“ESTIMATION OF WATER COVER USING SATELITE IMAGES”

ACKNOWLEDGEMENT

This year has been an extremely informative journey for, my friend and me. We would like to extend our gratitude to **Dr**. **Jyoti M. Divecha (Head of Department)** for entrusting upon me these invaluable projects. The journey of the study at the department and the projects gave me immense insight into the world of analytics. We are very thankful to **Mr. Agniva Das, Mr. Vishva Kapadi** and **Mr. Shrey Pandya** my internal guide for their incomparable affection during my projects works. Documentation is heart of project, so we take opportunity to express my heartfelt thanks to all my dear friends who support and encourage my project partner and me to complete our documentation successfully. These projects have been the outcome of ideas of combination of ideas suggestions and contribution of many people. We express our gratitude to **Mr. Agniva Das** and **Mr. Shrey Pandya** for their immense support and timely help and for their incomparable affection during our project work. Our project is dedicated to all the people whom we met, took guidance interviewed and something from them. At this occasion, we want to grab this opportunity to acknowledge our sincere thanks to all of them while submitting.

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Place: V.V. Nagar, Anand

Date:

A

PROJECT REPORT

PS04CAST23

ON

"ESTIMATION OF WATER COVER USING SATELLITE IMAGES"

BY

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2020-2021

CERTIFICATE

This is to certify that **MR. ANIKET ANIL MANE** student of Master of Science in Applied Statistics, Roll No. 03, Exam No. 13 has satisfactorily completed his Project Work on "**Estimation of water cover in Anand City using Satellite Images**" for M.Sc. (Applied Statistics) semester IV during the Dec 2020 – May 2021.

Place: Vallabh Vidyanagar

Date**:**

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CERTIFICATE

This is to certify that **MR. SWAPNIL SATLING KANADE** student of Master of Science in Applied Statistics, Roll No. 45, Exam No. 47 has satisfactorily completed his Project Work on "**Estimation of water cover in Anand City using Satellite Images**" for M.Sc. (Applied Statistics) semester IV during the Dec 2020 – May 2021.

Place: Vallabh Vidyanagar

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1. PREFACE

A practical knowledge in a student's life is very important. It helps a student to know the real-life situation and problems of life. Theoretical knowledge is very much needed but practical knowledge is equally important. This practical knowledge to a student is given in a form of project.

This project provides an opportunity and platform to know the current situation and the behaviour of environment.

For the preparation of this project, I feel deep sense of gratitude to all faculty members, staff members of the respective organization and all other persons who helped me to prepare such project report.

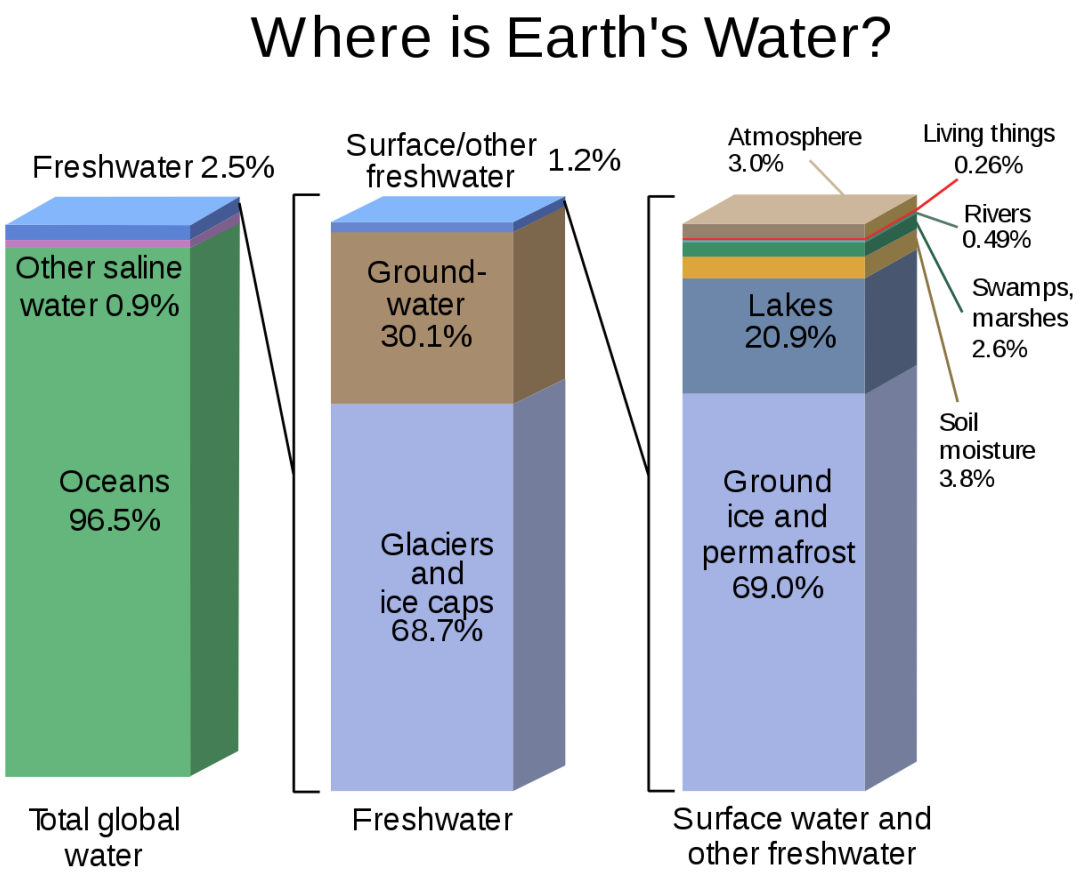
2. ABSTRACT

Water resources are natural resources of water that are potentially useful. Uses of water include agricultural, industrial, household, recreational and environmental activities. Surface water is water which includes water present in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge, evaporation, evapotranspiration and groundwater recharge. Monitoring the surface water and area covered by it continually is challenging task. Here where remote sensing technology comes into the picture. Due to its wide applications in different filed and also it is cost and time efficient it has gain its popularity over period of time. In the present study we have tried to use remote sensing data which is in form of image. In this we have focuses on the estimating area covered by surface water bodies in Anand City using remote sensing data. Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image. In Current study we have used the satellite images, acquired from the USGS (United States Geological Survey) site and Google earth pro to estimate the water cover in Anand city. Statistical and geostatistical analyses were performed on satellite data in ArcGIS to estimate the area statistics of water bodies. For this we use statistical technique like supervised classification in which maximum likelihood classification technique was used. Results from the study were determined in which estimated area covered surface water bodies was obtained and also it was tried to understand the relationship between area and the temperature for different time points.

3. INTRODUCTION

3.1 Introduction of Water Resources:

Water resources are natural resources of water that are potentially useful. Uses of water include agricultural, industrial, household, recreational and environmental activities. All living things require water to grow and reproduce.



3.2 Surface water:

Surface water is any body of water found on the Earth's surface, including both the saltwater in the ocean and the freshwater in rivers, streams, and lakes. Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge evaporation, evapotranspiration and groundwater recharge.

Human activities can have a large and sometimes devastating impact on these factors. Humans often increase storage capacity by constructing reservoirs and decrease it by draining wetlands. Humans often increase runoff quantities and velocities by paving areas and channelizing the stream flow.

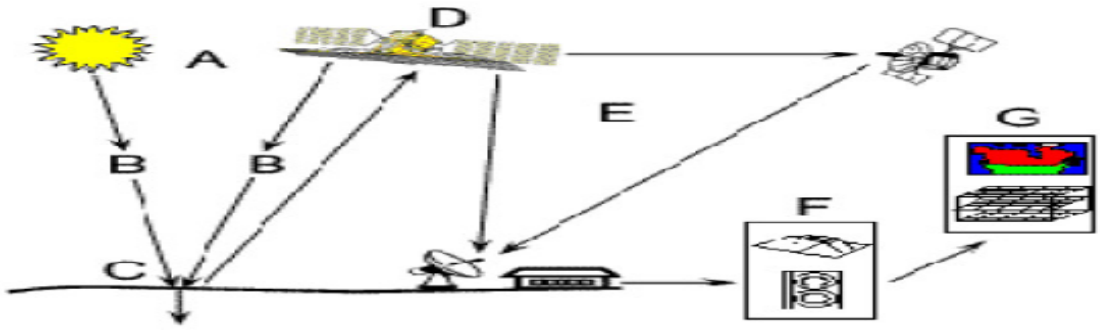
In Current project we will be using the satellite images provided by Sentinel-2 and Google earth pro to estimate the <u>Water cover</u>.

3.3 Remote Sensing

What is Remote Sensing?

"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven elements are involved. Note, however that remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors.



(A) Energy Source
(B) Radiation and the Atmosphere
(C) Interaction with the Target
(D) Recording of Energy by the Sensor
(E) Transmission, Reception, and Processing
(F) Interpretation and Analysis
(G) Application

1. Energy Source or Illumination (A) - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

5. Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

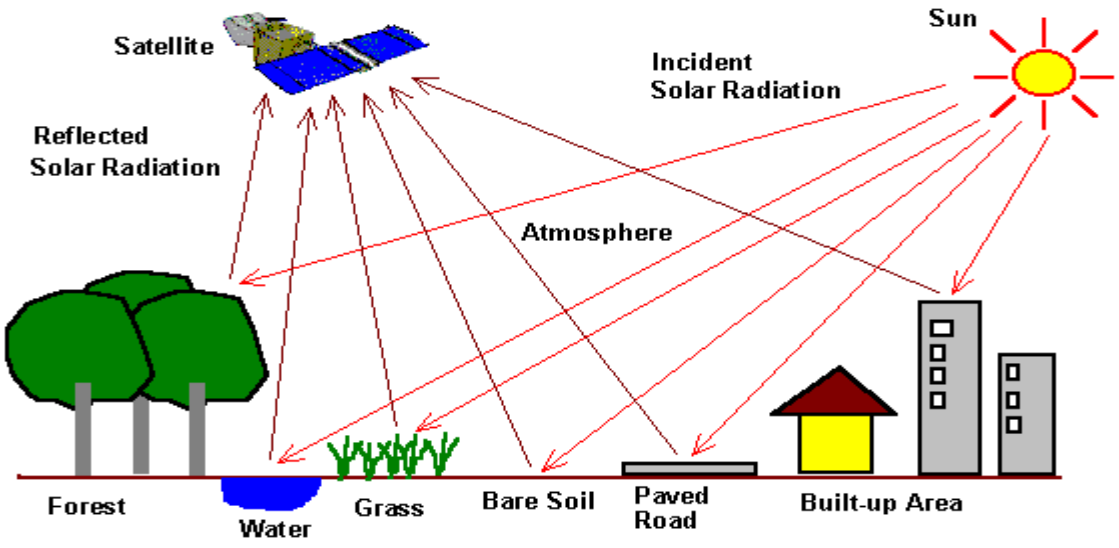
7. Application (G) - the final element of the remote sensing process is achieved when we apply the information, we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

These seven elements comprise the remote sensing process from beginning to end.

Introduction to Optical Wave and Micro Wave

3.3.1 Optical Wave

Optical remote sensing makes use of visible, near infrared and short-wave infrared sensors to form images of the earth's surface by detecting the solar radiation reflected from targets on the ground. Different materials reflect and absorb differently at different wavelengths. Thus, the targets can be differentiated by their spectral reflectance signatures in the remotely sensed images. Optical remote sensing systems are classified into the following types, depending on the number of spectral bands used in the imaging process.



- **Panchromatic imaging system:** The sensor is a single channel detector sensitive to radiation within a broad wavelength range. If the wavelength range coincide with the visible range, then the resulting image resembles a "black-and-white" photograph taken from space.
- **Multispectral imaging system:** The sensor is a multichannel detector with a few spectral bands. Each channel is sensitive to radiation within a narrow wavelength band. The resulting image is a **multilayer image** which contains both the brightness and spectral (colour) information of the targets being observed.
- **Superspectral Imaging Systems**: A super spectral imaging sensor has many more spectral channels (typically >10) than a multispectral sensor. The bands have narrower bandwidths, enabling the finer spectral characteristics of the targets to be captured by the sensor.
- **Hyperspectral Imaging Systems**: A hyperspectral imaging system is also known as an "imaging spectrometer". it acquires images in about a hundred or more contiguous spectral bands. The precise spectral information contained in a hyperspectral image enables better characterization and identification of targets.

3.3.2 Micro Wave

Microwave imaging is a science which has been evolved from older detecting/locating techniques (e.g., radar) in order to evaluate hidden or embedded objects in a structure. Microwave imaging techniques can be classified as either quantitative or qualitative. Quantitative imaging techniques give the geometrical parameters (i.e., shape, size and location) of an imaged object by solving a nonlinear inverse problem.

3.4 Sentinel 2 Dataset

Sentinel-2 (S2) is a wide-swath, high-resolution, multispectral imaging mission with a global 5-day revisit frequency. The S2 Multispectral Instrument (MSI) samples 13 spectral bands: visible and NIR at 10 meters, red edge and SWIR at 20 meters, and atmospheric bands at 60 meters spatial resolution. It provides data suitable for assessing state and change of vegetation, soil, and water cover. The images are stored in the JPEG 2000 file format, with each spectral band stored as a separate image for easy access. Images are organized in the Sentinel-2 tiling grid, which is based on the Military grid reference system that divides the Earth into square tiles of approximately 100 km on each side.

Where the components of this path are:

UTM_ZONE: A number indicating the longitude zone in the Universal Transverse Mercator (UTM) system.

LATITUDE_BAND: A letter in the range "C" through "X" (omitting "I" and "O") which indicates the latitude band.

GRID_SQUARE: A two-letter code indicating the particular 100 km square region.

GRANULE_ID: The Sentinel-2 id of a particular granule, which contains images of this grid square at some point in time.

Within the GRANULE_ID directory, the granule images and associated metadata are organized according to the Standard Archive Format for Europe (SAFE). Each GRANULE_ID directory contains a subdirectory named GRANULE that holds the granule data itself, along with additional metadata associated with the product that this granule belongs to

There are three subdirectories within the granule itself:

IMG_DATA/: Contains the actual image data in thirteen JPEG 2000 files (one for each spectral band).

QI_DATA/: Contains quality control reports for this granule.

AUX_DATA/: Contains ECMWF weather forecast data for this granule.

3.4.1 Dataset access

The image data can be used easily with any software that recognizes JPEG 2000 image files. The additional metadata files can be used with the Sentinel-2 Toolbox, an open-source toolbox developed for the European Space Agency (ESA). This toolbox includes visualization, analysis, and processing tools for Sentinel-2 data.

To help locate data of interest, an index CSV file of the sentinel-2 data is available. This CSV file lists the available granules, their acquisition dates, and their spatial extent as minimum and maximum latitudes and longitudes.

3.4.2 About the dataset

Dataset Source: European Commission (Copernicus), ESA.

Category: Satellite imagery, Geo.

Use: Sentinel data is free, full and open for public use under EU law. For full details of use, refer to the Copernicus Sentinel Data Terms and Conditions.

Update Frequency: New Sentinel-2 scenes are added daily as they become available. Data is typically available 1-2 days after publishing by Copernicus. There may occasionally be additional delays due to planned or unplanned maintenance.

Format: JPEG 2000, plus ancillary data.

Cloud Storage Location: gs://gcp-public-data-sentinel-2 (located in the EU multi-region).

3.5 What is an image:

An image is an artifact that depicts visual perception, such as a photograph or other two-dimensional picture, that resembles a subject usually a physical object and thus provides a depiction of it. In the context of signal processing, an image is a distributed amplitude of color(s). Images may be two-dimensional, such as a photograph or screen display, or three-dimensional, such as a statue or hologram. They may be captured by optical devices such as cameras, mirrors, lenses, telescopes, microscopes, etc. and natural objects and phenomena, such as the human eye or water.

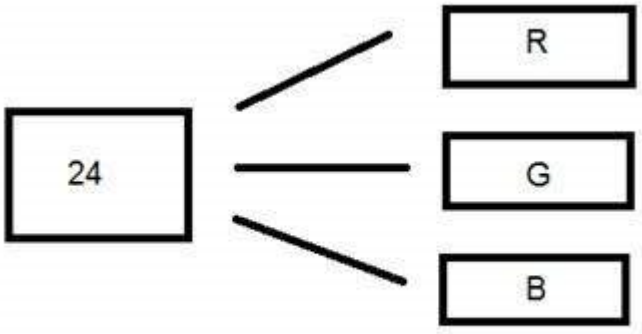
3.5.1 Types of Images:

1. Black and White Image:

   The resulting image that is formed hence consist of only black and white color and thus can also be called as Black and White image.

2. Color Image:

There are 24-bit color format. In a 24-bit color format, the 24 bits are distributed in three different formats of Red, Green and Blue.



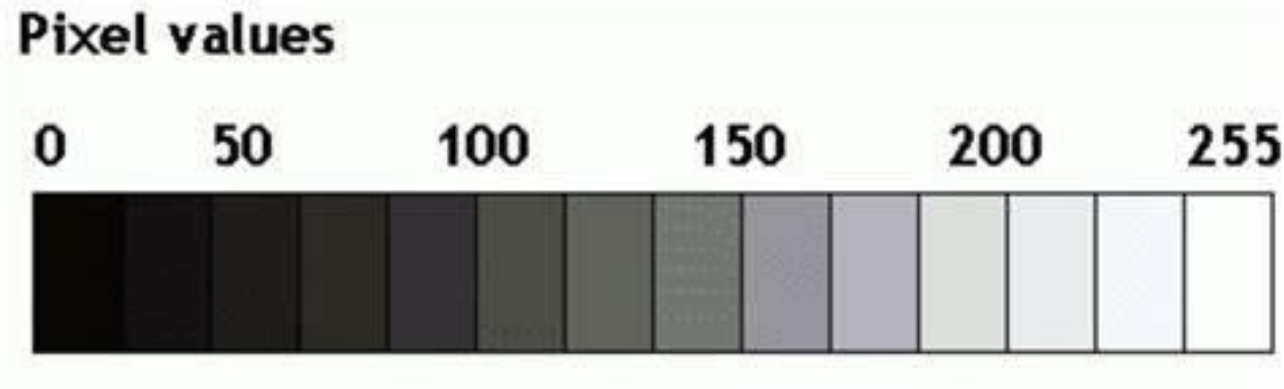
Their distribution is like these 8 bits for R, 8 bits for G, 8 bits for B.

3.5.2 What is an image processing?

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image.

3.5.3 Pixel:

In digital imaging, a pixel, or picture element is a smallest addressable element in a raster image, or the smallest addressable element in an all-points addressable display device; so, it is the smallest controllable element of a picture represented on the screen. A pixel consists of Red, Green, Blue (RGB) color subpixel each having values ranging 0 to 255 (8 bit).



Calculation of total number of pixels:

The number of Pixels would be equal to the number of rows multiply with number of columns**.**

Total number of pixels = number of rows * number of columns

4. OBJECTIVE

- **To estimate the area of Water Cover in Anand City.**
- **To measure Temperature.**

5. DATA COLLECTION

TO GET SATELLITE DATA WE USE FOLLOWING SOURCES OF SATELLITE DATA

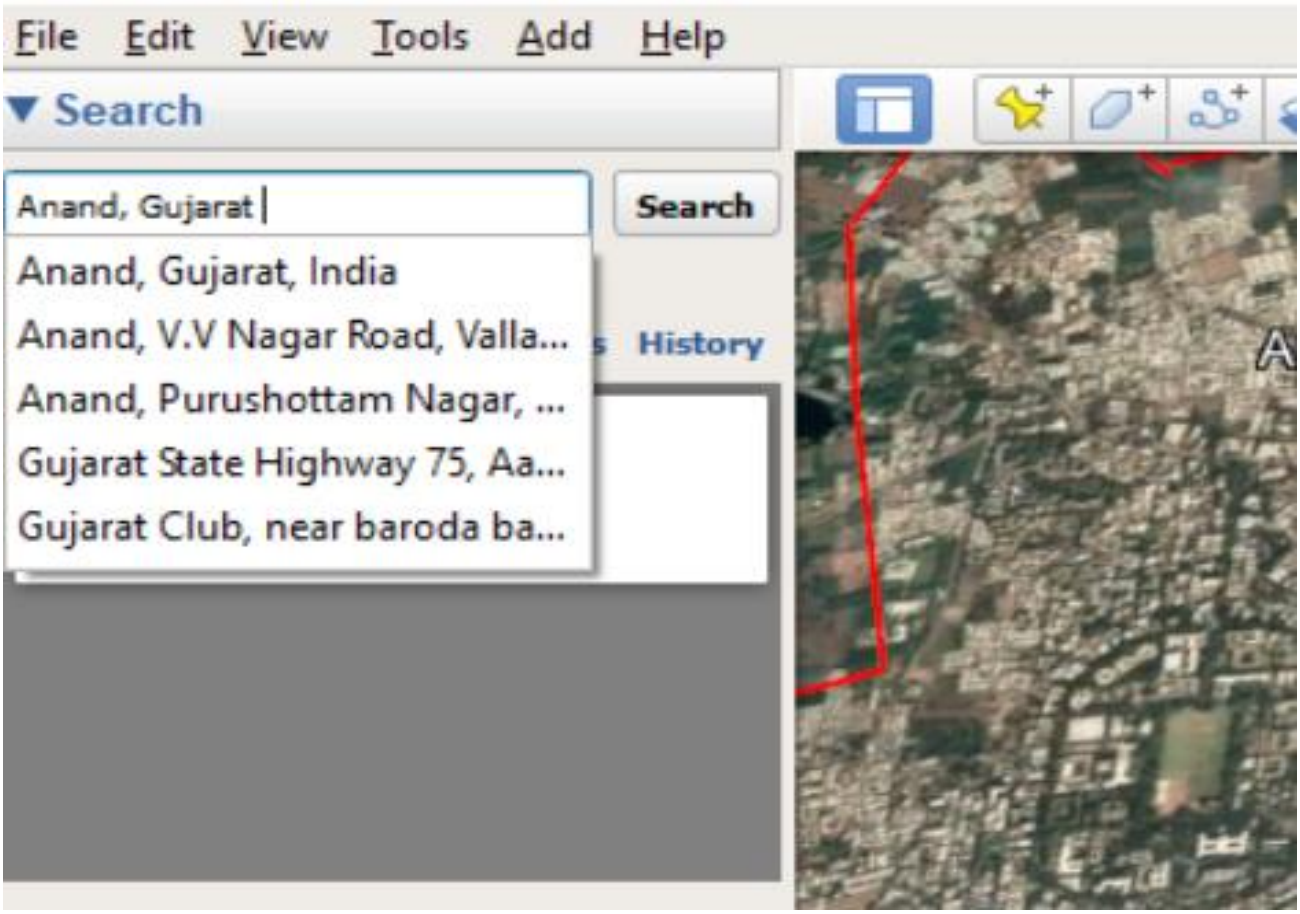
5.1 Google Earth Pro

Google Earth Pro was originally the business-oriented upgrade to Google Earth, with features such as a movie maker and data importer. Up until late January 2015, it was available for $399/year, though Google decided to make it free to the public. Google Earth Pro is currently the standard version of the Google Earth desktop application as of version 7.3. The Pro version includes add-on software for movie making, advanced printing, and precise measurements, and is currently available for Windows, Mac OS X 10.8 or later, and Linux.

5.1.1 How to Use Google Earth Pro?

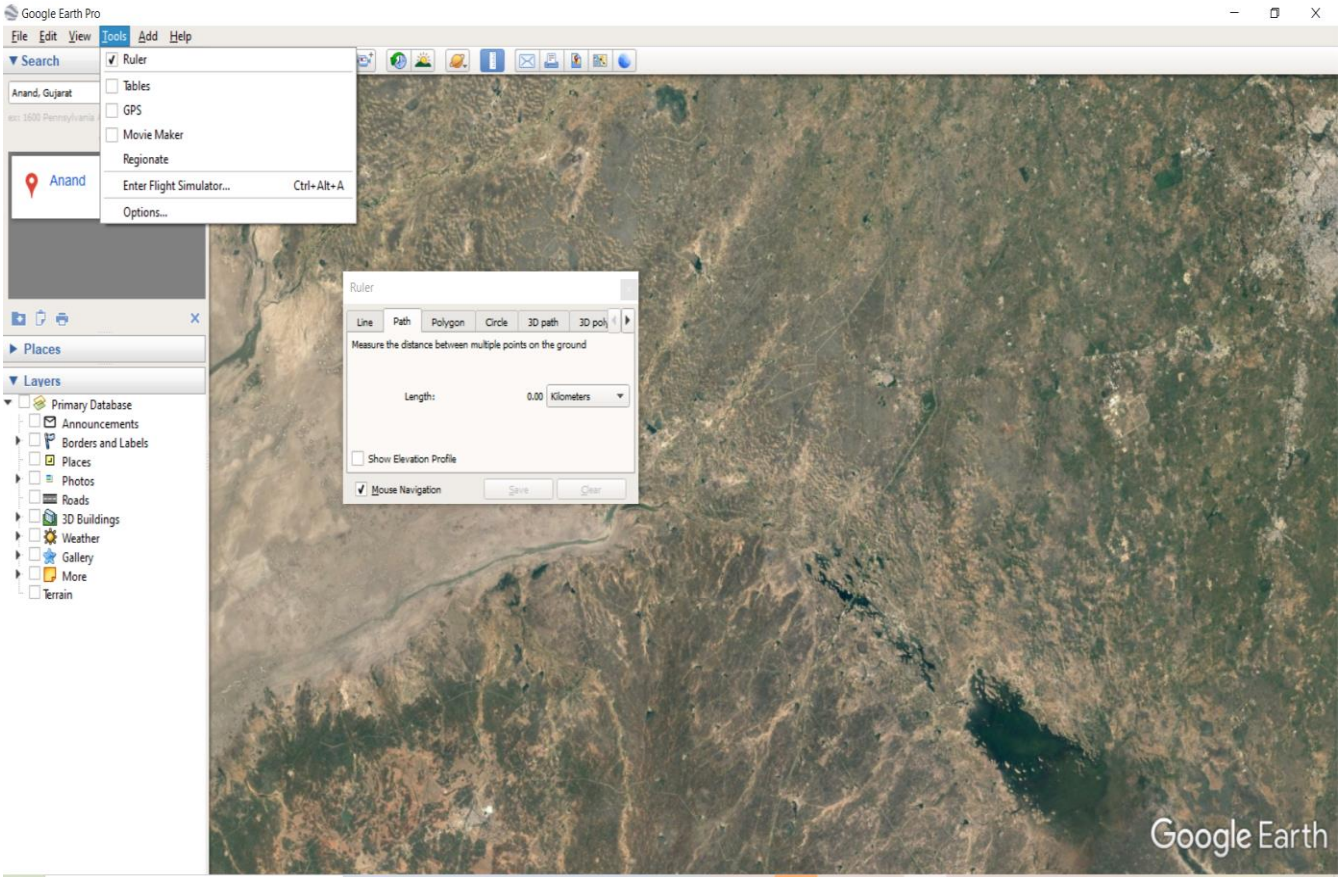
Step 1.

Download and install the Google Earth program from the Google Earth download page. Open Google Earth Pro then Perform searches from the search box at the top left side of the program. You can type a place name, postcode, a town/city name, an airport (three letter code or full name) or you can even try to type in a latitude-longitude location (in decimal format). Once you press the ↵ Enter key, you'll be "flown" to that destination. Be creative with your searches, but try to be realistic as to things you'd actually find on a city/county/country map worldwide. Show below in fig,1



Step 2.

Draw lines with help of Google map and mark the area of interest with the help of path **Tools > Ruler > Path**. Save the area under study. Which show below in Fig.2.

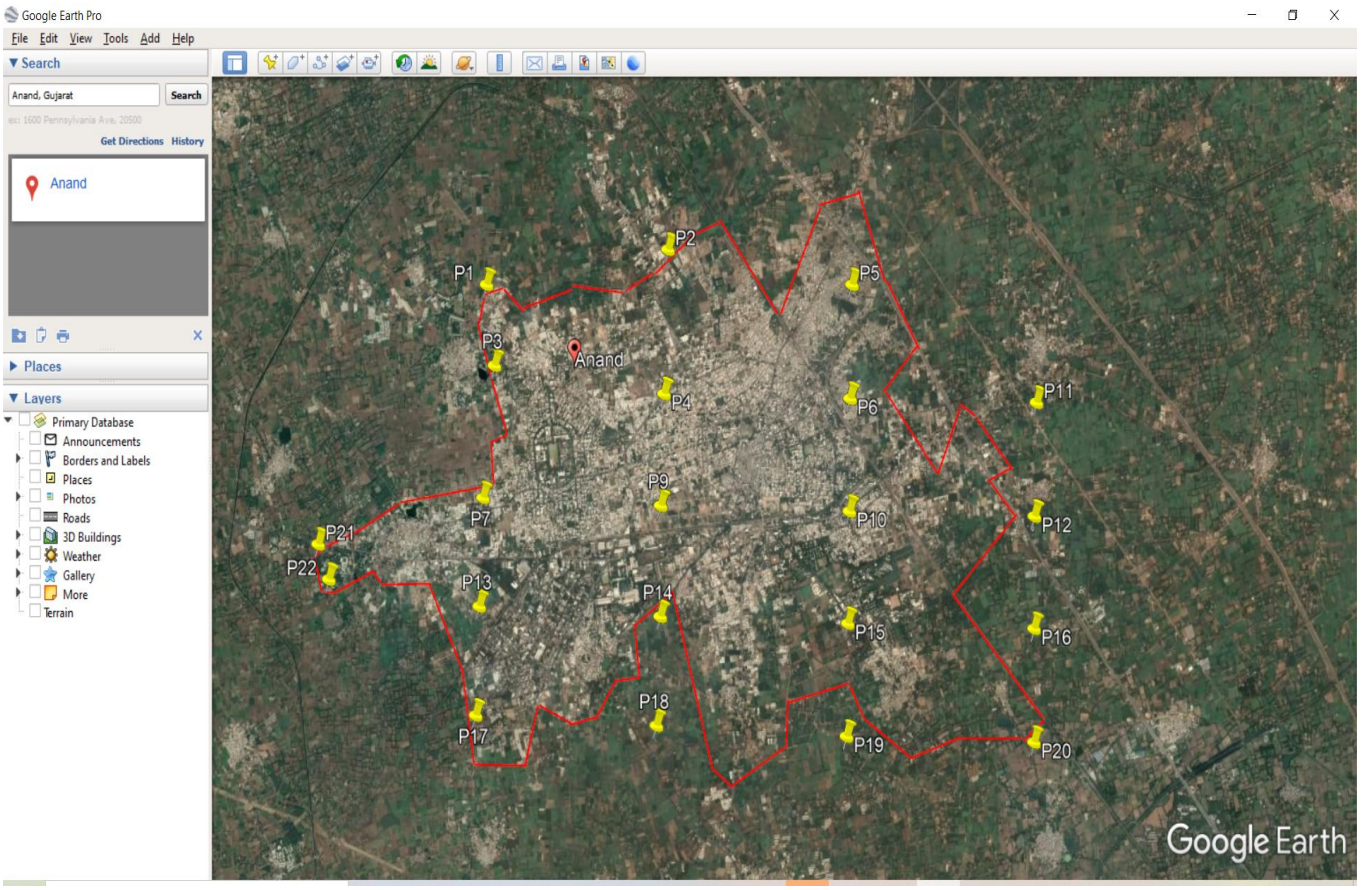


Step 3.

Now to download this data we have divided the area in 12 parts. Total Area covered is 48 Square Kilometers. Using the points as shown above.

Step 4.

Point the pins in selected area which are like corner points of images.

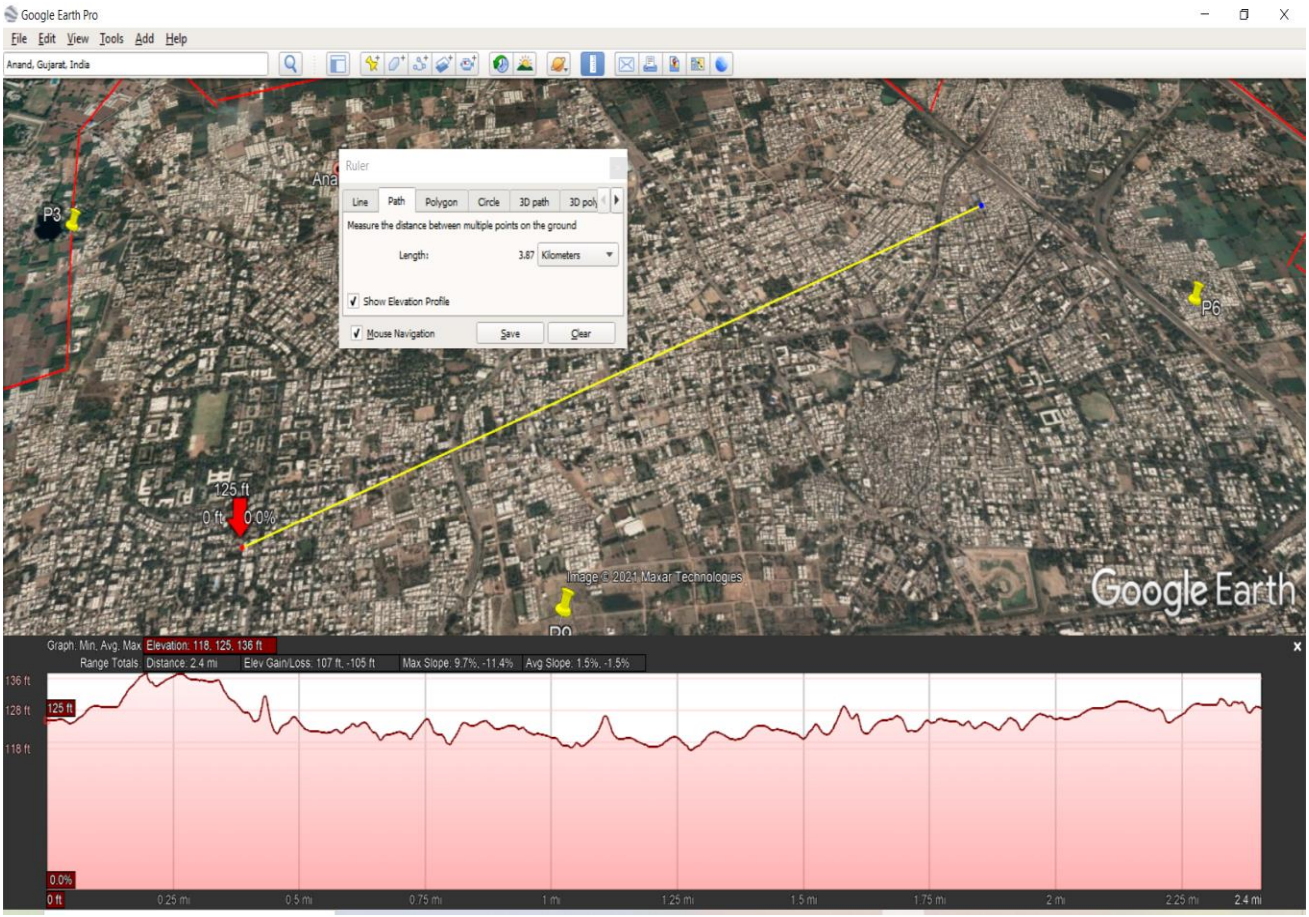


Step 5.

Now download the images according to points so that they can't be overlap. Steps to download image is as using key ctrl + alt + s and select resolution.

Step 6. (Elevation profile)

Now check the elevation profile of area by drawing path. It shows maximum, minimum and average elevation on that path with its length. Steps to draw path **Tools** > **Ruler** > **Path**.



5.1.2 Pros of Google Earth Pro:

1. Google Earth Pro offers the most comprehensive set of publicly available geospatial data, including high-resolution imagery, 3D cityscapes, detailed road maps, panoramic imagery at street level, historical imagery, and rich points of interest such as natural features, weather patterns, and business locations.

2. Google earth pro is easily available and free access app.

3. Available on a wide array of devices.

4. Additional layers available.

5. Free to use (for non-commercial applications), large library (entire world), no account needed, easily browsable, multiple resolutions available.

5.1.3 Cons Google Earth Pro:

1. Recent images might not be available, not downloadable, different licenses and pricing for commercial applications.

2. The satellite data on Google Maps is typically between 1 to 3 years old.

3. According to the Google Earth Blog, data updates usually happen about once a month, but they may not show real-time images.

4. Google Earth gathers data from various satellite and aerial photography sources, and it can take months to process, compare and set up the data before it appears on a map.

5. Low resolution in some areas.

6. Less developed countries are poorly presented on maps

5.2 Sentinel Hub

Sentinel Hub is a cloud-based GIS platform for distribution, management and analysis of satellite data. What we can do from Sentinel Hub

- **Explore Earth observation data.**
- **Import Imagery into Your GIS Application Using Standard OGC Web Services.**
- **Develop Remote Sensing Applications.**

We make satellite data (Sentinels, Landsat and other providers) easily accessible for you to be browsed or analyzed, within our cloud GIS or within your own environment.

Here we can access the data of Sentinel 2.

5.2.1 Sentinel-2

Sentinel-2 is an Earth observation mission from the Copernicus Programme that systematically acquires optical imagery at high spatial resolution (10 m to 60 m) over land and coastal waters. The mission is a constellation with two twin satellites, Sentinel-2A and Sentinel-2B. The mission supports a broad range of services and applications such as agricultural monitoring, emergencies management, land cover classification or water quality**.**

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

1. Multi-spectral data with 13 bands in the visible, near infrared, and short-wave infrared part of the spectrum.
2. Systematic global coverage of land surfaces from 56° S to 84° N, coastal waters, and all of the Mediterranean Sea.
3. Revisiting every 10 days under the same viewing angles. At high latitudes, Sentinel-2 swath overlap and some regions will be observed twice or more every 10 days, but with different viewing angles.
4. Spatial resolution of 10 m, 20 m and 60 m.
5. 290 km field of view.
6. Free and open data policy.

To achieve frequent revisits and high mission availability, two identical Sentinel-2 satellites (Sentinel-2A and Sentinel-2B) operate together. The satellites are phased 180 degrees from each other on the same orbit. This allows for what would be a 10-day revisit cycle to be completed in 5 days. The 290km swath is created by the VNIR and SWIR, which are each made of 12 detectors that are lined in two offset rows.

5.2.3 Instruments:

The Sentinel-2 satellites each carry a single multi-spectral instrument (MSI) with 13 spectral channels in the visible/near infrared (VNIR) and short wave infrared spectral range (SWIR). Within the 13 bands, the 10-meter spatial resolution allows for continued collaboration with the SPOT-5 and Landsat-8 missions, with the core focus being land classification.

5.2.4 Spectral bands

Spectral bands for Sentinel-2 sensors

Sentinel-2 bands	Sentinel-2A		Sentinel-2B		
	Central wavelength (nm)	Bandwidth (nm)	Central wavelength (nm)	Bandwidth (nm)	Spatial resolution (m)
Band 1 – Coastal aerosol	442.7	21	442.2	21	60
Band 2 – Blue	492.4	66	492.1	66	10
Band 3 – Green	559.8	36	559.0	36	10
Band 4 – Red	664.6	31	664.9	31	10
Band 5 – Vegetation red edge	704.1	15	703.8	16	20
Band 6 – Vegetation red edge	740.5	15	739.1	15	20
Band 7 – Vegetation red edge	782.8	20	779.7	20	20
Band 8 – NIR	832.8	106	832.9	106	10
Band 8A – Narrow NIR	864.7	21	864.0	22	20
Band 9 – Water vapour	945.1	20	943.2	21	60
Band 10 – SWIR – Cirrus	1373.5	31	1376.9	30	60
Band 11 – SWIR	1613.7	91	1610.4	94	20
Band 12 – SWIR	2202.4	175	2185.7	185	20

5.2.5 Sentinel Band Combinations

We use band combinations to better understand the features in imagery. The way we do this is by rearranging the available channels in creative ways. By using band combinations, we can extract specific information from an image. For example, there are band combinations that highlight geologic, agricultural, or vegetation features in an image.

We use

1. Natural Color (B4, B3, B2): - Its purpose is to display imagery the same way our eyes see the world.
2. Bathymetric (B4, B3, B1): - The bathymetric band combination is good for coastal studies. It's good for estimating suspended sediment in the water.
3. Moisture Index (B8A-B11)/(B8A+B11): - It uses the short-wave and near-infrared to generate an index of moisture content.
4. Short-Wave Infrared (B12, B8A, B4):- This composite shows vegetation in various shades of green. In general, darker shades of green indicate denser vegetation. But brown is indicative of bare soil and built-up areas.

5.2.6 Application

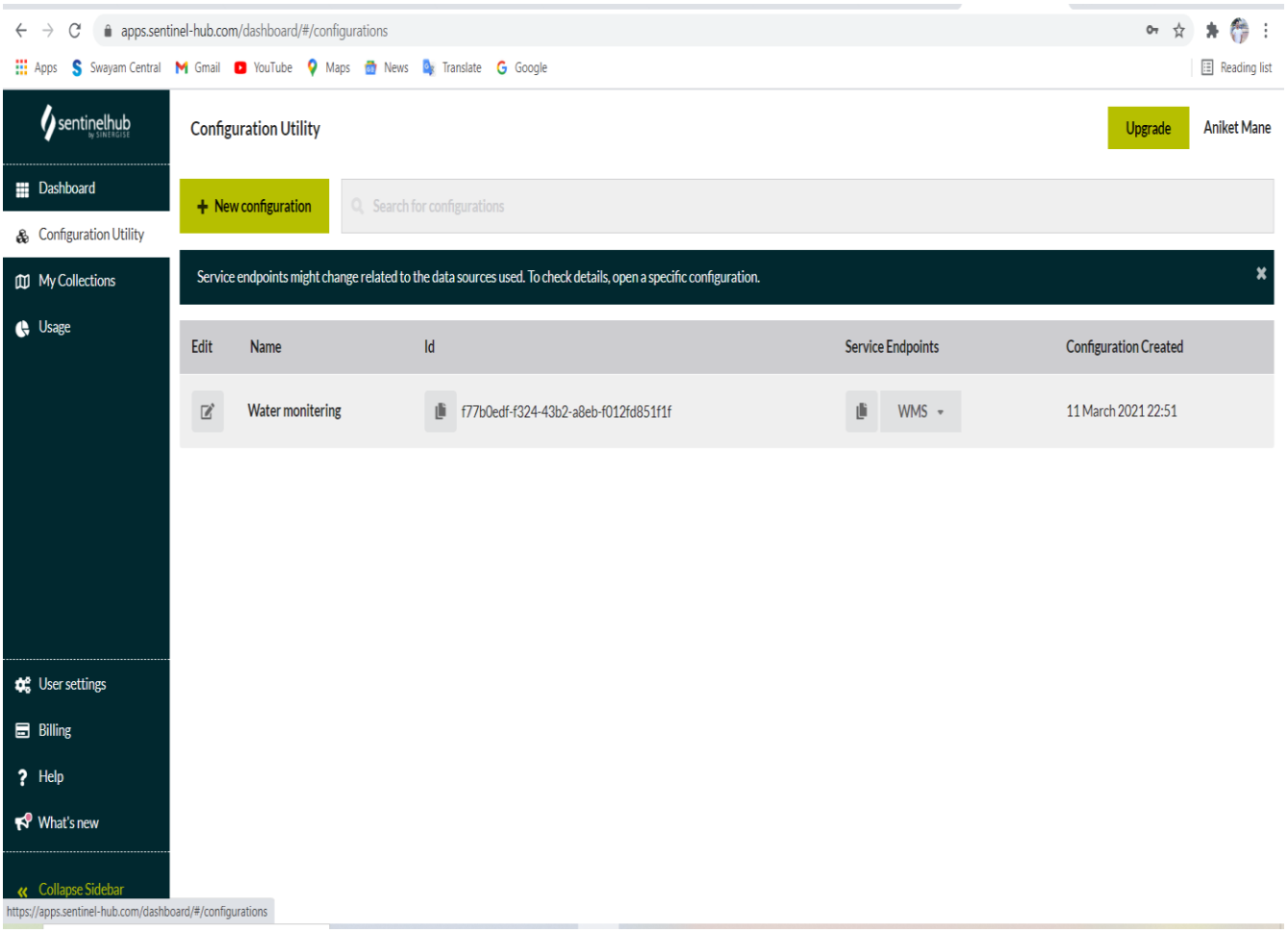
Sentinel-2 serves a wide range of applications related to Earth's land and coastal water.

- Monitoring land cover change for environmental monitoring.
- Agricultural applications, such as crop monitoring and management to help food security.
- Detailed vegetation and forest monitoring and parameter generation. (e.g., leaf area index, chlorophyll concentration, carbon mass estimations)
- Observation of coastal zones (marine environmental monitoring, coastal zone mapping)
- Inland water monitoring.
- Glacier monitoring, ice extent mapping, snow cover monitoring.
- Flood mapping & management (risk analysis, loss assessment, disaster management during floods)
- Lava flow mapping.

5.2.7 Get Sentinel 2 data in Sentinel hub:

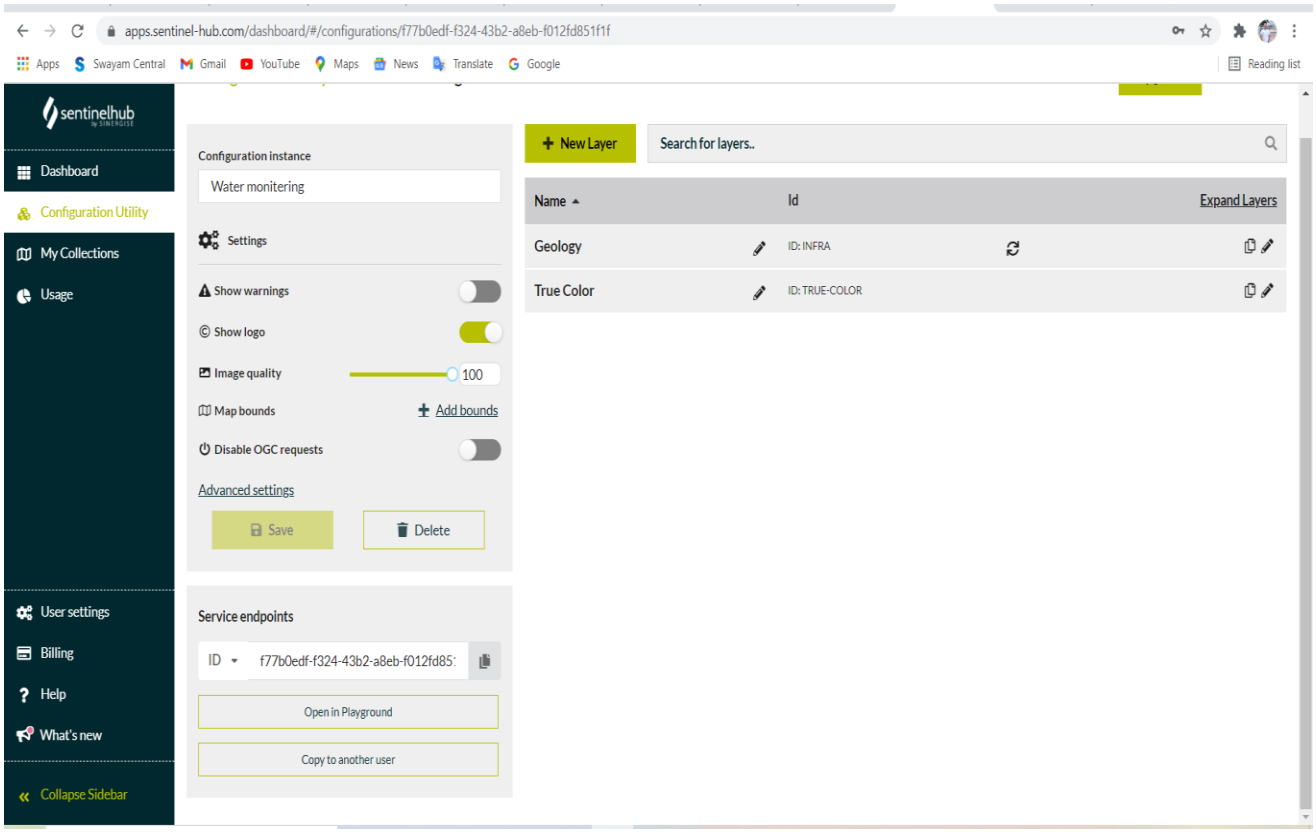
Steps:

1. Click on *www.sentinel-hub.com/* and sign in / sign up into Sentinel hub.
2. After signing in you appear a window.



3. Click on Configuration Utility at upper left corner.
4. Click on New Configuration, then give Configuration name and appropriate configuration.
5. Click create configuration.

6. Then your created configuration, click on Open in Playground.



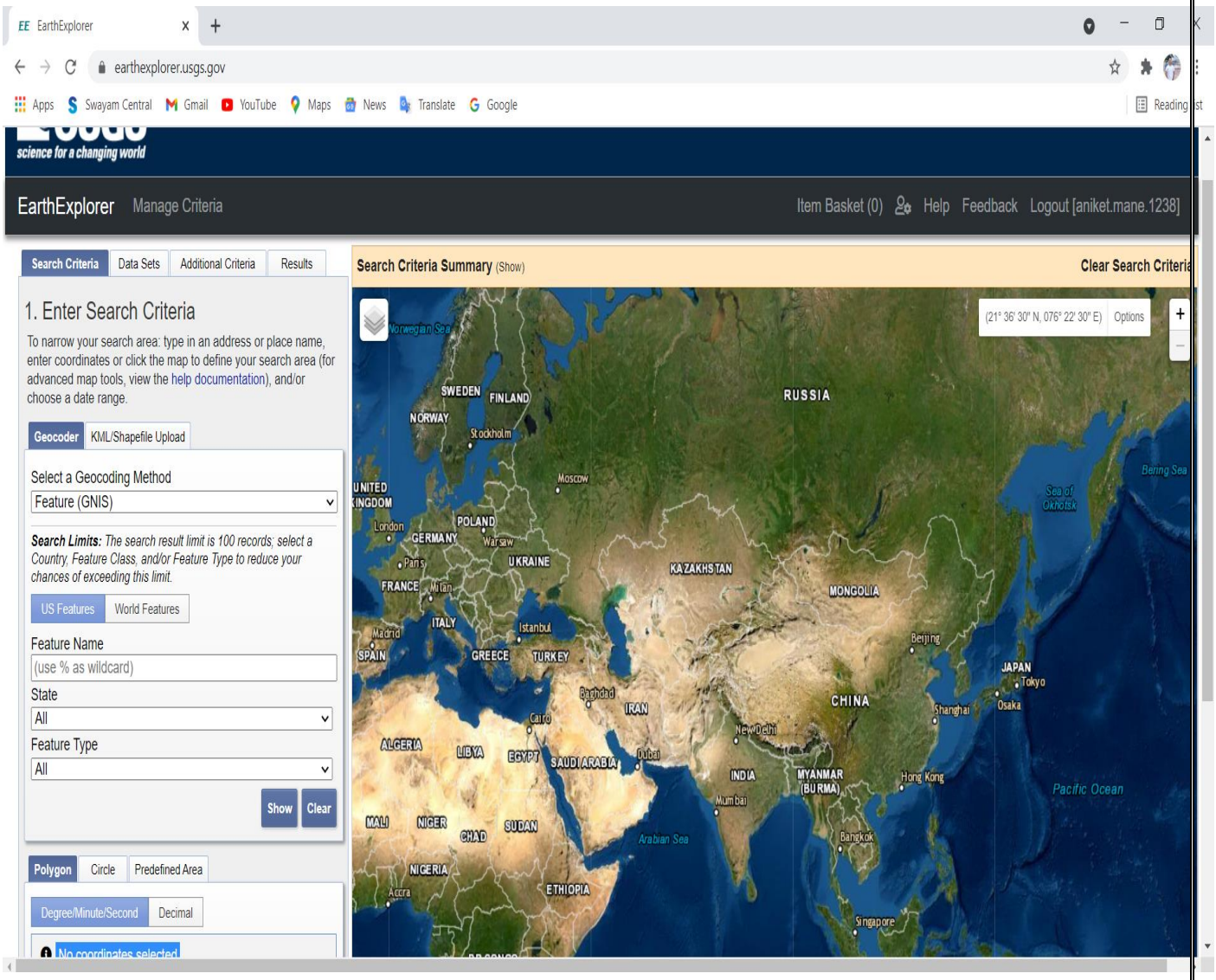
5.3 United States Geological Survey (USGS):

The United States Geological Survey (USGS, formerly simply Geological Survey) is a scientific agency of the United States government. The USGS is a bureau of the United States Department of the Interior; it is that department's sole scientific agency. The organization's work spans the disciplines of biology, geography, geology, and hydrology. The USGS is a fact-finding research organization with no regulatory responsibility.

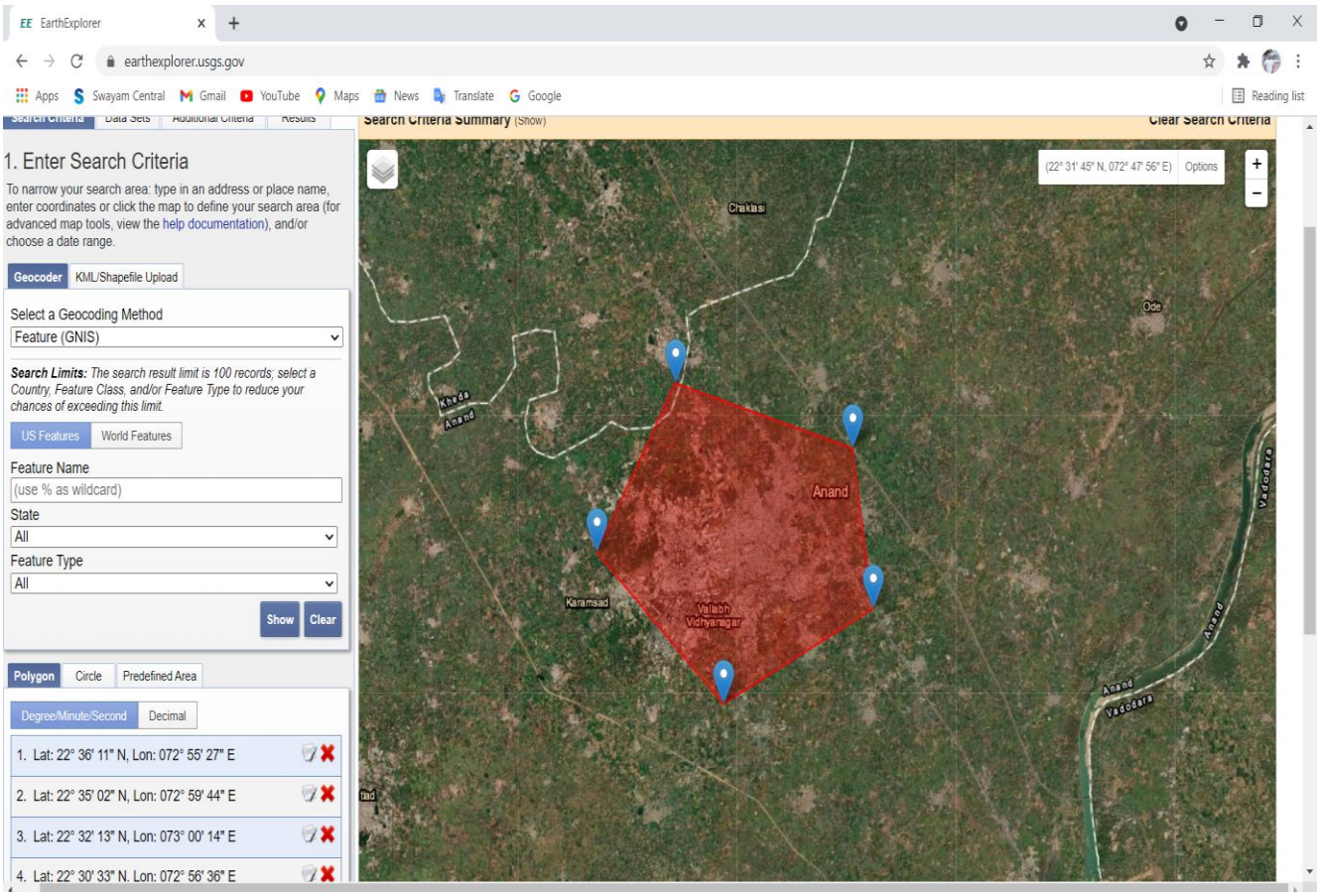
5.3.1 Steps for getting sentinel-2 data in USGS:

1. Open https://earthexplorer.usgs.gov/ and login.

2. You will get window like

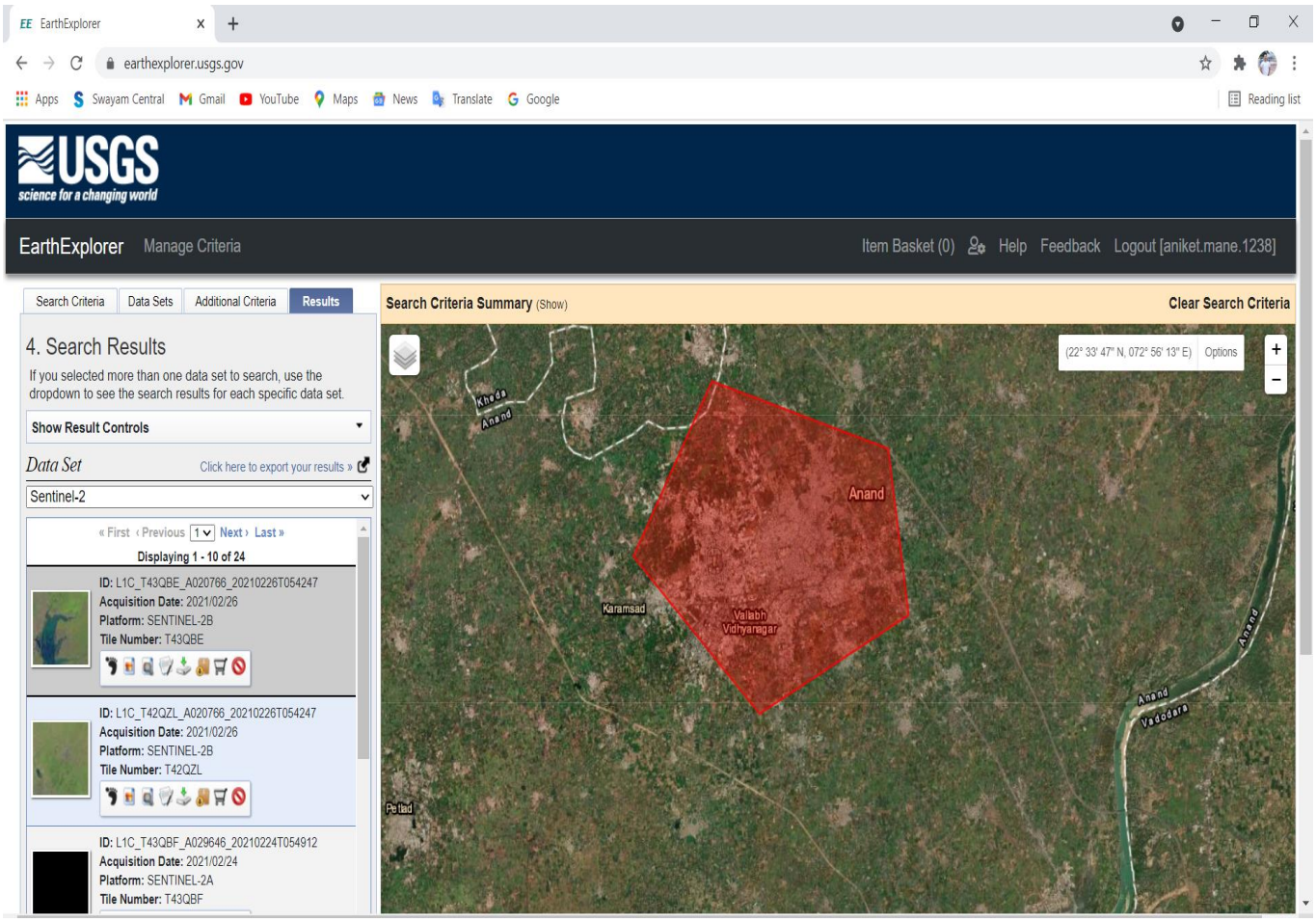


3. Find your area of interest and select points for polygon. Showed in figure.



4. In **Search Criteria** set Date range, Cloud Cover.
5. From **Data Sets** select Sentinel-2.
6. In **Additional criteria** select cloud cover (less is clear).

7. Then click on **Results** you will get datasets for selected Date range and download dataset. Which shows in below figure.



8. Then we get the Compressed (zipped) file which we have to extract.
9. Then these data files are used for further analysis in different apps like QGIS, SNAP, ArcGIS etc.

6. SOFTWARE FOR ANALYSIS OF SATELLITE DATA

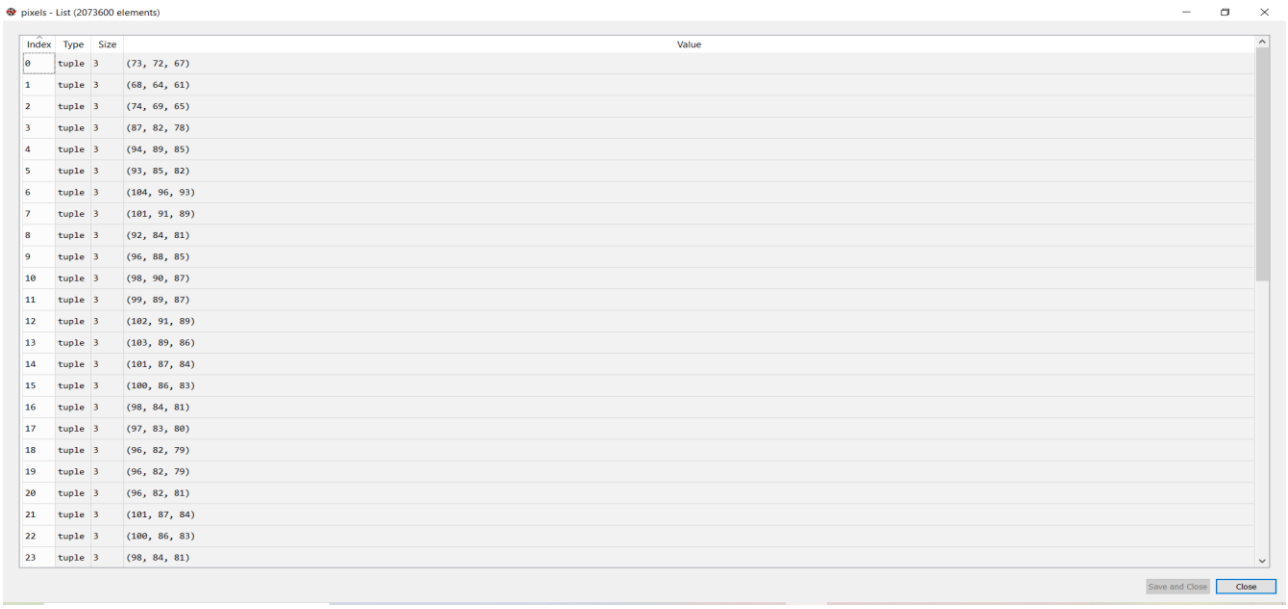
6.1 Python

We use this software for extracting vector data of an image.

We used following python code for extract pixel values from google earth pro images. In this we use the python libraries like PIL (Python Imaging Library) and glob.

```
1  from PIL import Image
2  import glob,os
3
4  paths = glob.glob("path")
5  im = list(map(Image.open, paths))
6  for  obj in im:
7      pixels = list(obj.getdata())
8
9  pixels
```

Then we get following output values.



In this we get Full HD (1080*1920) image pixel values but in this we can't extract the values of high-resolution images. That's why we use following software for extract the vector data.

6.2 QGIS (Quantum Geographic Information System)

QGIS is a free and open-source cross-platform desktop application that supports viewing, editing, and analysis of geospatial data. Also, for composing and exporting graphical maps. QGIS supports both raster and vector layers. QGIS supports shapefiles, coverages, personal geodatabases, dxf, MapInfo, PostGIS, and other formats.

6.2.1 Pros of QGIS:

1. Its Free to use-QGIS is one of the applications of its sort that is completely free to use. However, it comes with some features and core plugins that will provide basic usability.
2. Allows users to View and Overlay vector and raster data– The benefit is that this application will help you view and overlay two types of data which is Vector and Raster data. To add on that, it allows you to do this in many different projections.
3. The application has a surfeit of usable features-Some of these useful features include vector analysis, geometry tools, sampling, and geo-processing.
4. It's more versatile than ArcGIS. The fact that this platform is Mac and Linux friendly makes it one of the best out there for the versatility.

6.2.2 Cons of QGIS:

1. It is less Beginner Friendly-To some extent, most people think that this application is confusing to beginners.
2. The platform takes a lot from ArcGIS. If closely checked, you will realize that QGIS takes a lot of computing power from ArcGIS.
3. It lacks a proper online tutorial. The fact that there are no proper tutorials and online help makes this application hard to use.
4. Labeling Interface is complicated-The interface allows users to manually add the labels to relevant items because it's overly complicated.
5. It takes a lot of time to learn-This is a platform that will consume a lot of your time in order to understand it fully.

6.3 Sentinel Application Platform (SNAP)

The SNAP architecture is ideal for Earth Observation processing and analysis due to the following technological innovations: Extensibility, Portability, Modular Rich Client Platform, Generic EO Data Abstraction, Tiled Memory Management, and a Graph Processing Framework.

6.3.1 Pros of SNAP:

1. Very fast image display and navigation even of giga-pixel image
2. Graph Processing Framework (GPF): for creating user-defined processing chains.
3. Rich region-of-interest definitions for statistics and various plots.
4. Flexible band arithmetic using arbitrary mathematical expressions.

6.3.2 Cons of SNAP:

1. **It is less Beginner Friendly**-To some extent, most people think that this application is confusing to beginners.
2. **It lacks a proper online tutorial.** The fact that there are no proper tutorials and online help makes this application hard to use.
3. **It takes a lot of time to learn**-This is a platform that will consume a lot of your time in order to understand it fully.

6.4 ArcGIS:

ArcGIS is a geographic information system (GIS) for working with maps and geographic information maintained by the Environmental Systems Research Institute (Esri). It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web.

6.4.1 Pros of ArcGIS:

1. **The power-The power that this platform provides is the first and the most important benefit.** Most users like the power it offers for spatial analysis and the data. There have been a couple of improvements in the latest version. The latest version includes the most popular data analysis python libraries.

2. **It has a tool for almost anything you could think of doing**. This is another benefit that users are talking about. The platform has compelling tools that can help you in all dimensions. It has "smart maps" which offers a lot of functionalities.

3. **The software has preset** of tools-Everyone would agree that ArcGIS is a very powerful tool with a stipulated of tools. Though it takes some training and playing around to learn the whole thing.

4. This software has an excellent reputation and experience in GIS software. This is the reason why this is an excellent and competitive computerized geographic analysis.

5. **Advanced statistical tools**-The software has a couple of advanced statistical tools that are much helpful in the whole process.

6. **Effective handling of a large amount of vector data**. The software will correctly and effectively handle a large amount of vector and raster data. This is another thing that makes this software merely the best.

7. Has applications for publishing web maps for the public. These applications make reporting easy and very fast.

8. **Most of its features, specifically the ArcMap, are easier to navigate**. The best thing about this is that there are a couple of tutorials on YouTube. There are also many books in the software to make your work easier.

6.4.2 Cons of ArcGIS:

1. **Price-**The first con to spot is the price. The standard licenses are scary high.

2. **ArcGIS online search from a pro is limited**. The software is regarded as less flexible than the traditional ArcGIS server. This is examined in terms of hosting services and mapping capacities,

3. **You will not get all the features before paying for a premium subscription**.

4. **Esri products are presented as the only solution to the problem.** I think using Programming solutions and using FOSS can save you a lot of money and time. Learning the Esri products can as well be very difficult.

5. **Customer care may ignore some bugs and issues**. The reality is that this software has a significant market share, and for that reason, they will not be very wary of any complains or issues by a single customer.

6. **You can wait for a long time for the software to open**. This is another con that makes a lot of people think this software is not highly reliable. You will have to wait for a long time for it to open after you launch.

7. **The interface is not very friendly**. Though, this is not a big issue compared to the features the software hosts. Though, sometimes it can be very hard to know where the specific tools are.

7. STATISTICAL THEORY

7.1 PCA (Principal Component Analysis)

7.2 Supervised Classification

7.3 Maximum Likelihood Classification

7.1 Principal component analysis (PCA)

7.1.1 WHAT IS PCA:

Principal Component data usually capture all the spectral information from the bands, and compressed/merged it all into principal components, Principal Component has the most of spectral information, followed by Principal Component 2 stored the rest of the spectral information which can't be stored in Principal Component. PCA analysis is useful if you want to extract earth surface information from multispectral/hyperspectral satellite imagery, which has so much of spectral signature information, in an easy way. Based on the PCA result, you then can-do information extraction using image classification or image segmentation.

Principal component analysis (PCA) is one of the statistical techniques frequently used in signal processing to the data dimension reduction or to the data decorrelation.

7.2 Supervised Classification

With the ArcGIS Spatial Analyst extension, the Multivariate toolset provides tools for both supervised and unsupervised classification. The Image Classification toolbar provides a user-friendly environment for creating training samples and signature files used in supervised classification. The Maximum Likelihood Classification tool is the main classification method. A signature file, which identifies the classes and their statistics, is a required input to this tool. For supervised classification, the signature file is created using training samples through the Image Classification toolbar. For unsupervised classification, the signature file is created by running a clustering tool. Spatial Analyst also provides tools for post-classification processing, such as filtering and boundary cleaning.

In supervised classification the user or image analyst "supervises" the pixel classification process. The user specifies the various pixels values or spectral signatures that should be associated with each class. This is done by selecting representative sample sites of a known cover type called Training Sites or Areas. The computer algorithm then uses the spectral signatures from these training areas to classify the whole image. Ideally, the classes should not overlap or should only minimally overlap with other classes.

7.2.1 Training Sites

Training sites are areas that are known to be representative of a particular land cover type. The computer determines the spectral signature of the pixels within each training area, and uses this information to define the statistics, including the mean and variance of each of the classes. Preferably the location of the training sites should be based on field collected data or high-resolution reference imagery. It is important to choose training sites that cover the full range of variability within each class to allow the software to accurately classify the rest of the image. If the training areas are not representative of the range of variability found within a particular land cover type, the classification may be much less accurate. Multiple, small training sites should be selected for each class. The more time and effort spent in collecting and selecting training site the better the classification results.

7.2.2 Advantages of Supervised Classification:

1. In supervised classification the majority of the effort is done prior to the actual classification process.

2. Once the classification is run the output is a thematic image with classes that are labeled and correspond to information classes or land cover types.

3. Supervised classification can be much more accurate than unsupervised classification.

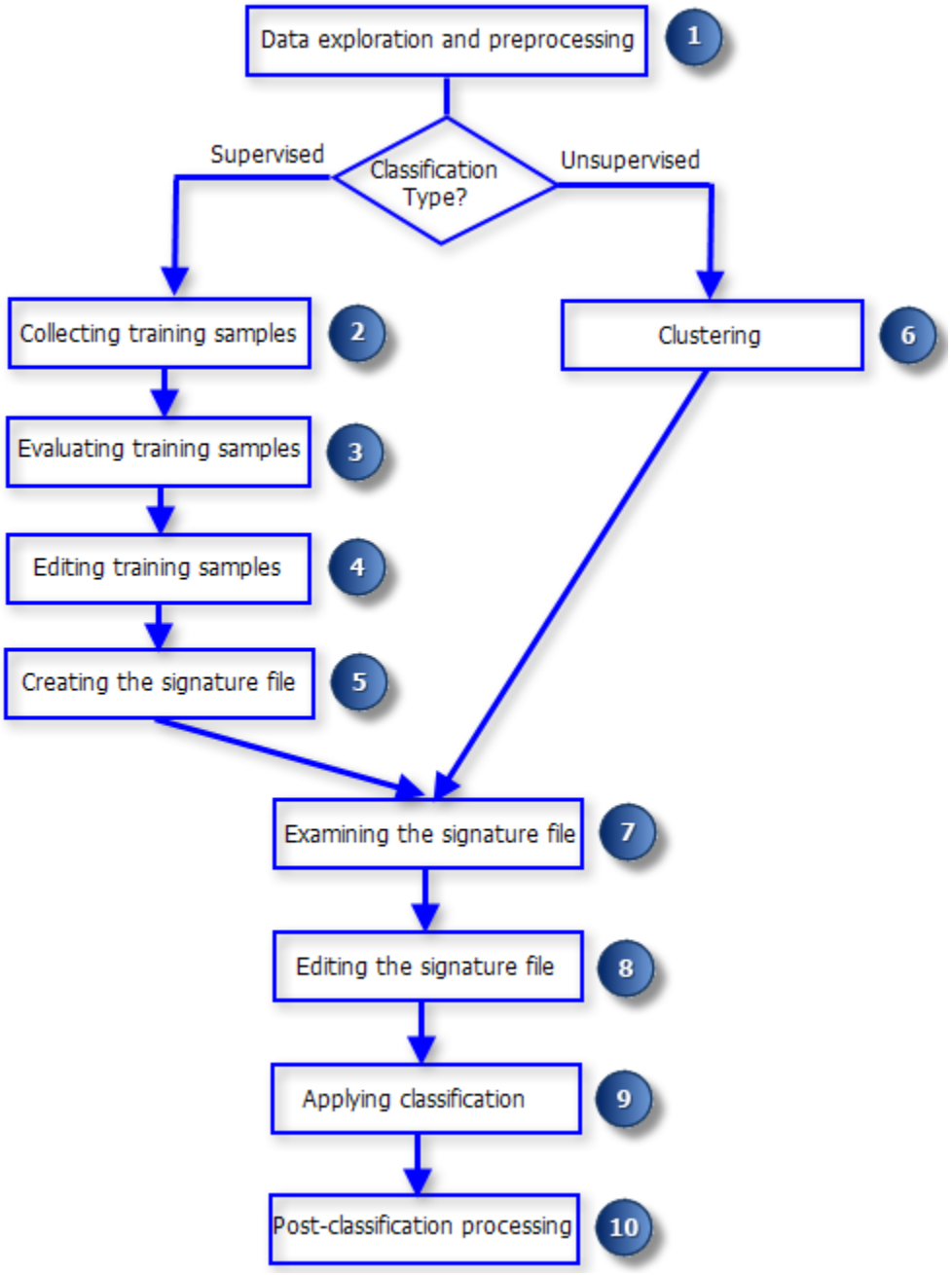
7.2.3 Disadvantages of Supervised Classification:

1. Depends heavily on the training sites.

2. If two or more classes are very similar to each other in terms of their spectral reflectance (e.g., annual-dominated grasslands vs. perennial grasslands), mis-classifications will tend to be high.

3. If the training data is poor or not representative the classification results will also be poor.

The detailed steps of the image classification workflow are illustrated in the following chart.



7.3 Maximum Likelihood Classification

Maximum likelihood classification assumes that the statistics for each class in each band are normally distributed and calculates the probability that a given pixel belongs to a specific class. Unless you select a probability threshold, all pixels are classified. Each pixel is assigned to the class that has the highest probability (that is, the maximum likelihood). If the highest probability is smaller than a threshold you specify, the pixel remains unclassified.

7.3.1 How Maximum Likelihood Classification works

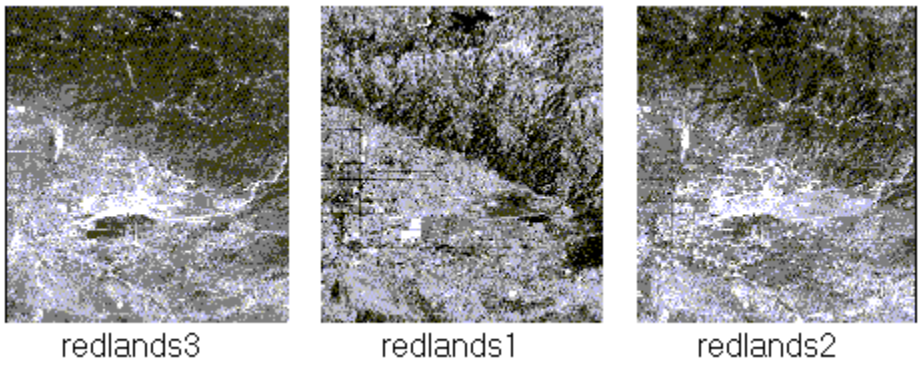
The algorithm used by the Maximum Likelihood Classification tool is based on two principles:

- The cells in each class sample in the multidimensional space being normally distributed
- Bayes' theorem of decision making

When a maximum likelihood classification is performed, an optional output confidence raster can also be produced. This raster shows the levels of classification confidence.

7.3.2 Example

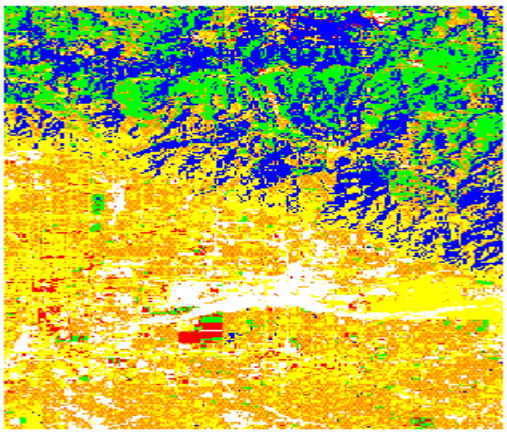
The following example shows the classification of a multiband raster with three bands into five classes. The five classes are dry riverbed, forest, lake, residential/grove, and rangeland. An output confidence raster will also be produced. The input raster bands are displayed below.



Example inputs to Maximum Likelihood Classification

The Maximum Likelihood Classification tool is used to classify the raster into five classes.

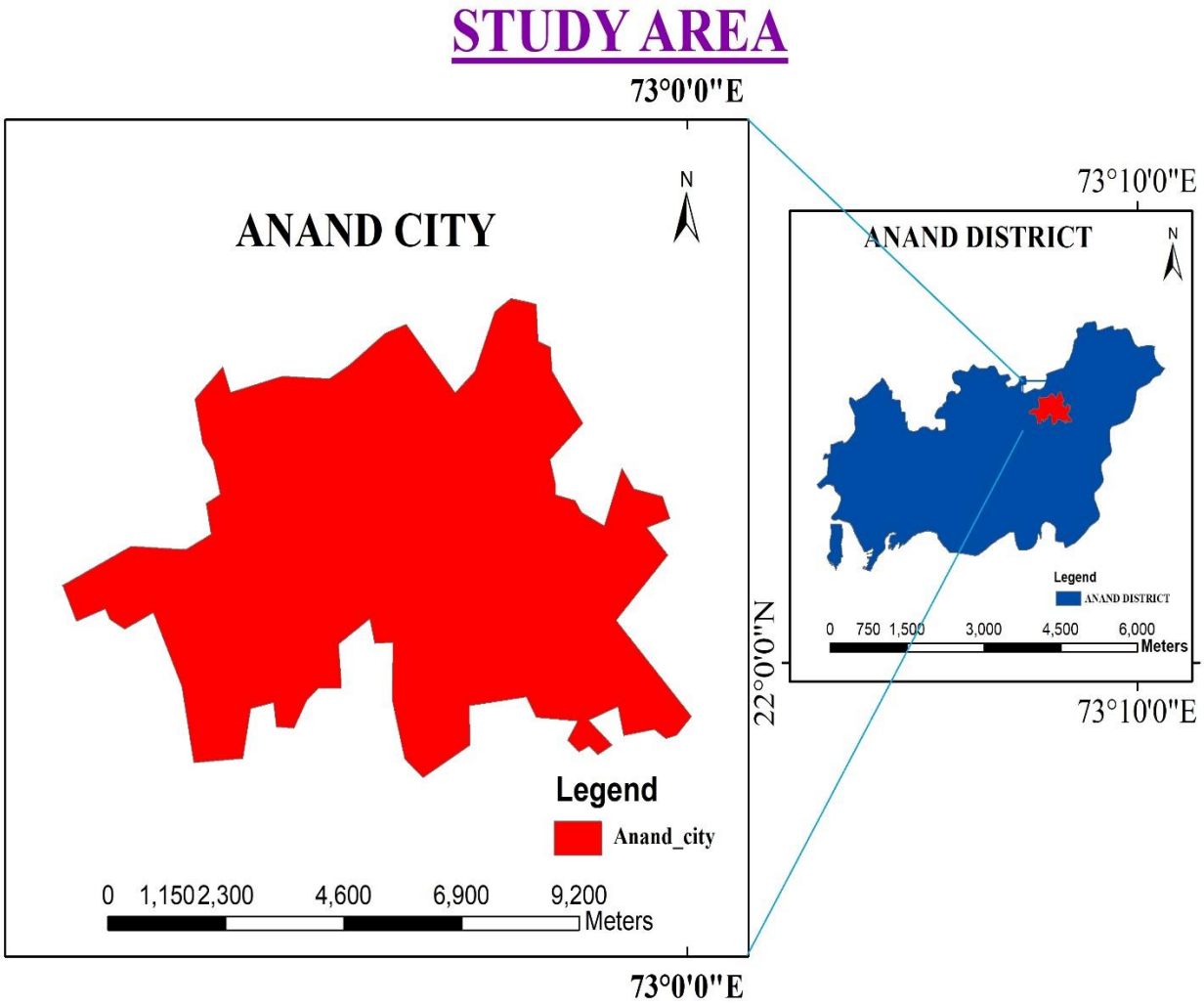
The classified raster appears as shown:



Example output from Maximum Likelihood Classification

The dry riverbed class is displayed as white, with the forest class as green, lake class as blue, residential/grove class as yellow, and rangeland as orange.

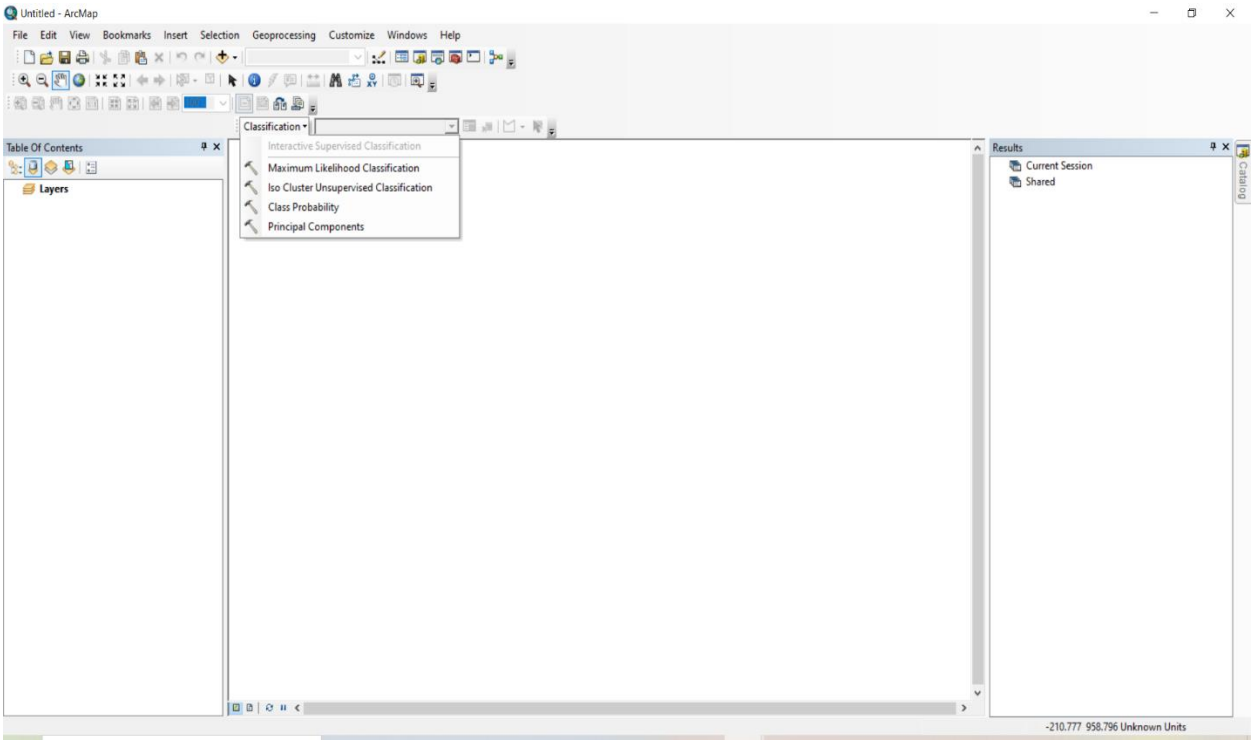
8. STUDY AREA


STUDY AREA
73°0'0"E
ANAND CITY
N
Legend
Anand_city
0 1,150 2,300 4,600 6,900 9,200
Meters
73°0'0"E
73°10'0"E
ANAND DISTRICT
N
Legend
ANAND DISTRICT
0 750 1,500 3,000 4,500 6,000
Meters
22°0'0"N
73°10'0"E

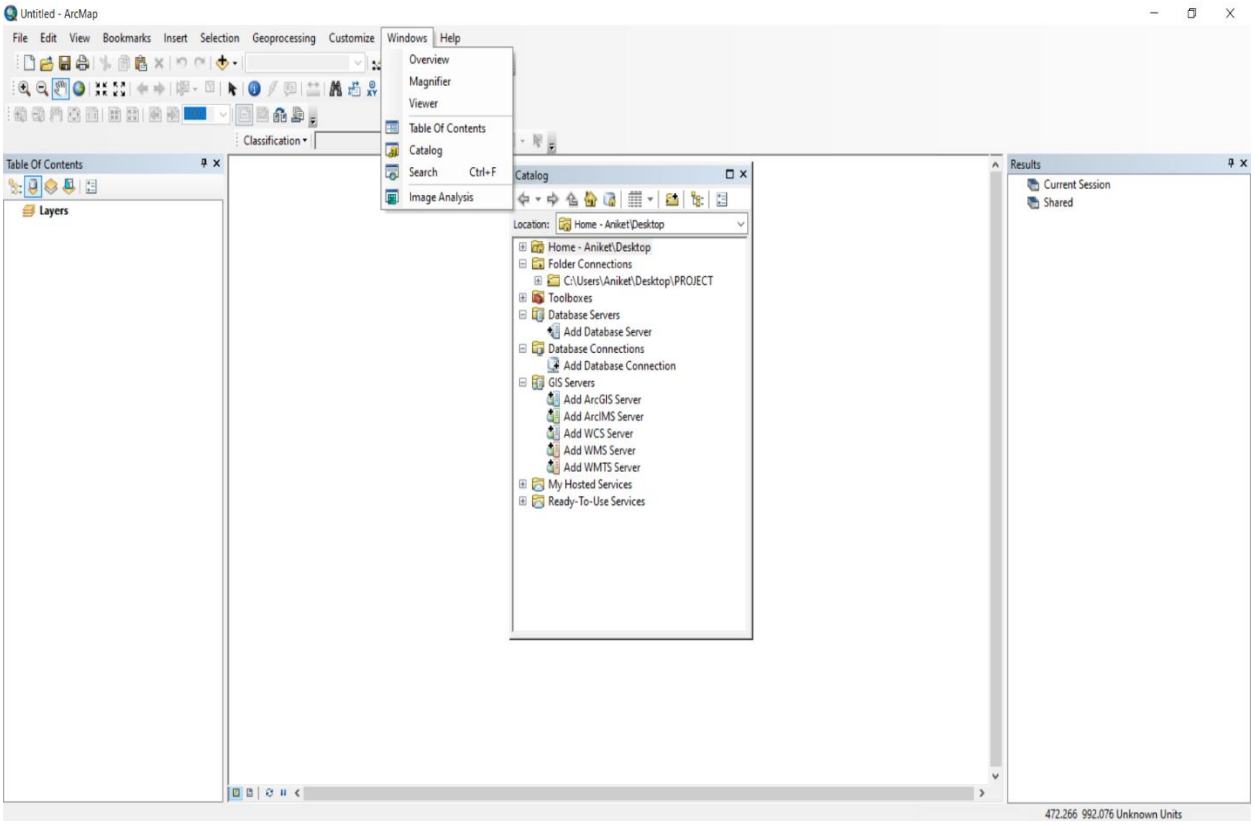
9. ANALYSIS

9.1 Steps for Principal Component Analysis (PCA):

1. Activate image classification toolbar from ArcMap menu list. The toolbar will be display in the user interface.

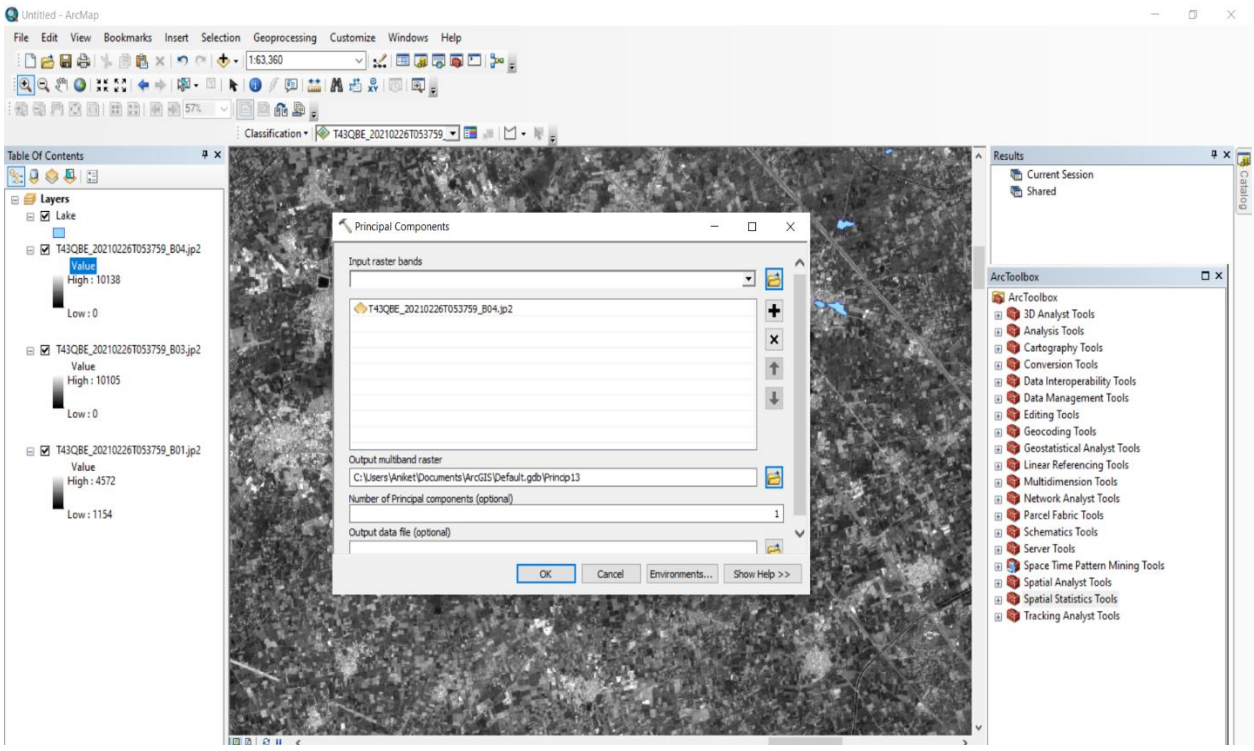


2. Open sentinel-2 data downloaded from USGS earth explorer from catalog window.

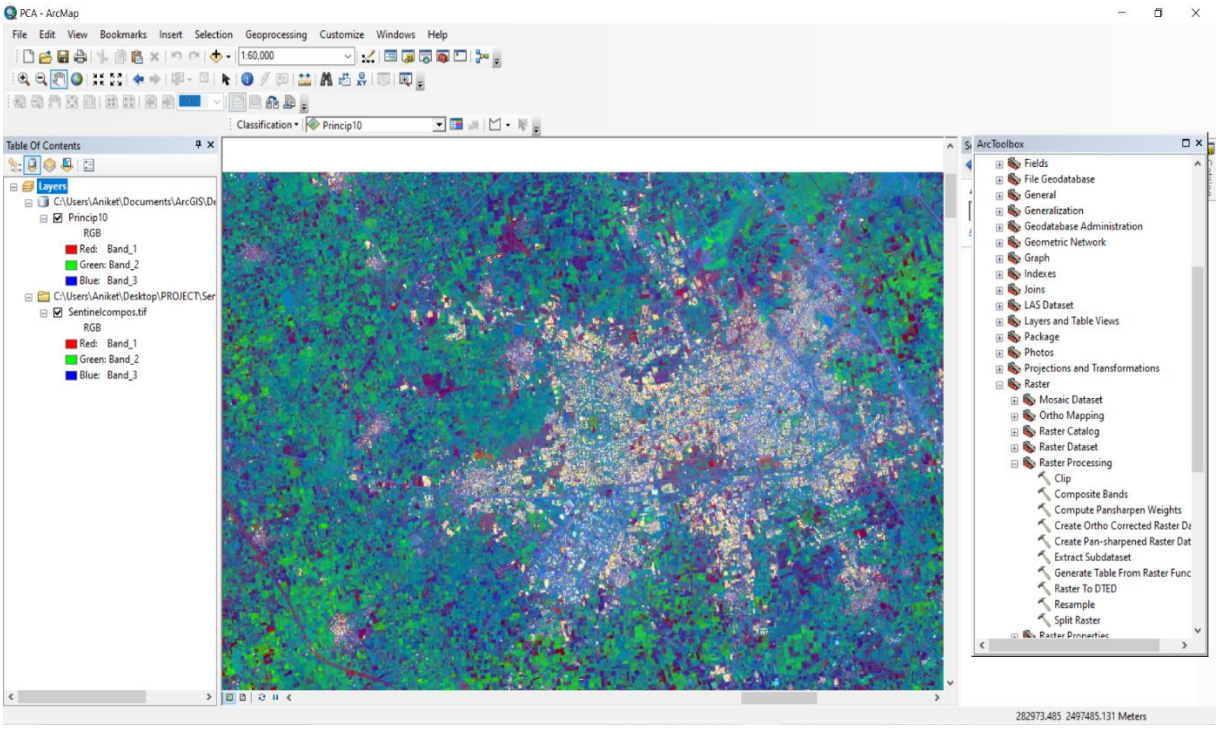


3. Open the data by drag and drop the metadata file (True color dataset) into ArcMap view.
4. The data has been loaded, it is covered large extent of area, so we will subset it into smaller area coverage.

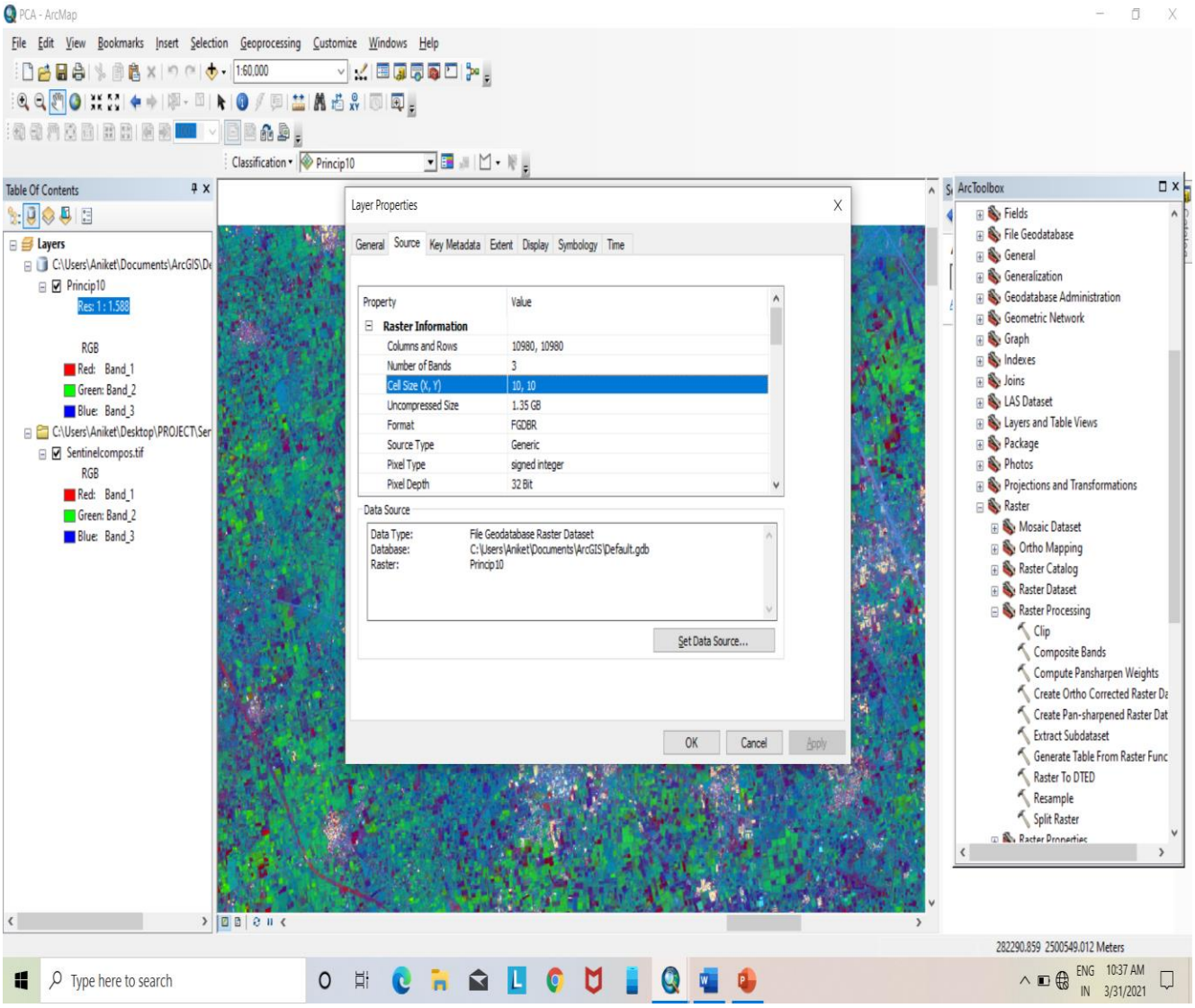
5. Click the classification menu and choose principal Component. Principal Component menu shows up, the input bar is automatic filled, specify output location, number extracted Principal Component.



6. We got result by clicking on **Princip10** from layers.



7. Result of PCA is as:



9.2 To Estimate Area of Water Cover in Anand City

For finding area of statistics, we used Short-Wave Infrared (B12, B8A, B4) and we use Statistical Tools Supervised Classification and Maximum Likelihood Classification.

9.2.1 Steps in ArcGIS:

1. Creating a multiband image (SWIR BAND)

2.Make shapefile of study area

3.Extraction of study area

4. Collecting training samples

5. Evaluating training samples

6. Editing classes

7. Creating the signature file

I. **Examining the signature file**
II. **Editing the signature file**

8. Applying classification

9.Conversion of file from Raster to Polygon

10. Calculate Geometry

11. Export data

12.Find Area of Statistics

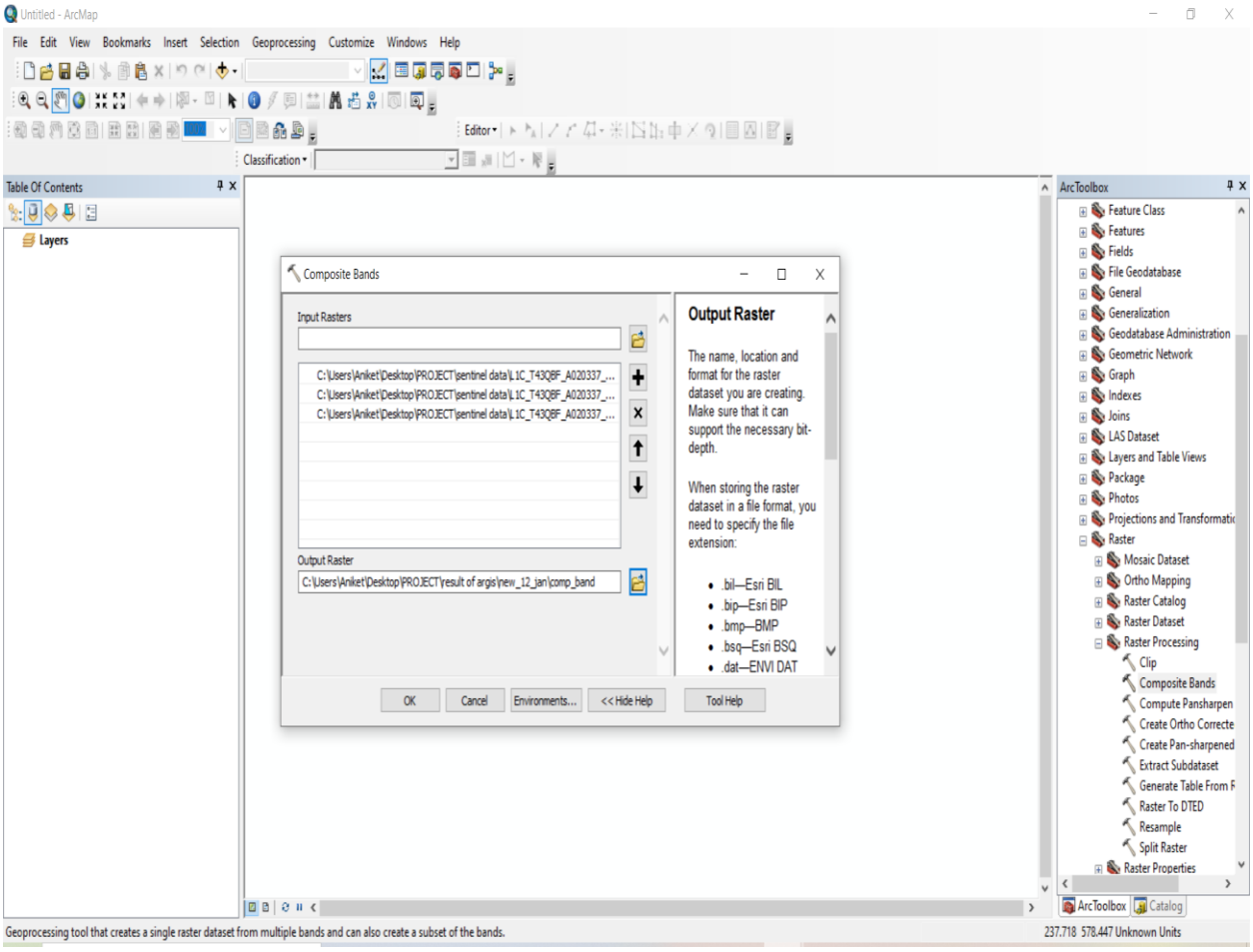
- **How to Create a multiband image?**

The Image Classification toolbar works with a multiband image layer. To load individual bands to a new multiband image, use the Composite Bands tool.

To make composite bands in ArcMap enable Arc Toolbox.

Click **Data Management Tools > Raster > Raster Processing > Composite Bands.**

Then give **Input Rasters** and **Output Raster.** Click OK



- **How to make shapefile?**

Enable Catalog. Then Right Click on it.

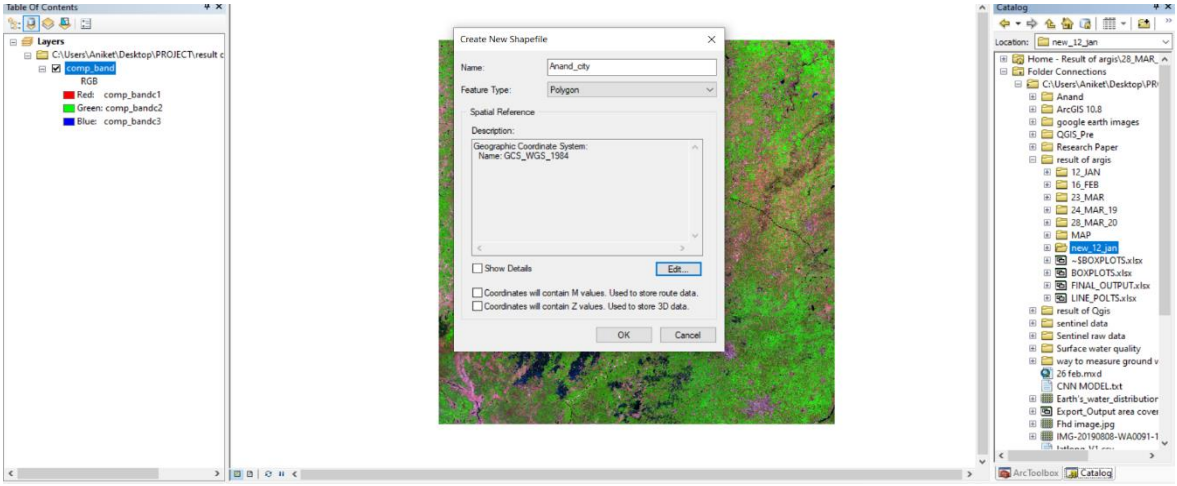
Click **New > Shapefile.** Give **Name**, select Feature type as '**Polygon**' then click on **Edit…**

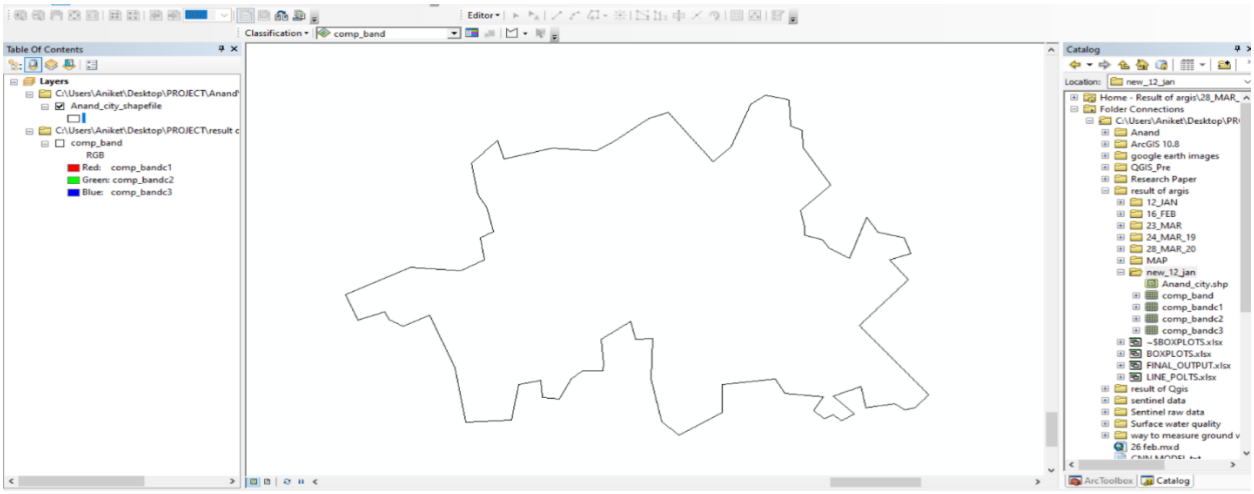
In **XY Coordinate system > Geographic Coordinate System > World > WGS 1984. Then click OK.**

Then click on **Editor > Start Editing > Shapefile_Name > OK > Shapefile_Name > Continue.**

Now go to **Create Features** select **Shapefile_Name** and **Polygon**

Then select area as polygon, Save Edits and Stop Edits.





- **How to Extract area by Mask?**

In Arc Toolbox go to **Spatial Analyst Tools > Extraction > Extract by Mask.**

Then give **Input raster** and **Output raster.** Click OK.

- **How to make Signature file?**

In supervised classification, training samples are used to identify classes and calculate their signatures. Training samples can be created interactively using the training sample drawing tools on the Image Classification toolbar. Creating a training sample is similar to drawing a graphic in ArcMap except training sample shapes are managed with Training Sample Manager instead of in an ArcMap graphic layer. To create a training sample, select one of the training sample drawing tools (for example, the polygon tool) on the Image Classification toolbar and draw on the input image layer. The number of pixels in each training sample should not be too small nor too large. If the training sample is too small, it may not provide enough information to adequately create the class signature. If the training sample is too large, you might include pixels that are not part of that class. If the number of bands in the image is n, the optimal number of pixels for each training sample would be between 10n and 100n.

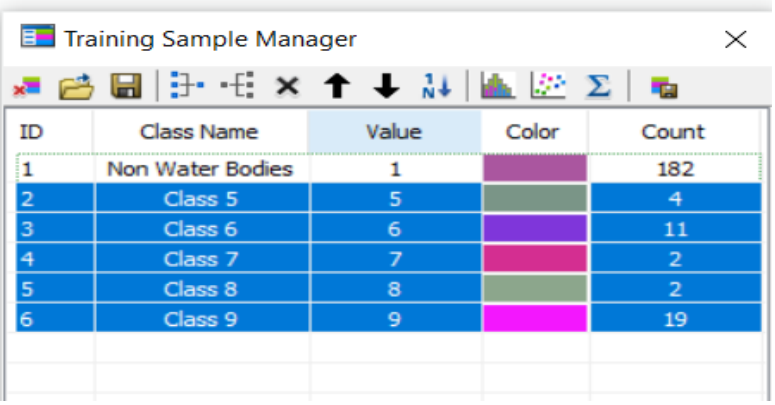
Click **Training Sample Manager.** Then select different training samples, merge them and name it.

I. Collecting Training Samples: -

When training samples are drawn in the display, new classes are automatically created in the Training Sample Manager.

II. Evaluating training samples :-

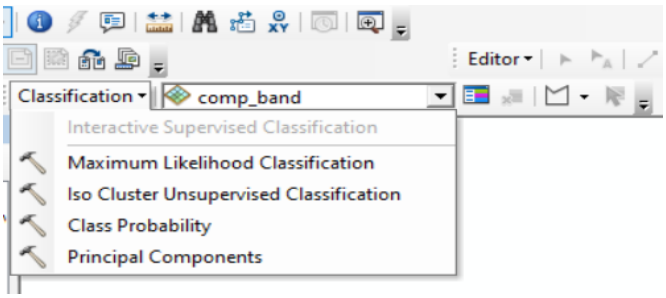
Depending on the outcome of the training sample evaluation, you may need to merge the classes that are overlapping each other into one class. This can be done using the **Merge** tool in the manager window. In addition, you can rename or renumber a class, change the display color, split a class, delete classes, save and load training samples, and so forth. The following image shows how to merge two classes:



Once you determine the training samples are representative of the desired classes and are distinguishable from one another, a signature file can be created using the **Create Signature File** tool in the manager window.

- **Maximum likelihood classification**

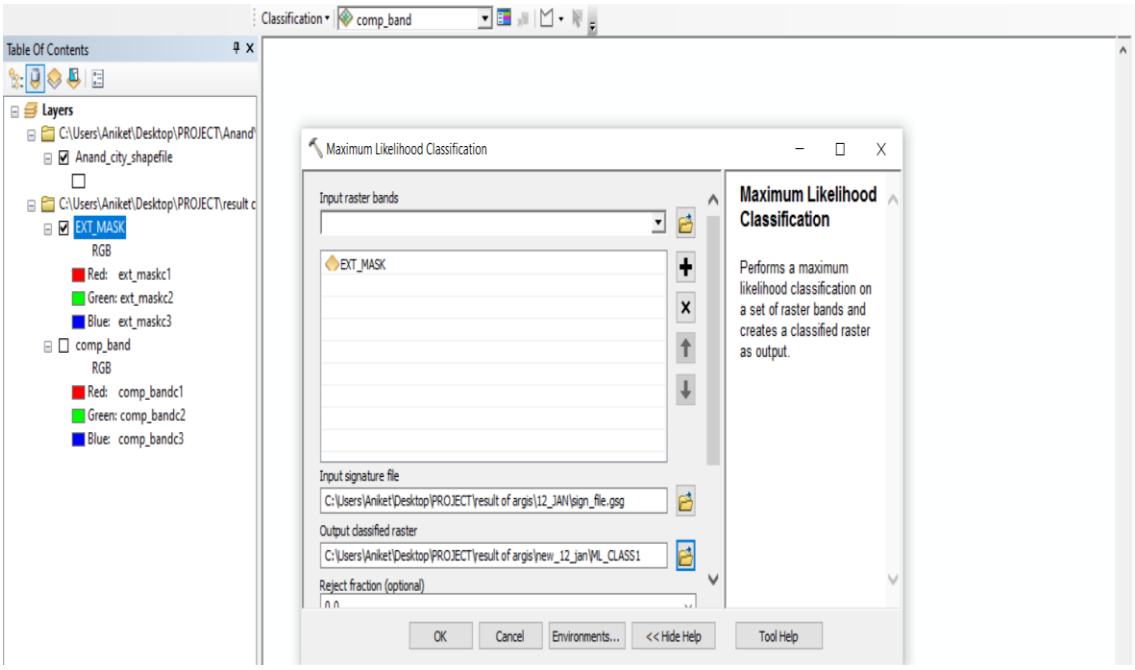
Click **Classification > Maximum likelihood classification.**



Then provide Input raster bands, Input signature file, Output classified raster. Click OK.

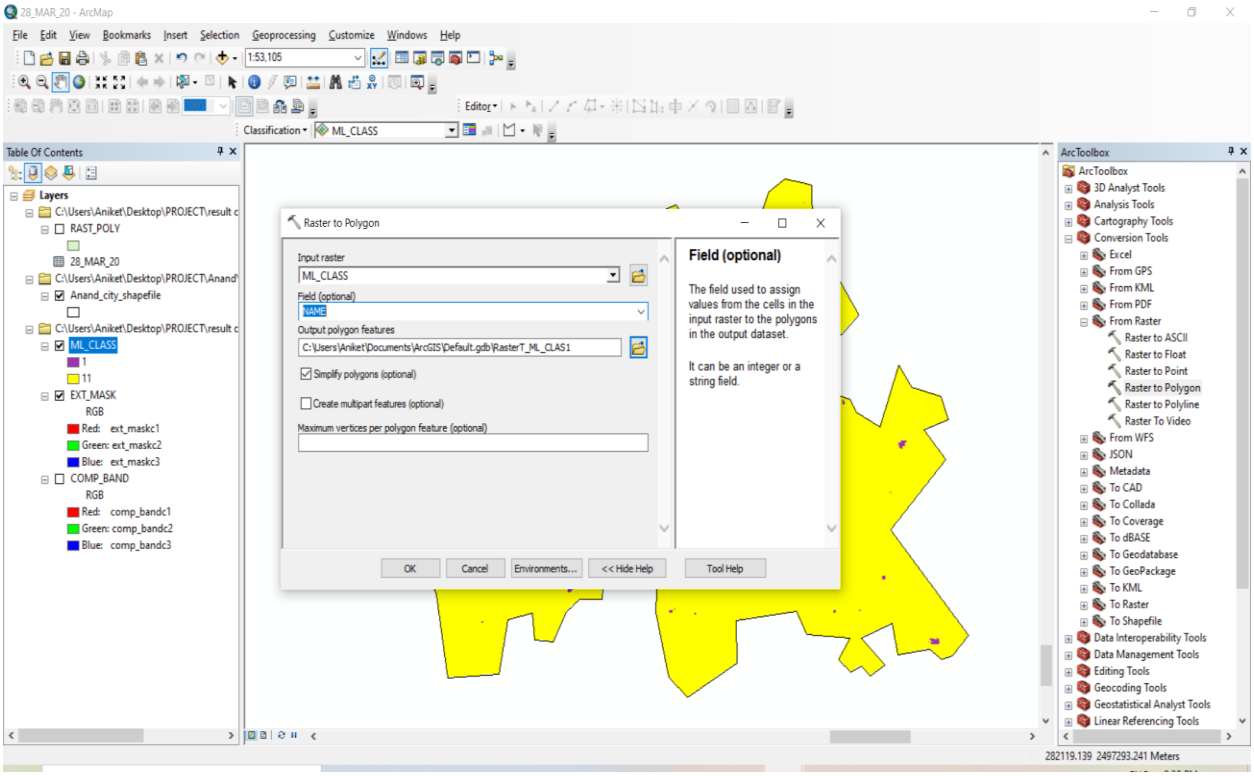
It will create layer of ML_Class. Open Attribute Table of ML_Class then click add fields, give their name & type.

.



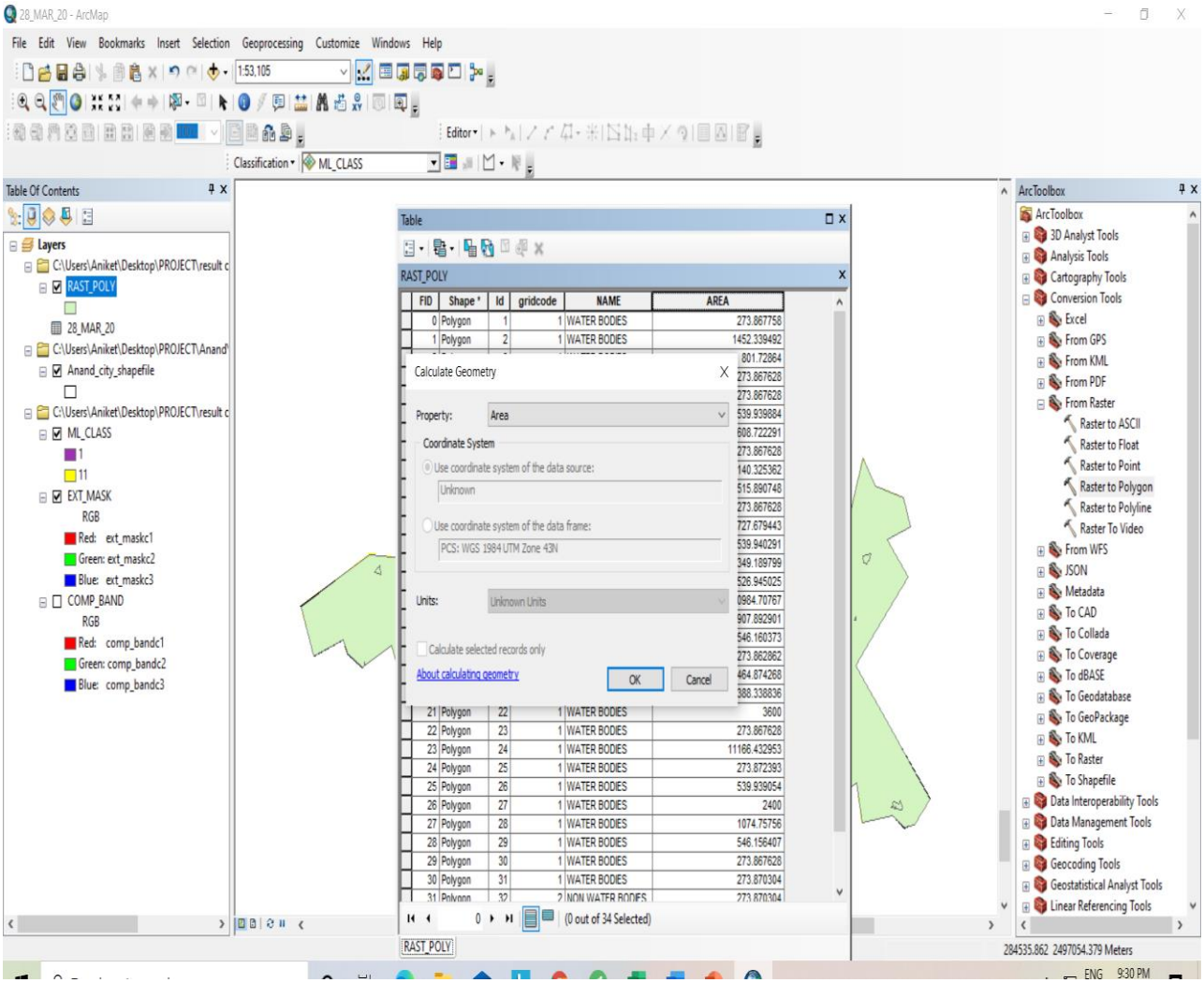
- **Conversion Tools**

In Arc Toolbox click **Conversion Tools > From Raster > Raster to Polygon.** Provide Input raster, Output polygon features. It will create layer **Rast_Poly.**



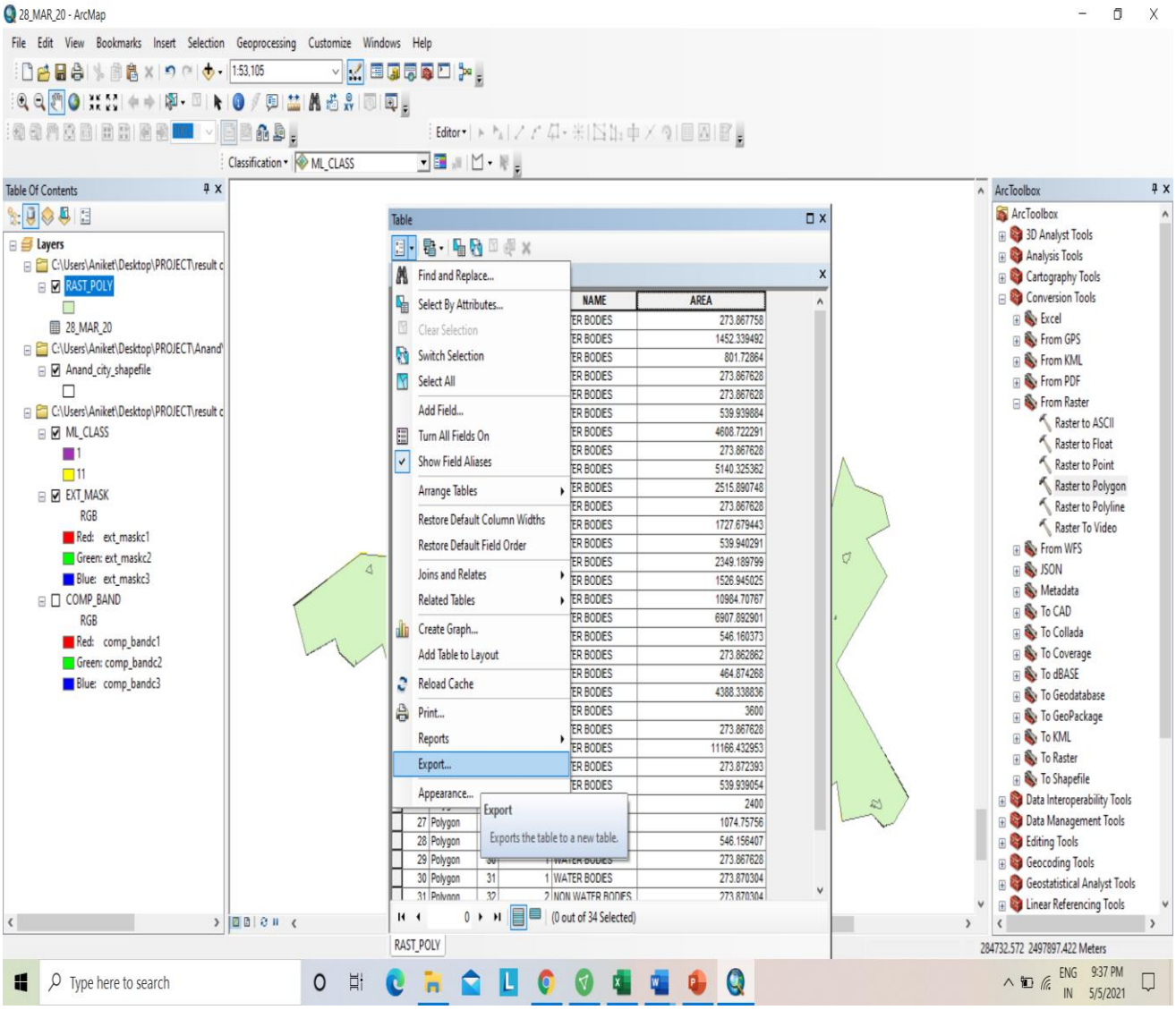
- **Calculate geometry**

Open attribute table of **Rast_Poly** layer and select Area column and right click for calculating Geometry.



- **Export Data**

Then export data into dBase format file into Excel.



10. RESULTS

10.1 Principal Component Analysis (PCA)

COVARIANCE MATRIX			
Layer	1	2	3
1	395179.944	-33058.97955	192623.2621
2	-33058.97955	494411.3359	-63846.42697
3	192623.2621	-63846.42697	133673.1388

CORRELATION MATRIX			
Layer	1	2	3
1	1	-0.07479	0.83809
2	-0.07479	1	-0.24835
3	0.83809	-0.24835	1

EIGENVALUES AND EIGENVECTORS	
Number of Input Layers	Number of Principal Component Layers
3	3

PC Layer	1	2	3

Eigenvalues		
556523.6092	438775.1428	27965.66653

Eigenvectors			
Input Layer			
1	-0.59708	0.65969	-0.4564
2	0.70713	0.70148	0.08884
3	-0.37876	0.26969	0.88533

PERCENT AND ACCUMULATIVE EIGENVALUES			
PC Layer	Eigen Value	Percent of Eigen Values	Accumulative of Eigen Values
1	556523.6092	54.3871	54.3871
2	438775.1428	42.8799	97.267
3	27965.66653	2.733	100

Interpretation:

1. Here Covariance and Correlation matrix explains relationship between different bands.

2. Eigenvalues represents amount of variance explained as we can that the first one is much higher and then decrease.

3. Eigenvectors are used to get principal component bands from the raw data.

The first principal component would be

PC1 = (-0.59708) * Band1 + (0.65969) * Band2 + (-0.4564) * Band3

So, this shows how to map your principal components from your raw input.

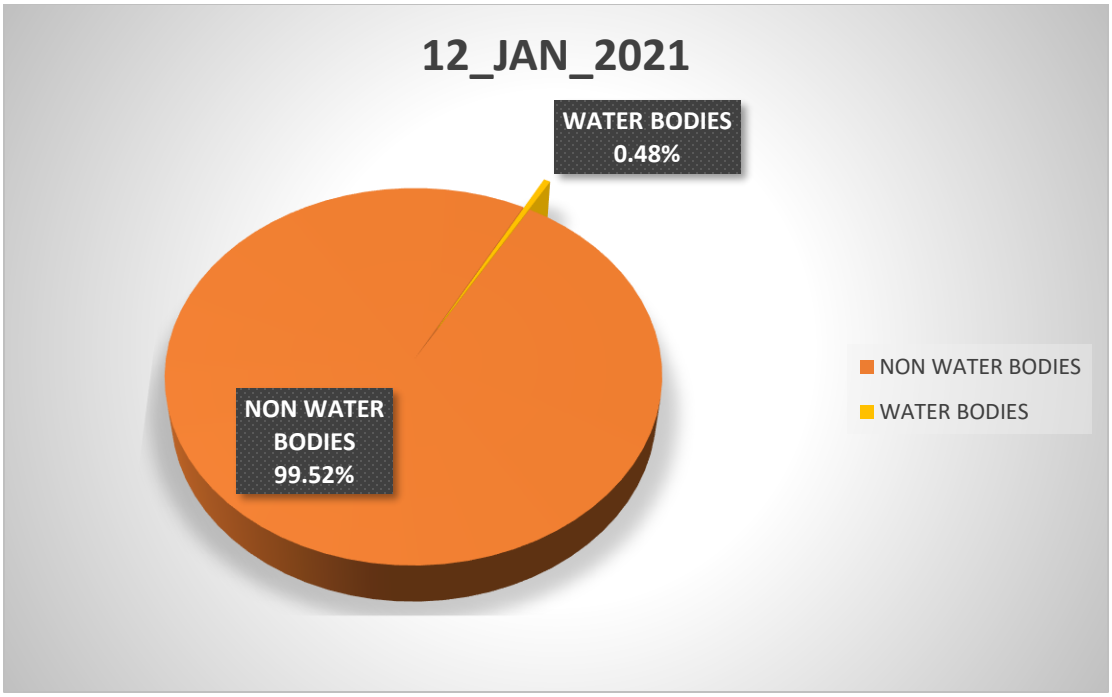
4. Percent and Accumulative eigenvalues explain percent of variance captured by each of original image bands.

Here, 54.3871% of information got captured in PC1 and both PC1, PC2 accumulatively shows 97.267% of variation

10.2.1 Area of Statistics in Months of 2021

I. 12_JAN_2021

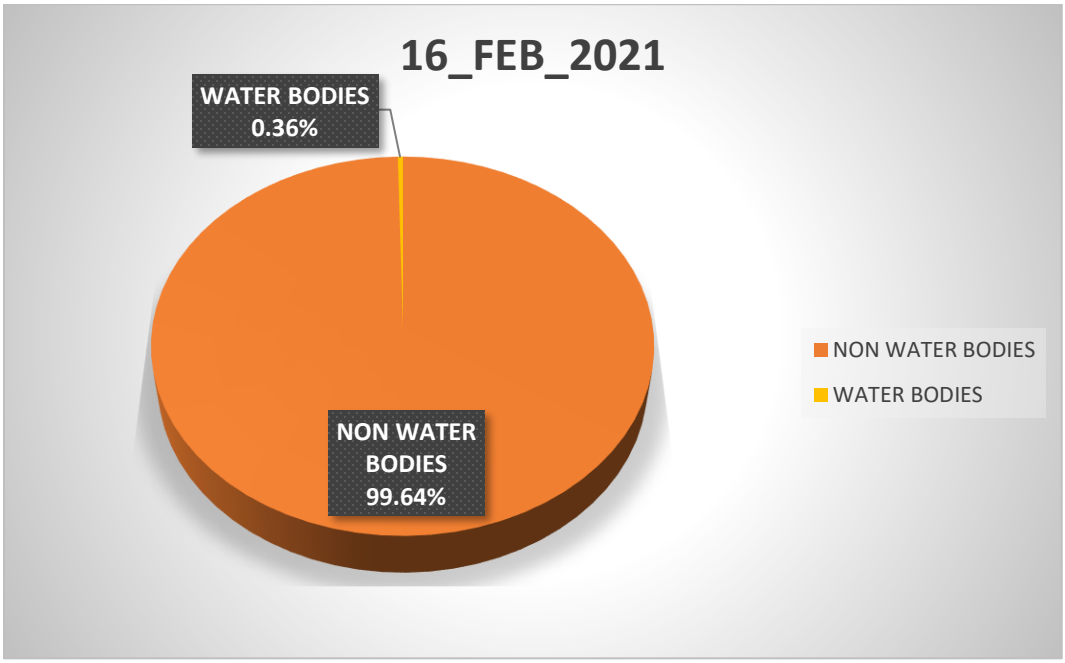
Row Labels	Sum of AREA	%	TEMP
NON WATER BODIES	47631065.32	99.52137988	21' C
WATER BODIES	229068.2289	0.478620121	
Grand Total	47862751.28		



Here, we can see that in Anand city the area of water cover was **0.48%** on 12th January 2021 at 21ºC which is nearly **0.23 km^2** out of 47.86 km^2.

II. 16_FEB_2021

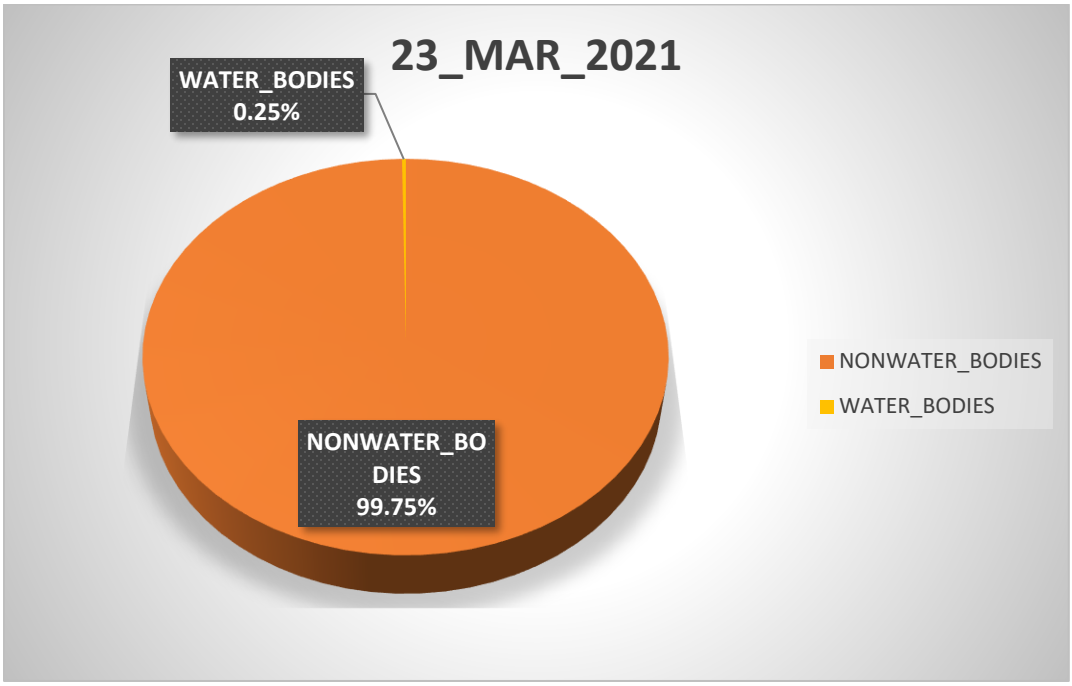
Row Labels	Sum of AREA	%	TEMP
NON WATER BODIES	47692136.1	99.64421745	23' C
WATER BODIES	170286.147	0.355782551	
Grand Total	47862751.28		



Here, we can see that the area of water cover was **0.36%** on 16th February 2021 at 23ºC. Which is nearly **0.17 km²** out of 47.86 km².

III. 23_MAR_2021

Row Labels	Sum of AREA	%	TEMP
NONWATER_BODIES	47745046.98	99.74794	28' C
WATER_BODIES	120651.0682	0.252062	
Grand Total	47862751.28		

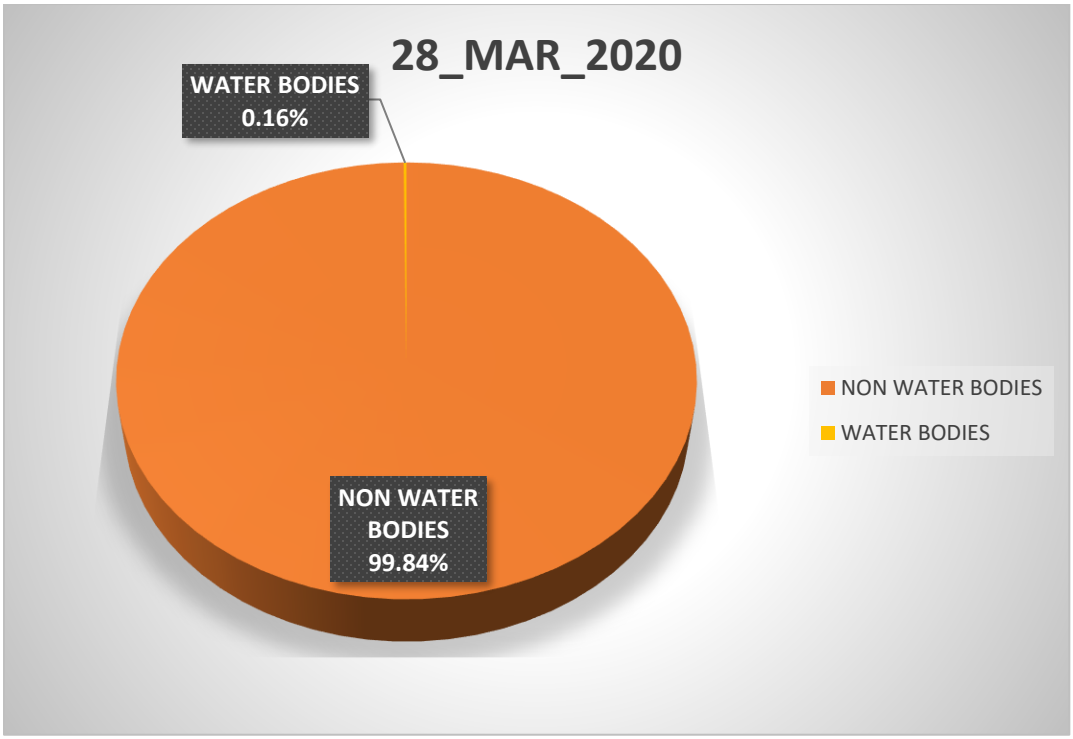


Here, we can see that in Anand city the area of water cover was **0.25%** on 23th March 2021 at 28ºC. Which is nearly **0.12 km^2** out of 47.86 km^2.

10.2.2 Area of statistics for previous Years

I. 28_MAR_2020

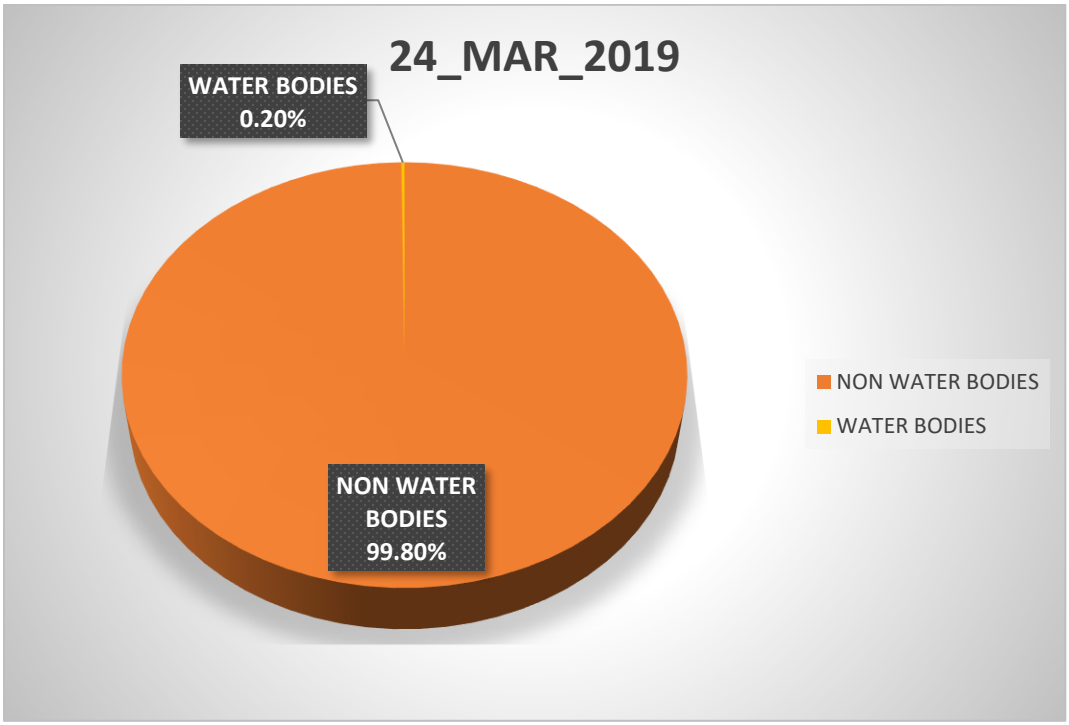
Row Labels	Sum of AREA	%	TEMP
NON WATER BODIES	47784975.66	99.83672704	30.5' C
WATER BODIES	78147.53855	0.163272961	
Grand Total	47862751.28		



Here, we can see that the area of water cover was **0.16%** on 28th March 2020 at 30.5ºC. Which is nearly **0.078 km^2** out of 47.86 km^2.

II. 24_MAR_2019

Row Labels	Sum of AREA	%	TEMP
NON WATER BODIES	47765686.44	99.80293745	33' C
WATER BODIES	94314.13632	0.197062547	
Grand Total	47862751.28		

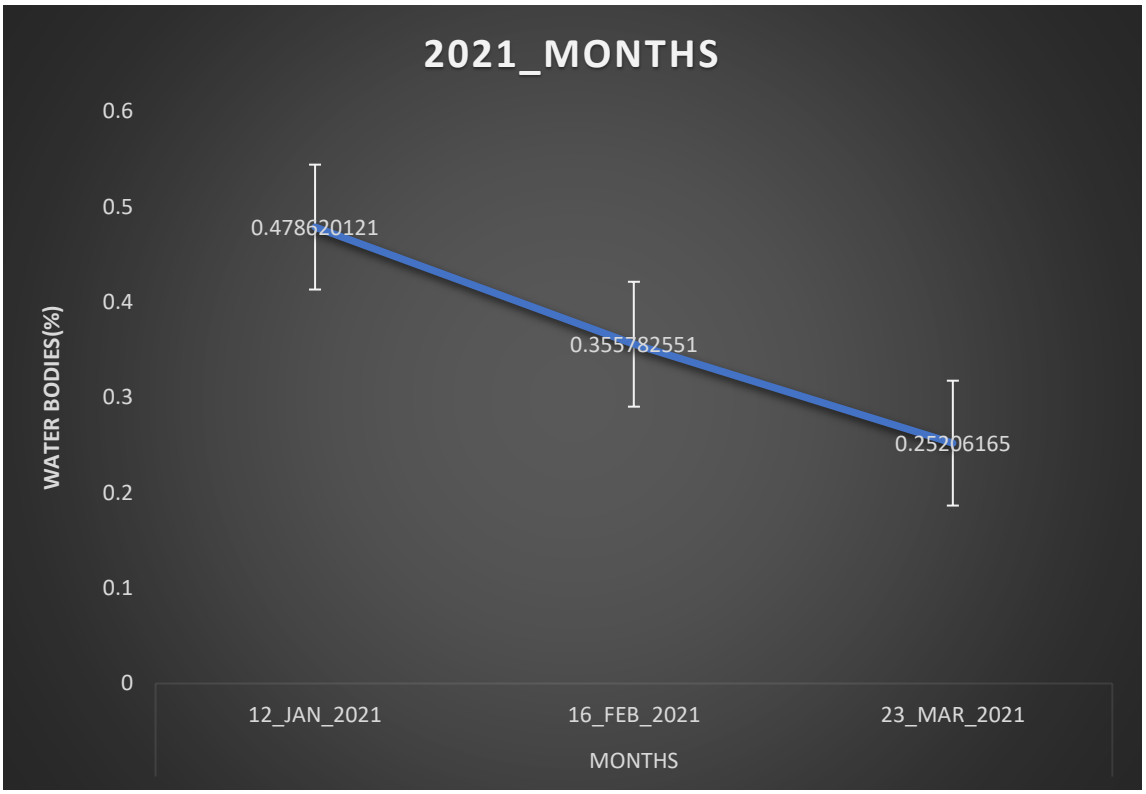


On 24th March 2019 the area of water cover was **0.20%** in Anand city. Which is **0.094 km^2** out of 47.86 km^2 of total area.

11. GRAPHICAL REPRESENTATION

11.1 Months _2021

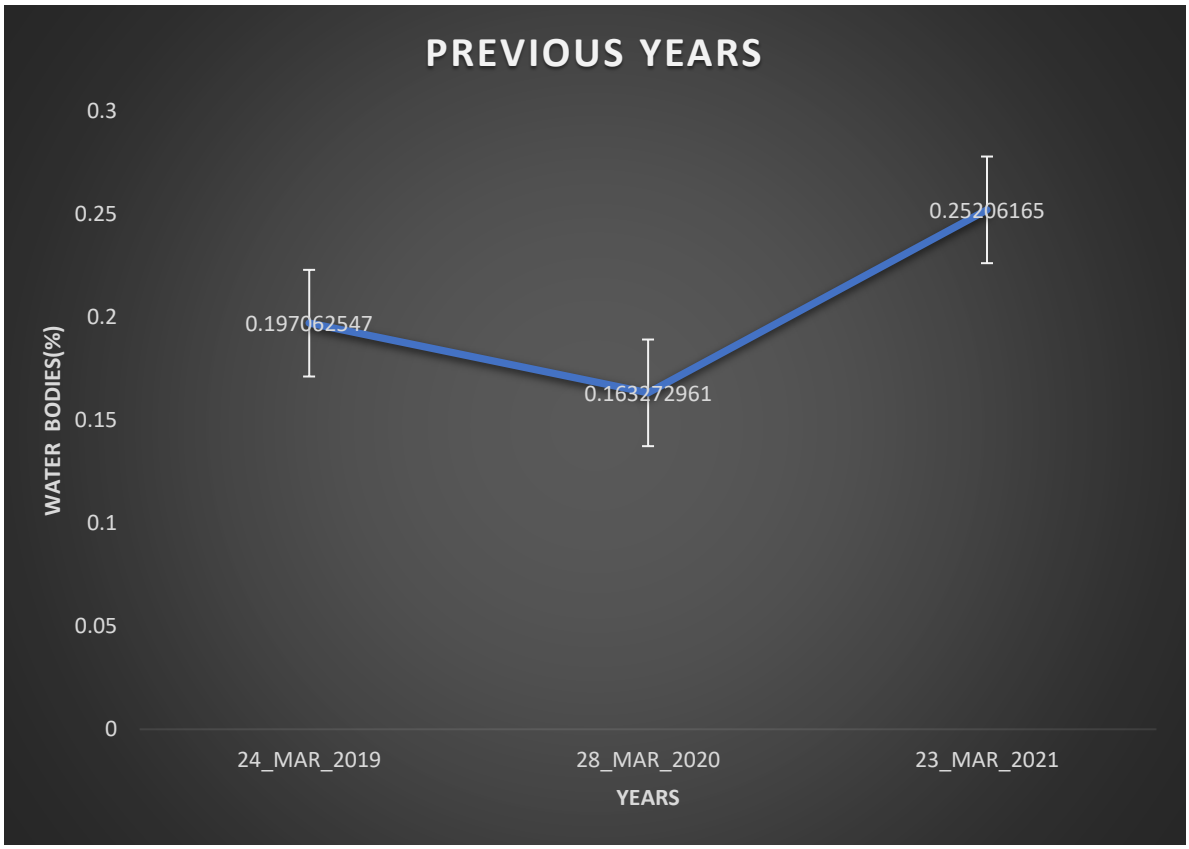
	MONTHS		
	12_JAN_2021	16_FEB_2021	23_MAR_2021
WATER BODIES(%)	0.478620121	0.355782551	0.25206165



From above line plot we can say that in 2021 from January to March % of water bodies is decreased from 0.47% to 0.25%.

11.2 Previous Years

YEARS			
	24_MAR_2019	28_MAR_2020	23_MAR_2021
WATER BODIES(%)	0.197062547	0.163272961	0.25206165



Above line plot shows year wise percent of water bodies in month of March. It shows that this year (2021) have more percent of available water which is 0.25% while previous year (2020) it was lowest (0.16%) and in March 2019 it was 0.19%.

12. CONCLUSION

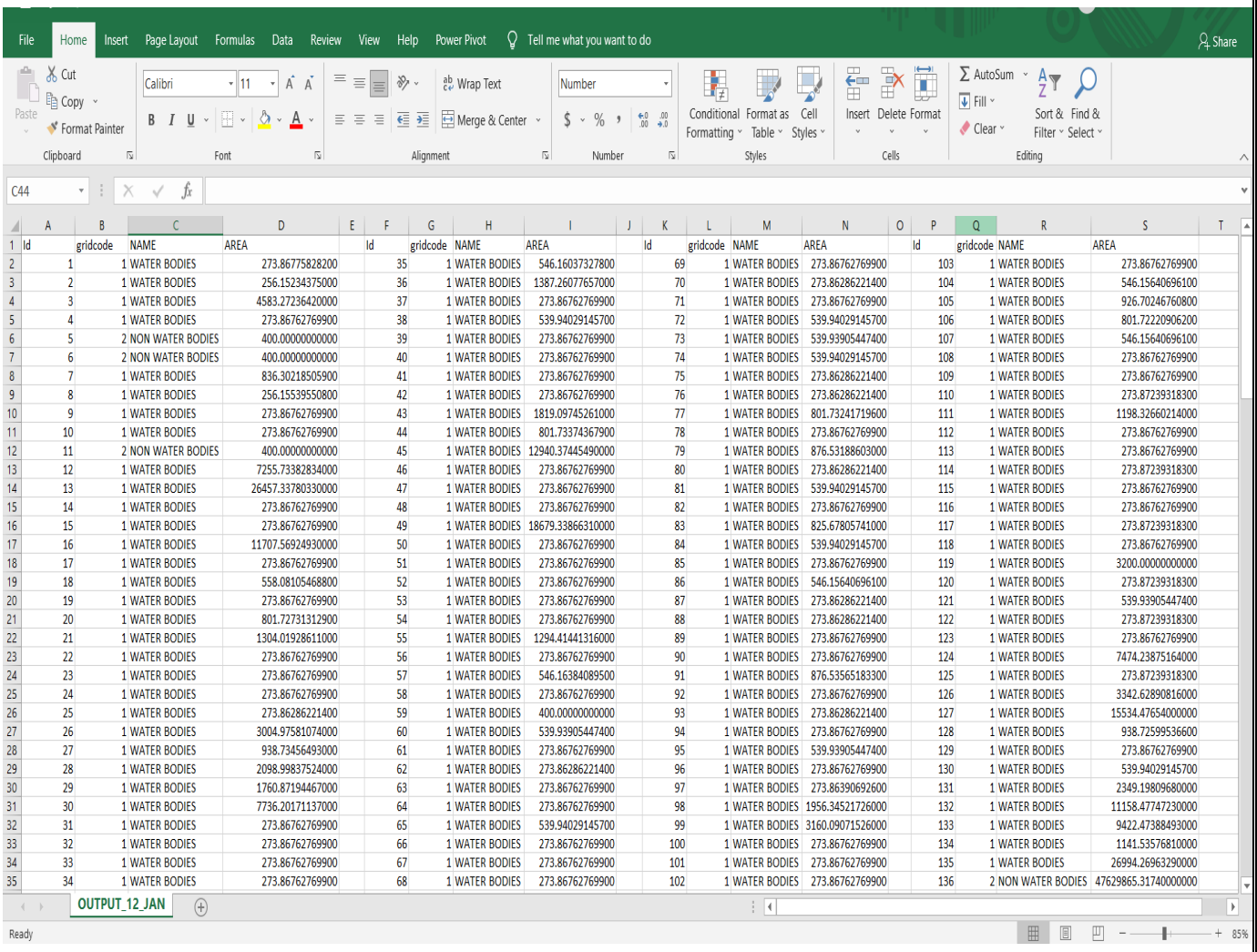
- **In 2021 percentage of water bodies decreasing gradually as increase in temperature from 0.4786 % to 0.252 % in first three months.**
- **As compared to previous years this year have more water available in month of March.**

13. LIMITATIONS OF STUDY

For further measurement analysis we can use **regression analysis**. For that we need to know different parameters like **slope**, **rainfall of previous year, uses of water** and **vegetation area around the water bodies**. After including all these parameters, we can also try to model the area coverage of the water bodies in future.

14. APPENDIX

14.1 Data structure



Id	gridcode	NAME	AREA	Id	gridcode	NAME	AREA	Id	gridcode	NAME	AREA	Id	gridcode	NAME	AREA
1	1	WATER BODIES	273.86775828200	35	1	WATER BODIES	546.16037327800	69	1	WATER BODIES	273.86762769900	103	1	WATER BODIES	273.86762769900
2	1	WATER BODIES	256.15234375000	36	1	WATER BODIES	1387.26077657000	70	1	WATER BODIES	273.86286221400	104	1	WATER BODIES	546.15640696100
3	1	WATER BODIES	4583.27236420000	37	1	WATER BODIES	273.86762769900	71	1	WATER BODIES	273.86762769900	105	1	WATER BODIES	926.70246760800
4	1	WATER BODIES	273.86762769900	38	1	WATER BODIES	539.94029145700	72	1	WATER BODIES	539.94029145700	106	1	WATER BODIES	801.72220906200
5	2	NON WATER BODIES	400.00000000000	39	1	WATER BODIES	273.86762769900	73	1	WATER BODIES	539.93905447400	107	1	WATER BODIES	546.15640696100
6	2	NON WATER BODIES	400.00000000000	40	1	WATER BODIES	273.86762769900	74	1	WATER BODIES	539.94029145700	108	1	WATER BODIES	273.86762769900
7	1	WATER BODIES	836.30218505900	41	1	WATER BODIES	273.86762769900	75	1	WATER BODIES	273.86286221400	109	1	WATER BODIES	273.86762769900
8	1	WATER BODIES	256.15539550800	42	1	WATER BODIES	273.86762769900	76	1	WATER BODIES	273.86286221400	110	1	WATER BODIES	273.87239318300
9	1	WATER BODIES	273.86762769900	43	1	WATER BODIES	1819.09745261000	77	1	WATER BODIES	801.73241719600	111	1	WATER BODIES	1198.32660214000
10	1	WATER BODIES	273.86762769900	44	1	WATER BODIES	801.73374367900	78	1	WATER BODIES	273.86762769900	112	1	WATER BODIES	273.86762769900
11	2	NON WATER BODIES	400.00000000000	45	1	WATER BODIES	12940.37445490000	79	1	WATER BODIES	876.53188603000	113	1	WATER BODIES	273.86762769900
12	1	WATER BODIES	7255.73382834000	46	1	WATER BODIES	273.86762769900	80	1	WATER BODIES	273.86286221400	114	1	WATER BODIES	273.87239318300
13	1	WATER BODIES	26457.33780330000	47	1	WATER BODIES	273.86762769900	81	1	WATER BODIES	539.94029145700	115	1	WATER BODIES	273.86762769900
14	1	WATER BODIES	273.86762769900	48	1	WATER BODIES	273.86762769900	82	1	WATER BODIES	273.86762769900	116	1	WATER BODIES	273.86762769900
15	1	WATER BODIES	273.86762769900	49	1	WATER BODIES	18679.33866310000	83	1	WATER BODIES	825.67805741000	117	1	WATER BODIES	273.87239318300
16	1	WATER BODIES	11707.56924930000	50	1	WATER BODIES	273.86762769900	84	1	WATER BODIES	539.94029145700	118	1	WATER BODIES	273.86762769900
17	1	WATER BODIES	273.86762769900	51	1	WATER BODIES	273.86762769900	85	1	WATER BODIES	273.86762769900	119	1	WATER BODIES	3200.00000000000
18	1	WATER BODIES	558.08105468800	52	1	WATER BODIES	273.86762769900	86	1	WATER BODIES	546.15640696100	120	1	WATER BODIES	273.87239318300
19	1	WATER BODIES	273.86762769900	53	1	WATER BODIES	273.86762769900	87	1	WATER BODIES	273.86286221400	121	1	WATER BODIES	539.93905447400
20	1	WATER BODIES	801.72731312900	54	1	WATER BODIES	273.86762769900	88	1	WATER BODIES	273.86286221400	122	1	WATER BODIES	273.87239318300
21	1	WATER BODIES	1304.01928611000	55	1	WATER BODIES	1294.41441316000	89	1	WATER BODIES	273.86762769900	123	1	WATER BODIES	273.86762769900
22	1	WATER BODIES	273.86762769900	56	1	WATER BODIES	273.86762769900	90	1	WATER BODIES	273.86762769900	124	1	WATER BODIES	7474.23875164000
23	1	WATER BODIES	273.86762769900	57	1	WATER BODIES	546.16384089500	91	1	WATER BODIES	876.53565183300	125	1	WATER BODIES	273.87239318300
24	1	WATER BODIES	273.86762769900	58	1	WATER BODIES	273.86762769900	92	1	WATER BODIES	273.86762769900	126	1	WATER BODIES	3342.62890816000
25	1	WATER BODIES	273.86286221400	59	1	WATER BODIES	400.00000000000	93	1	WATER BODIES	273.86286221400	127	1	WATER BODIES	15534.47654000000
26	1	WATER BODIES	3004.97581074000	60	1	WATER BODIES	539.93905447400	94	1	WATER BODIES	273.86762769900	128	1	WATER BODIES	938.72599536600
27	1	WATER BODIES	938.73456493000	61	1	WATER BODIES	273.86762769900	95	1	WATER BODIES	539.93905447400	129	1	WATER BODIES	273.86762769900
28	1	WATER BODIES	2098.99837524000	62	1	WATER BODIES	273.86286221400	96	1	WATER BODIES	273.86762769900	130	1	WATER BODIES	539.94029145700
29	1	WATER BODIES	1760.87194467000	63	1	WATER BODIES	273.86762769900	97	1	WATER BODIES	273.86390692600	131	1	WATER BODIES	2349.19809680000
30	1	WATER BODIES	7736.20171137000	64	1	WATER BODIES	273.86762769900	98	1	WATER BODIES	1956.34521726000	132	1	WATER BODIES	11158.47747230000
31	1	WATER BODIES	273.86762769900	65	1	WATER BODIES	539.94029145700	99	1	WATER BODIES	3160.09071526000	133	1	WATER BODIES	9422.47388493000
32	1	WATER BODIES	273.86762769900	66	1	WATER BODIES	273.86762769900	100	1	WATER BODIES	273.86762769900	134	1	WATER BODIES	1141.53576810000
33	1	WATER BODIES	273.86762769900	67	1	WATER BODIES	273.86762769900	101	1	WATER BODIES	273.86762769900	135	1	WATER BODIES	26994.26963290000
34	1	WATER BODIES	273.86762769900	68	1	WATER BODIES	273.86762769900	102	1	WATER BODIES	273.86762769900	136	2	NON WATER BODIES	47629865.31740000000

15. REFERENCES

1. Data Access

https://earthexplorer.usgs.gov/

2.Band Combination

https://gisgeography.com/sentinel-2-bands-combinations/

3.Convert Raster to Shapefile

https://youtu.be/weGDAJVP5ek

https://youtu.be/sGC4y80Ikf4

4.Principal Component Analysis

https://youtu.be/-CdzURXwwVU

https://youtu.be/U9A-8-Bkjgo

https://youtu.be/U9A-8-Bkjgo

5. Supervised Classification (LULC in ArcGIS)

https://youtu.be/DYGJf-WMFkI

https://youtu.be/6bloybH8RBw

Supervised Classification In QGIS

https://youtu.be/NgIdt3b6Q6o

https://m.youtube.com/watch?v=2SrQn1hed34&feature=share

https://youtu.be/NgIdt3b6Q6o

https://youtu.be/zAWA4NTw0Zs

6. Study Area Mapping

https://youtu.be/BFth4IJK4ec

https://youtu.be/BFth4IJK4ec

16. PROJECT LEARNING

- We learned and discussed different statistical tools like Principal Component Analysis, Supervised Classification in which Maximum Likelihood Classification.
- We got knowledge regarding geospatial data.
- Also, learned different statistical software related to geographic information system like ArcGIS, QGIS etc.
- Learn project management.
- Real world problem simulation.