers with image processing software. But GEE makes ease of image processing through its interface by writing code. The satellite images in the Kharif season contain high clouds, which can also be corrected with various algorithms in GEE. The identification of Rabi and Kharif crop were identified with help of crop mask obtained from LULC map and run random forest algorithm for respective season croplands. The rice crop extent map was prepared with help of NDVI thresholds because of less ground data. In future, there are many technologies will be used for crop classification with the help of machine learning, deep learning and also integration of various cloud computing techniques.

1. Mapping lulc of Gujarat state

Using Google earth pro i called random set of points and collected data from training data these points are generated.

For the mapping of the lulc of the Gujarat state used Google earth pro software given classification are crop, built-up, shrub lands, barren, forest, water, further classification &mapping is done in arcgis.

2. Mapping Kharif and rabi croplands

Mapping of the Kharif and Rabi crop lands are done by using the arcgis software and the resultant outputs is obtained in the Google earth engine by the classification.

3. Identification of rice crop extent

By the erdas software using ndvi threshold signatures from the Rabi,

Kharif rain crops extracted only rice crops which value is greater than 0.7

CHAPTER 7

Limitations and scope for further study

7.1 Limitations

- During the monsoon season, difficulty in image classification due to high cloud cover in optical data (sentinel 2)
- In optical data, the vegetation indices depend upon local agro-ecological conditions
- Standard algorithms are not applicable in Google Earth Engine due to the sensitivity of satellite data
- Limitation of Ground Data reflects in classification

7.2 Scope for further study

- Improving machine learning algorithms and standardisation of classification algorithms
- High usage of SAR data during monsoon season
- Preparation of high-resolution crop mask, help in crop type classification
- Collection of quality ground data using optimised techniques

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