



Land Use Land Cover Mapping of Kannur District

Muhammad Rasy PC ^[1], Sreelakshmi E ^[2], Thanwi Rajeev ^[3],
Razeen Moosa V ^[4], Abhijath I P ^[5]

^{1,2,3,4} UG Student, Civil Engineering Department, Vimal Jyothi Engineering College, Kannur

⁵Asst. Professor, Civil Engineering Department, Vimal Jyothi Engineering College, Kannur

Date of Submission: 04-08-2023

Date of Acceptance: 17-08-2023

ABSTRACT: The terms land use and land cover are often used interchangeably, but each term has its own unique meaning. Land cover refers to the surface cover on the ground like vegetation, urban infrastructure, water, bare soil, etc. Identification of land cover establishes the baseline information for activities like thematic mapping and change detection analysis. Land use refers to the purpose the land serves, for example, recreation, wildlife habitat, or agriculture. Stress on natural resources has been increasing daily due to steady population increase. In particular misuse of lands constitute a significant potential threat. Effective planning strategies have been developed in order to reduce stress on productive lands. Land Use Land Cover (LULC) maps of an area provide information to help users to understand the current landscape. LULC maps also help us to study the changes that are happening in our ecosystem and environment. If we have an inch-by-inch information about Land Use/Land Cover of the study unit we can make policies and launch programs to save our environment. Annual LULC information on national spatial databases will enable the monitoring of temporal dynamics of agricultural ecosystems, forest conversions, surface water bodies, etc. on an annual basis. The knowledge of land use and land cover is important for many planning and management activities as it is considered as an essential element for modelling and understanding the earth feature system. Land Use Land Cover change detection helps the policy makers to understand the environmental change dynamics to ensure sustainable development. Hence, LULC feature identification has emerged as an important research aspect and thus, a proper and accurate methodology for LULC classification is the need of time. In this we will be doing the LULC mapping of Kannur district in the state of Kerala between the year 1991 and 2022.

KEYWORDS: Change Detection, Landsat Images, Land use land cover, LULC, Urban sprawl

I. INTRODUCTION

A. General

Land is the most important natural resource which embodies soil, water and associated flora and fauna involving total ecosystem. The knowledge of land use and land cover is important for many planning and management activities as it is considered as an essential element for modelling and understanding the earth feature system. The term land use relates to the human activity or economic function associated with a specific piece of land, while the term land cover relates to the type of feature present on the surface of the earth. Land use or land cover inventories are assessed in increasing importance in various sectors like agricultural planning, settlement and cadastral surveys, environmental studies and operational planning based on agro-climatic zones. Information on land use or land cover allows a better understanding of the land utilization aspects like cropping patterns, fallow lands, forests, pasture lands, wastelands and surface water-bodies which are vital for development planning. Land cover maps are presently being developed from local to national to global scales.

Land use is constrained by environmental factors such as soil characteristics, climate, topography and vegetation. It also reflects the importance of land as a key and finite resource for most human activities including agriculture, industry, forestry, energy production, settlement, recreation, and water catchment and storage. Land is a fundamental factor of production, and through much of the course of human history, it has been tightly coupled with economic growth. Often improper land use causes various forms of environmental degradation. For sustainable utilization of the land ecosystems, it is essential to know the natural characteristics, extent and location, its quality, productivity, suitability and limitations of various land uses. Land use is a product of interactions between a society's cultural background, state, and its physical needs on the one hand, and the natural potential of land on the other. In order to



improve the economic condition of the area without further deteriorating the bio environment, every bit of the available land has to be used in the most rational way.

In order to understand the dynamics of LULC, it is essential to identify the causes of land degradation across landscapes which are often the product of diverse natural processes and human interventions within a landscape mosaic. Satellite remote sensing technology has found its acceptance worldwide for rapid resource assessment and monitoring, particularly in the developing world. Satellite images have been utilized for land use and land cover mapping. National Aeronautical and Space Administration (NASA) of USA has made most significant contributions with satellite based remote sensing techniques. Since 1972, after the Landsat-1 was launched, remote sensing technology and its application has undergone a tremendous change in terms of sensing development, aerial flights with improved sensors, satellite design development and operations including data reception, processing, interpretation, and utilization of satellite images. All these advancements have widened the applicability of remotely sensed data in various areas like forest cover, vegetation type mapping, and their changes on a regional scale. If satellite data is judiciously used along with the sufficient ground data, it is possible to carry out detailed forest inventories, monitoring of land use, and vegetation cover at various scales.

The rapid urban growth and development have resulted in the increase in the share of India's urban population from 79 million in 1961 that was about 17.92 percent of India's total population to 388 million in 2011 that is 31.30 percent of India's total population. This fast rate of increase in urban population is mainly due to large scale migration of people from rural and smaller towns to bigger cities in search of better employment opportunities and better quality of life. Urban sprawl has resulted in loss of productive agricultural lands, open green spaces and loss of surface water bodies. Although, urban areas cover a very small fraction of the world's land surface, their rapid expansion has significantly altered the natural landscape and created enormous environmental, ecosystem, and social impacts. The inevitable outcomes from this process are the spatial expansion of towns and cities beyond their juridical limits and into their hinterlands and peripheries in order to accommodate the growing urban population. Due to the acceleration of the global urbanization in both intensity and area, there is a growing interest in understanding its implications with respect to a broad set of environmental factors including loss of arable land, decline in natural vegetation cover and

climate at local, regional, and global scales. The unplanned and uncontrolled rapid growth has resulted in serious negative effects on the urban dwellers and their environment. It is also associated with health risks including air pollution, occupational hazards and traffic injury, and risks caused by dietary and social changes. Primary causes of urbanization are population eruption, migration from other places, industries, economy and proximity to resources and basic amenities. The built-up is generally considered as the parameter for quantifying urban sprawl. As population increases in an area or a city, the boundary of the city expands to accommodate the growth; this expansion is deemed as sprawl. Although India is one of the less urbanized countries of the world with only 31.30 percent of her population living in urban agglomerations/towns, this country is facing a serious crisis of urban growth. This phenomenon of urban growth is not now confined only to plain areas, but Himalayan Mountainous areas being one of the fragile ecosystems on the earth are also experiencing the urban revolution. This process of urban sprawl is rapidly encroaching the precious land and consequently changing the land use/land cover of the area.

B. Study Area

Kannur is a coastal city and a municipal corporation in the state of Kerala, India. It is situated 274 kilometres (170 mi) north of the major port city and commercial hub Kochi and 137 kilometres (85 mi) south of the major port city and a commercial hub, Mangalore. During the period of British colonial rule in India, when Kannur was a part of the Malabar District (Madras Presidency), the city was known as Cannanore. Kannur is the sixth largest urban agglomeration in Kerala. The district was established in 1957. Fig. 1 shows the map of Kannur District. Kannur lies within $11^{\circ} 40'$ and $12^{\circ} 48'$ North latitudes and $74^{\circ} 52'$ and $76^{\circ} 07'$ East longitudes with a total area of 2,966 square kilometres.



Fig.1. Kannur District Map



C. Scope

LULC maps play a significant and prime role in planning, management, and monitoring programs at local, regional, and national levels. This type of information, on one hand, provides a better understanding of land utilization aspects and on the other hand, it plays an important role in the formation of policies and programs required for development planning. For ensuring sustainable development, it is necessary to monitor the ongoing process of land use/land cover pattern over a period of time.

D. Objectives

- Prepare a Land Use Land Cover (LULC) map for the Kannur district.
- Detect changes between the time period 1991-2022 and to identify the changes that occurred within this time period using supervised classification.
- Assess LULC classes results and compare the difference between them.

II. METHODOLOGY

A. General

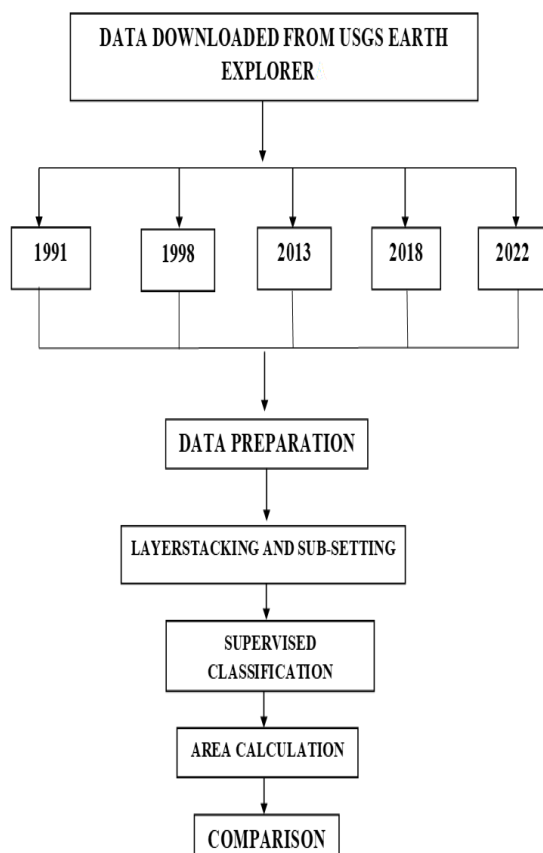


Fig. 2. Workflow of the methodology

The data required are downloaded from USGS earth explorer site. The steps involved in data downloading are detailed in B-1 Details of the downloaded data are studied which includes the band designations. The data preparation and classification are done using ENVI 5.3. The data preparation which includes Layers tacking and sub-setting. C-1 explains the steps for layer stacking and sub-setting. After data preparation Supervised classification is done. For that we will be creating four classes including Vegetation, Water body, Barren Land and Urban area. It is being detailed in D-1. After classification the classified map is opened in ArcMap 10.3 for area calculation. Area calculation done as explained in E-1. With the information gathered after area calculation for respective years, comparison can be done to detect the changes.

B. Data Collection

As the land use land cover mapping of Kannur district from the year 1991 to 2022 to be conducted, the data required can be downloaded from the USGS Earth Explore site. The data downloaded will be the space-based images of earth's land surface of the specific year which is needed from the corresponding Landsat's. While downloading data care should be taken to download data of same weather condition in corresponding years. i.e.; for example, if we are comparing data of 2015 and 2020 both the images should be of same weather condition. It seems the rain calendar of Kerala has changed altogether. Unseasonal rains have been wreaking havoc during the months between August and October in the last few years. So, it is better to download the data's during the monsoon season for the year 1991-2022. Another important thing to be considered is the cloud cover. As the data downloaded are satellite images and of rainy season, images having cloud cover less than 10 percentage must be downloaded. This is done because, if cloud cover is more, it is difficult to recognize the land details as the clouds are formed below the satellites effecting image quality. We will be downloading better data available, approximately with a decade gaps.

1. Steps for data downloading from USGS earth explorer:

STEP 1: Select Geocoding Method as Address/Place. Enter the name of place whose data to be downloaded in the Address/Place region. Click on 'show', we get the longitude and latitude of the entered region. Fig. 3 shows the Selecting Geocoding method and Entering Location details.

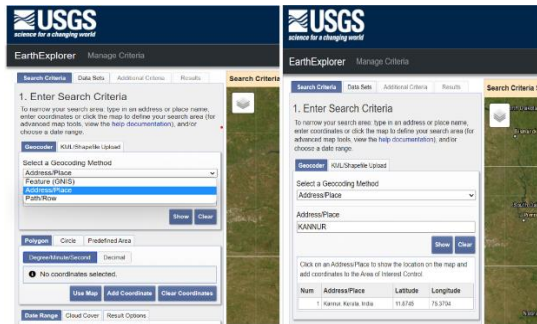


Fig. 3. Selecting Geocoding method and Entering Location details

STEP 2: Click on ‘Add Coordinates’. Enter the latitude and longitude of the place as obtained in previous step. Fig. 4 shows the Entry of Latitude and Longitude.

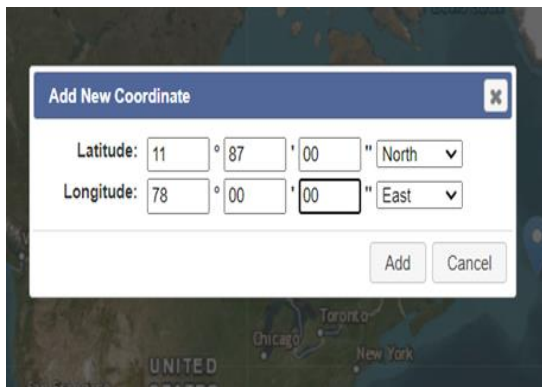


Fig. 4. Entering Latitude and Longitude

Clicking on ‘Add’ displays the point of interest. Fig.5 indicates the Displayed Point of Interest.

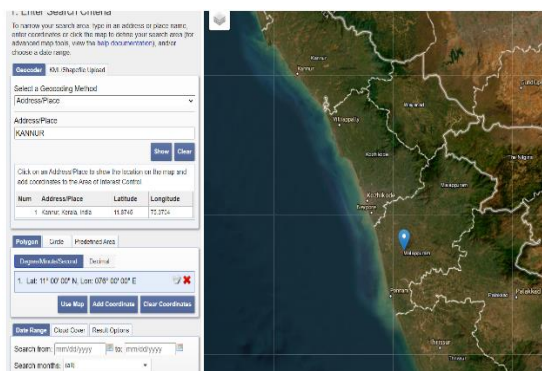


Fig.5. Displayed Point of Interest

STEP 3: Create a Polygon to select the region of interest. Fig. 6 indicates the selection of region of interest. The region marked in red is the projected area.

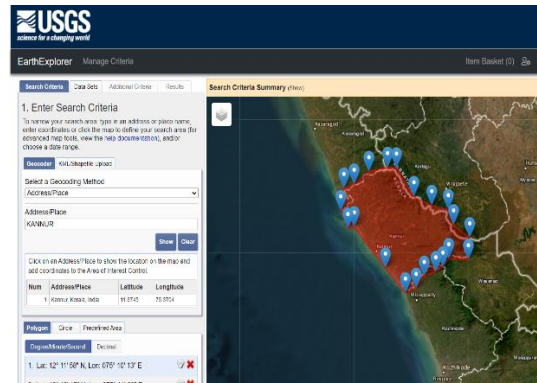


Fig. 6. Selecting region of interest

STEP 4: Select the date range, for which data needed to be downloaded. Fig.7 shows the date range setting.

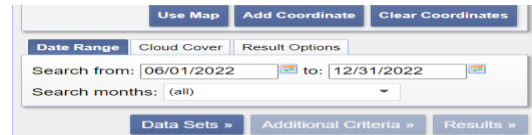


Fig. 7. Setting date range

STEP 5: Set the cloud cover as 0-10%, as we need to obtain images with a cloud cover less than 10%. Fig. 8 shows the setting of cloud cover.



Fig.8. Setting cloud cover

STEP 6: Click on ‘Data Sets’. Fig. 9 shows selecting Data Sets.

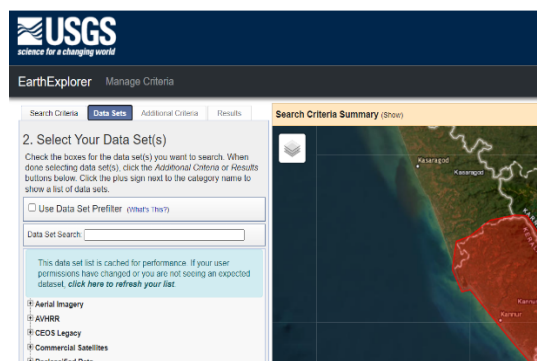


Fig. 9. Select Data Set

Select ‘Landsat’, then select ‘Landsat Collection 2 Level 1’ as Level 1 data is needed. Fig. 10 shows the selection of Landsat Collection.

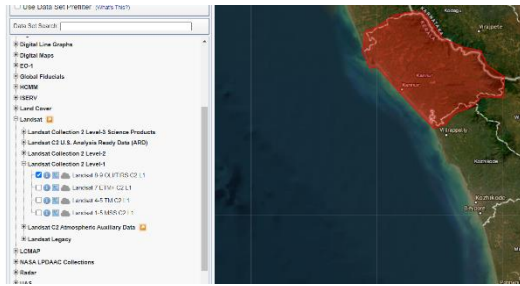


Fig. 10. selecting Landsat collection

STEP 7: Go to Results. Numbers of images will be available for download. Data can be downloaded for satisfactory dates considering on image quality. Fig. 11 shows the displayed results.

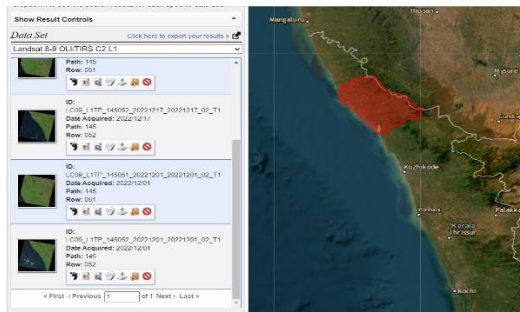


Fig. 11. Displayed results

Data will be available for separate and combined bands. Download the data with all bands. Fig. 12 shows downloading data with all bands.

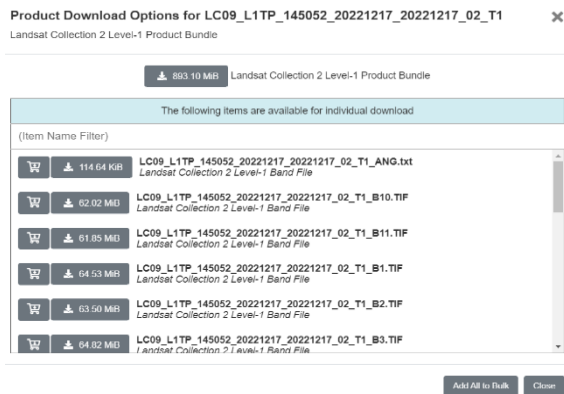


Fig. 12. Downloading data with all bands

2. Details of the satellite data used

For the years 1991, 1998, 2013, 2018 and 2022, data downloaded from United States Geological Survey (USGS) Earth Explorer has been used in this study for LULC mapping. The spatial resolution of corresponding satellites given in Table 1.

The data downloaded for same season of the year, i.e., December or January or February months. The details of the satellite data used in this study are given in Table 1.

Table - 1
Details of Satellite Data

Sl No.	Satellite	Sensor	Spectral Bands	Date of Acquisition
1	Landsat 5	TM	7	03/02/1991
2	Landsat 5	TM	7	23/12/1998
3	Landsat 8	OLI/TIRS	11	16/12/2013
4	Landsat 8	OLI/TIRS	11	28/11/2018
5	Landsat 9	OLI/TIRS	11	01/12/2022

The data downloaded includes data of Landsat 5, Landsat 8 and Landsat 9.

3) Band designations for the Landsat satellites

The sensors aboard each of the Landsat satellites were designed to acquire data in different ranges of frequencies along the electromagnetic spectrum. The Multispectral Scanner (MSS) carried on Landsat 1,2,3,4 and 5 collected data in four ranges (bands); the Thematic Mapper (TM) sensor on Landsat 4 and Landsat 5 included those found on earlier satellites and also introduced a thermal and a shortwave infrared band. A panchromatic band was added to Landsat 7's Enhanced Thematic Mapper Plus (ETM+) sensor.

While the earlier satellites carried just one sensor, Landsat 8 acquires data in 11 bands from two separate sensors: the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). The instruments on Landsat 9 were designed as improved copies of the Landsat 8 sensors.

Landsat 1-5 Multispectral Scanner (MSS) images consist of four spectral bands with 60meter spatial resolution. Specific band designations differ from Landsat 1-3 to Landsat 4-5.

Table 2 shows the details of Landsat 1-5 with Multispectral Scanner (MSS) sensor.

Table - 2
Landsat 1-5 Multispectral Scanner (MSS)

Landsat 1-3	Landsat 4-5	Wavelength (micrometres)	Resolution (meters)
Band 4 - Green	Band 1 - Green	0.5 - 0.6	60
Band 5 - Red	Band 2 - Red	0.6 - 0.7	60
Band 6 - NIR	Band 3 - NIR	0.7 - 0.8	60
Band 7 - NIR	Band 4 - NR	0.8 - 1,1	60



Landsat 4-5 Thematic Mapper (TM) images consist of seven spectral bands with a spatial resolution of 30 meters for Bands 1 to 5 and 7. Spatial resolution for Band 6 (thermal infrared) is 120 meters, but is resampled to 30-meter pixels. The Table 3 shows the details of Landsat 4-5 with Thematic Mapper (TM) sensor.

Table - 3
Landsat 4-5 Thematic Mapper (TM)

Landsat 4-5	Wavelength (micrometres)	Resolution (metres)
Band 1- Blue	0.45-0.52	30
Band 2- Green	0.52-0.60	30
Band 3-Red	0.63-0.69	30
Band 4-NIR	0.76-0.90	30
Band 5-SWIR 1	1.55-1.75	30
Band 6-TIR	10.40-12.50	120(30)
Band 7- SWIR 2	2.08-2.35	30

Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images consist of eight spectral bands with a spatial resolution of 30 meters for Bands 1 to 7. The resolution for Band 8 (panchromatic) is 15 meters. Table 4 shows the Landsat 7 with Enhanced Thematic Mapper Plus (ETM+) sensor.

Table - 4
Enhanced Thematic Mapper Plus (ETM+)

Landsat 7	Wavelength (micrometres)	Resolution (metres)
Band 1- Blue	0.42-0.52	30
Band 2- Green	0.52-0.60	30
Band 3- Red	0.63-0.69	30
Band 4- NIR	0.77-0.90	30
Band 5- SWIR 1	1.55-1.75	30
Band 6- TIR	10.40-12.50	60(30)
Band 7- SWIR 2	2.09-2.35	30
Band 8- Panchromatic	0.52-0.90	15

All bands can collect one of two gain settings (high or low) for increased radiometric sensitivity and dynamic range, while Band 6 collects both high and low gain for all scenes.

Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) images consist of nine spectral bands with a spatial resolution of 30 meters for Bands 1 to 7 and 9. New band 1 (ultra-blue) is useful for coastal and aerosol studies. New

band 9 is useful for cirrus cloud detection. Table 5 shows the details of Landsat 8-9 with Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) sensor.

Table - 5
Landsat 8-9 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS)

Bands	Wavelength (micrometres)	Resolution (metres)
Band 1- Coastal Aerosol	0.43-0.45	30
Band 2- Blue	0.45-0.51	30
Band 3- Green	0.53-0.59	30
Band 4- Red	0.64-0.67	30
Band 5- NIR	0.85-0.88	30
Band 6- SWIR 1	1.57-1.65	30
Band 7- SWIR 2	2.11-2.29	30
Band 8- Panchromatic	0.50-0.68	15
Band 9- Cirrus	1.36-1.38	30
Band 10- TIR 1	10.6-11.19	100
Band 11- TIR 2	11.50-12.51	100

The resolution for Band 8 (panchromatic) is 15 meters. Thermal bands 10 and 11 are useful in providing more accurate surface temperatures and are collected at 100 meters. The instruments on Landsat 9 are improved copies of those on Landsat 8.

4) Shapefile of Kannur District

The Shapefile of Administrative Boundary Database including entire country up to district level being downloaded from Survey of India. The shapefile of Kannur district is extracted after digitization using ArcGIS. Fig. 13 shows the shapefile of Kannur District.



Fig. 13. Shapefile of Kannur District



C. Data preparation

The images downloaded will be in the form of bands. The bands will be as red, green, blue, near infrared, far infrared, mid short wave etc. for example the image obtained from Landsat 8 consist of eleven spectral bands with a special resolution of 30 meters. For our purpose we just only need 4 bands, the red, green, blue and near infrared. When we view the image in ENVI 5.3, only a single band can be opened. When viewing only a single band the image will be in black and white scale. The process of combining all the four bands together is called as Layer Stacking.

After layer stacking, in some cases mosaicking should be done. Mosaicking is joining several overlapping images to form a single, uniform image. This is done since the images downloaded will be in the form of tiles. All the small tiles are cemented together to form a single image. Then subset is to be done. This is done to cut the boundary by removing the unwanted area or extracting only the study area which need to be analyzed.

After all these only 3 bands can be viewed at a time. When the three bands are viewed, the original color is obtained. This original color is known as true color composite. The main problem with true color composite is that, the vegetation and the building which is painted green will appear as green, so that it can't be classified as urban area since green painted building is included as vegetation. The infrared band is introduced for the separation. Then it becomes false color composites. In false color composite original color is not a concern. In infrared the color actually seen is the color reflected back from the sunlight. So, in the case of green color building, it will also be reflecting green color. But in infrared the body which absorb more heat reflects more heat waves. The roads and buildings which absorbs more heat reflect more, but the vegetation reflects less. Thus, the vegetation and green painted buildings can be classified separately.

In false color composites the vegetation is seen as red color, the dense forest seen as dark red, the shrubs and agricultural field which is not that dense seen as pinkish. The roads, houses etc. are seen as bluish. Water is seen as black since it will not reflect back heat. Thus, making classification easier.

1) Steps for Layer Stacking and Subset using ENVI 5.3

STEP 1: Start ENVI 5.3

STEP 2: Click 'OPEN'. Fig.14 shows the opening of Landsat bands.

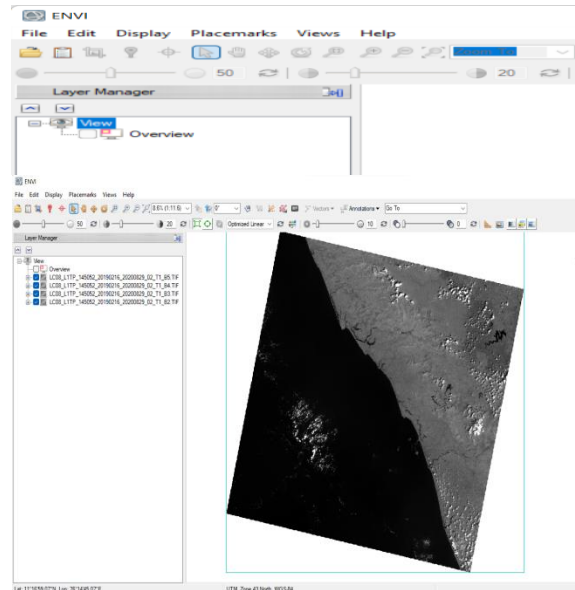


Fig. 14. opening Landsat bands

Now select Landsat bands including red, green, blue and NIR using band designation chart.

STEP 3: In Tool box write 'Layer Stacking' and click on it. A new window appears. Set UTM as Map projection. Fig. 15 shows the selection of layer stacking parameters.

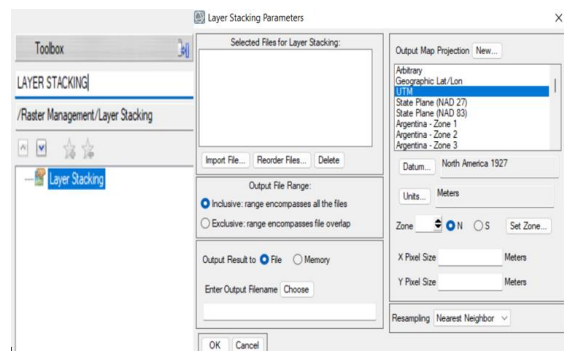


Fig. 15. Select Layer stacking parameters

STEP 4: Click on 'Import Files'. Fig. 16 shows selection of Input File.

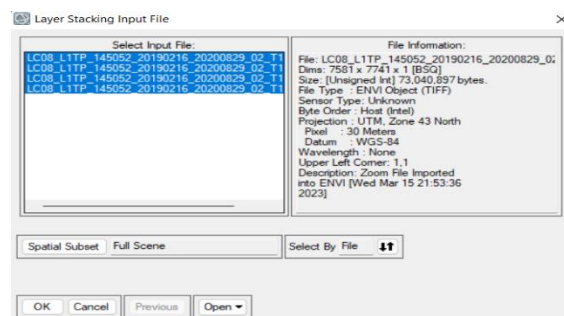


Fig. 16. Selecting Input File

Now select all the files and then click 'OK'.



STEP 5: Choose the folder where to save output files. Fig. 17 shows choosing of output file location.

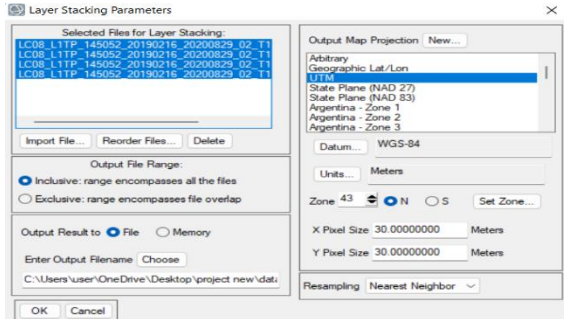


Fig. 17. Choose Output File Location

STEP 6: Go to 'Data Manager'. Keep only the output file. Fig. 18 shows deleting of all individual bands.

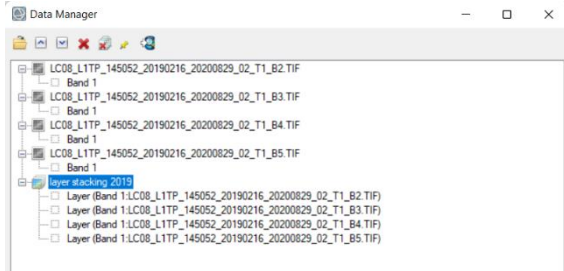


Fig. 18. Deleting all individual bands

All individual bands are deleted as they are not needed further, as layer stacked file is obtained.

STEP 7: Now select required bands for natural color and click 'Load Data'. Fig. 19 shows selection of required bands. The image obtained after layer stacking is shown in Fig. 20.

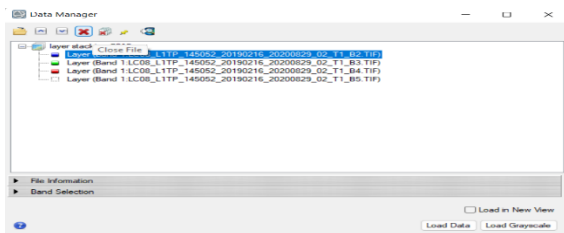


Fig. 19. Selecting required bands

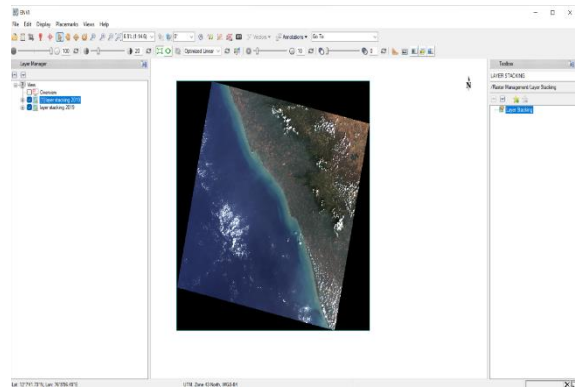


Fig. 20. Image obtained after Layer Stacking
The obtained image will be in the form of true color composite.

STEP 8: Now click on 'Open' and select the shapefile of study area. Fig. 21 indicates the projected study area.

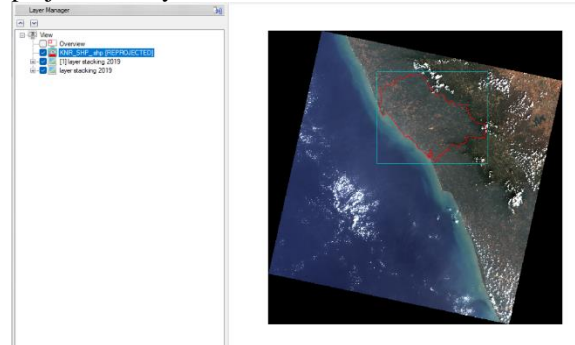


Fig. 21. Projected study area

STEP 9: On the 'Tool Box' write 'Subset' and click on 'Subset Data from ROIs'. Now select 'Input File'. Fig.22 shows Searching Subset and selecting input file.

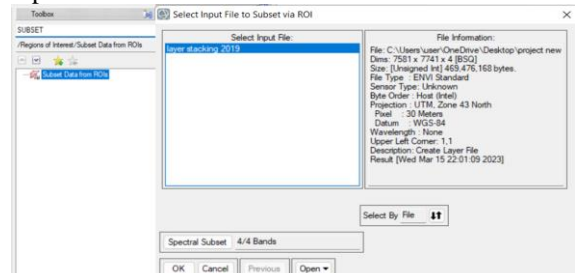


Fig. 22. Searching Subset and selecting input file

Now click 'OK' to continue.

STEP 10: Now select 'Input ROIs', Change Mask Pixels output of ROI to 'YES'. Then choose output file name and click 'OK'. Fig. 23 shows Selection of input ROIs and choosing file name.

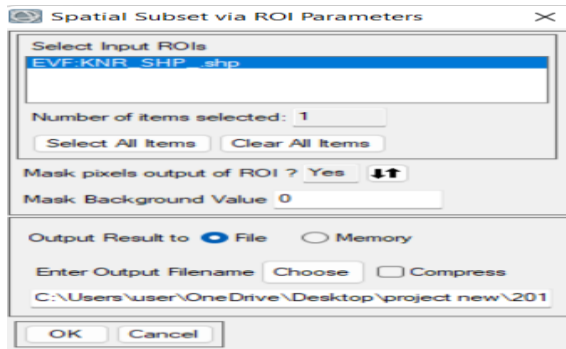


Fig. 23. Selecting input ROIs and choosing file name

STEP 11: Now the study area has been extracted from the total image. Fig. 24 shows the Extracted study area.

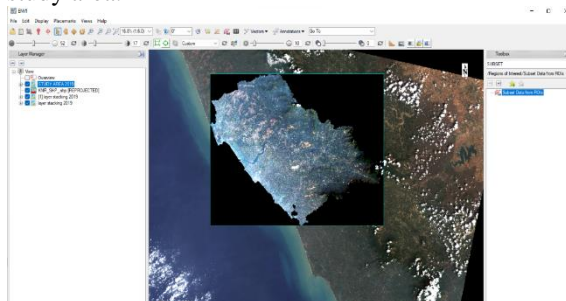


Fig. 24. Extracted study area

Now only Study Area is needed further and remaining layers can be unselected or removed.

STEP 12: Now go to 'Data Manager'. Select red, green, and blue bands for original color and click 'Load Data'. Fig. 25 shows the Selecting of bands for original color. The displayed study area is shown in Fig. 26.

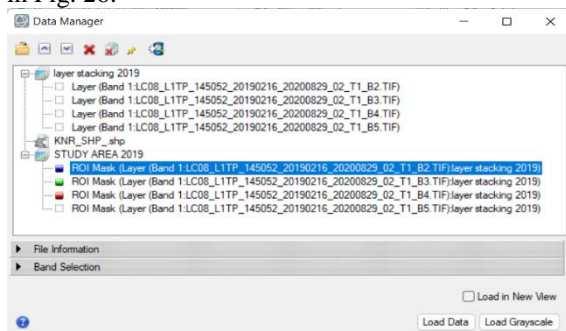


Fig. 25. Selecting bands for original color

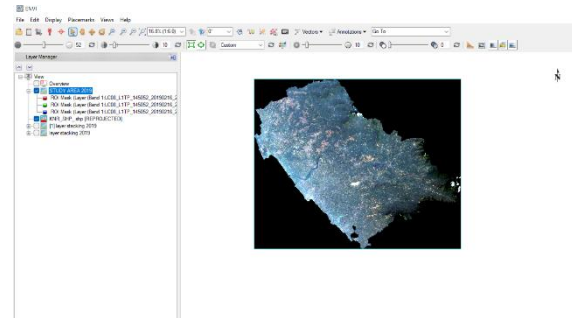


Fig. 26. Displayed study area

This will be the image used further for conducting supervised classification.

D. Classification

Remote sensing imagery always covers a large geographical area with high temporal frequency. To easily understand and derive land use and land cover information, there is always a need to process image interpretation and classification. Therefore, Image classification is the process of assigning land cover classes to pixels. In remote sensing, photographic images are grouped into different classifications. The supervised and unsupervised image classification techniques are considered the major categories. Supervised is mainly a human-guided classification. In contrast, unsupervised classification is calculated by the software. The problem with unsupervised classification is that, there will not be any accuracy, so supervised classification is opted. So, we will be choosing different classes as water bodies, land area etc. we make the software identify all the classes and get the data classified. Supervised classification is carried out after subset.

1) Steps for supervised classification

STEP 1: The study area is displayed after subset. In the 'Layer Manager' right click on the 'Study Area' and select 'Change RGB Bands'. Fig. 27 shows Selecting 'Change RGB Bands' in Layer Manager.

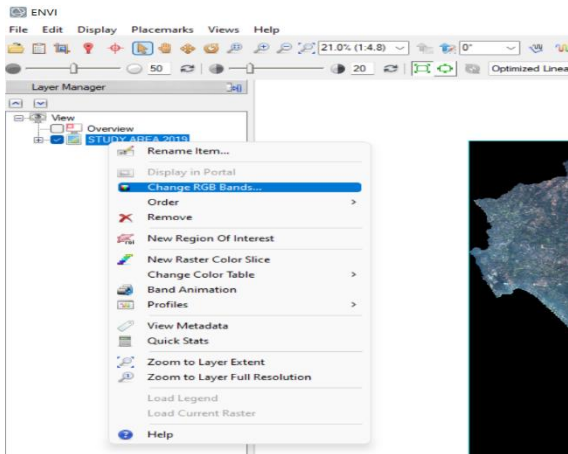


Fig. 27. Selecting 'Change RGB Bands' in Layer Manager

On the displayed window select bands according to Landsat to change to false color composite. click 'OK', then image with false color composite displayed.

Fig. 28 shows the Selection of bands to change to false color composite. The displayed image with false color composite is shown in figure. 29.

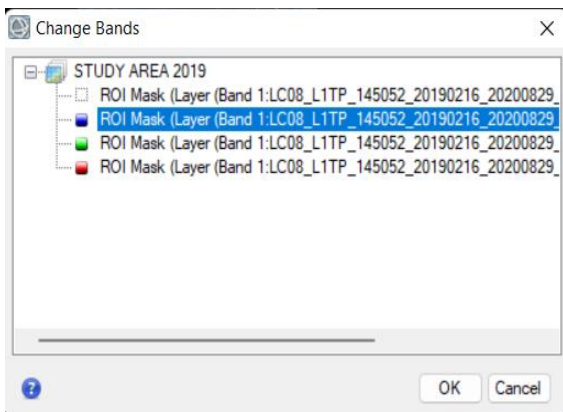


Fig. 28. Selecting bands to change to false color composite

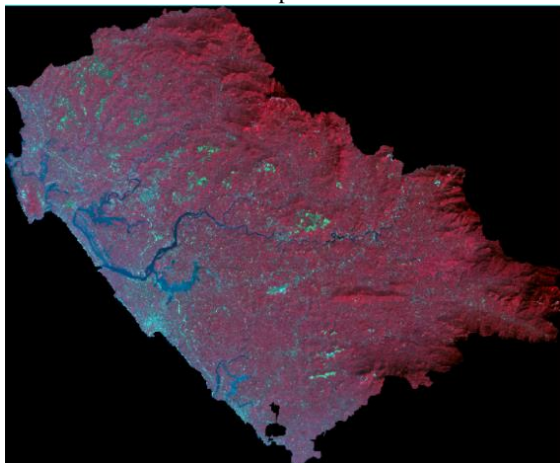


Fig. 29. Displayed image with false color composite

This image with false color composite makes supervised classification easier by allowing the selection of samples based on color. I.e., red or pinkish indicates the vegetation, the cyan color indicates urban area and etc.

STEP 2: In the Tool Box search 'Classification'. Double click on 'Classification Workflow'. Then the file selection window appears. Fig. 30 shows Searching for Classification in Tool Box.

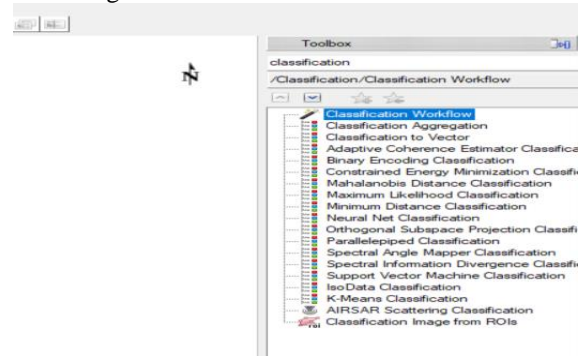


Fig. 30. Search Classification in Tool Box

STEP 3: In file selection window for 'Input Raster', add image file of Study Area. Fig. 31 shows the Adding of image file of study area as Input Raster.

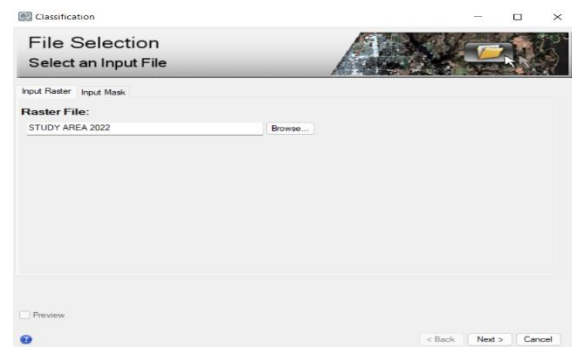


Fig. 31. Adding image file of study area as Input Raster

After that we need to add the shape file of study area as input mask file to avoid interference of the masked pixels in classified data.

STEP 4: For 'Input Mask', add the Study Area shapefile and click 'Next'. Fig. 32 shows the adding of study area shapefile as Input Mask.

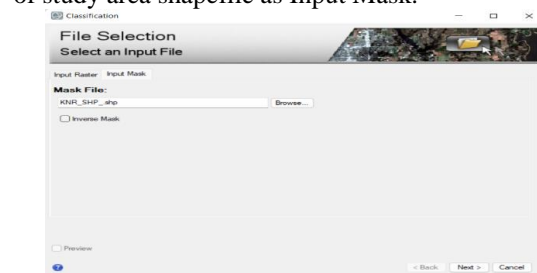


Fig. 32. Adding study area shapefile as Input Mask



STEP 5: Classification type window appears. Two types of classification available. 'No Training Data' represents unsupervised classification. So, select 'Use Training Data' for supervised classification. Fig. 33 shows the selection of supervised classification. By clicking 'Next', supervised classification window appears.

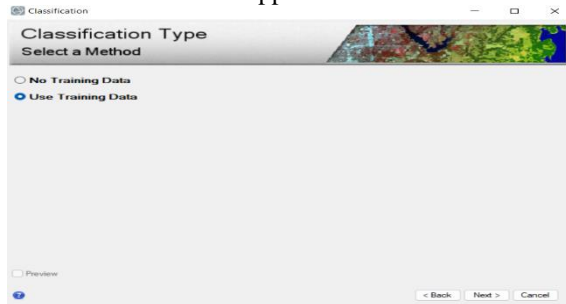


Fig. 33. Selecting supervised classification

STEP 6: In the supervised classification window we will be creating different classes as vegetation, water body and urban area. Class color is selected as Red for urban area, Blue for water body, Green for vegetation and yellow for Barren Land. Fig. 34 shows the Creation of different classes.

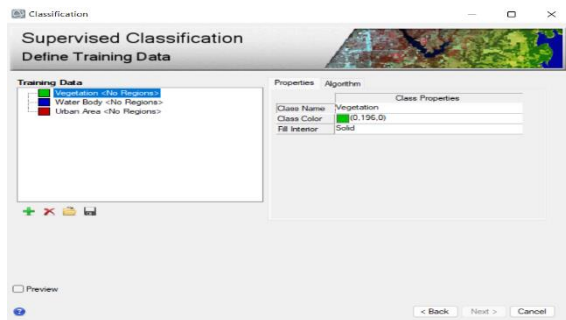


Fig. 34. Creating different classes

STEP 7: Now select numbers of samples for each class as polygons. These are referred to as 'Training Data'. Training data plays an important role in supervised classification process. Its quality is an important factor affecting accuracy. Fig. 35 shows Creating of Training Data.

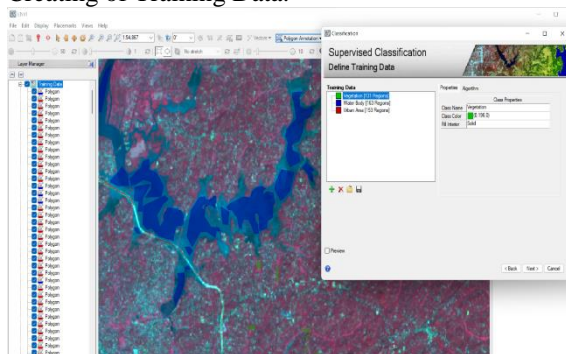


Fig. 35. Creating Training Data

More the number of samples selected for each class more will be the accuracy of classification.

STEP 8: Click on 'Save Training Data Set' to save the training data. Fig. 36 shows the Saving of Training Data Set. In the appeared window select output file location.

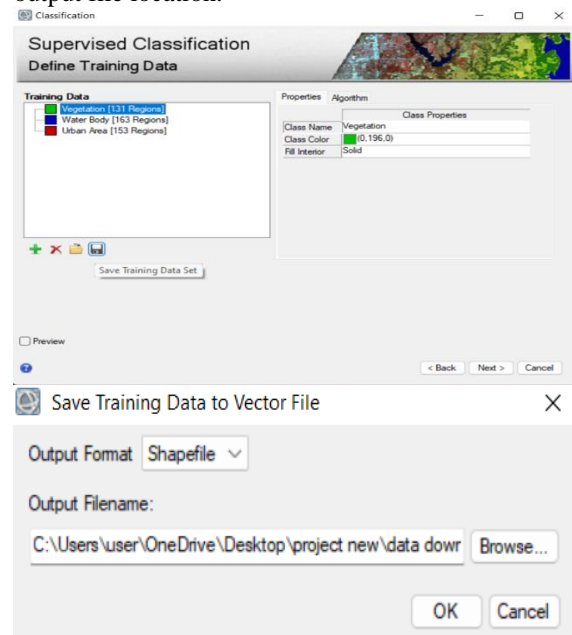


Fig. 36. Saving Training Data Set

Now click 'OK' to save the Output Filename.

STEP 9: Now click on 'Algorithm'. Select 'Maximum Likelihood'. Fig. 37 shows the Selection of Maximum Likelihood classification. By clicking 'Next', 'Refine Results' window appears. Fig. 38 indicates the Appeared Cleanup Refined Results window.

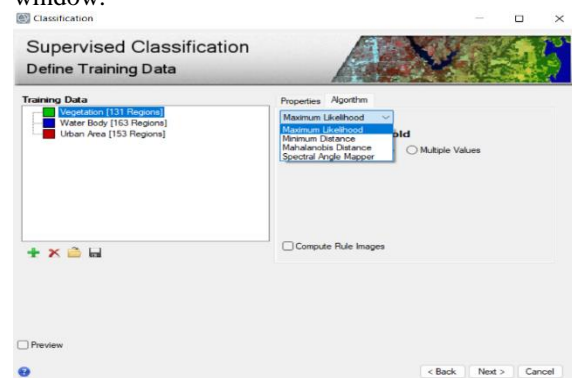


Fig. 37. Selecting Maximum Likelihood classification

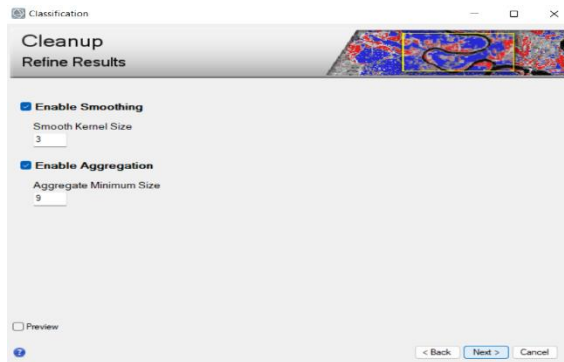


Fig. 38. Appeared Cleanup Refined Results window

Now click 'Next' and supervised classification is done.

STEP 10: Now 'Export, Save Results' window appears. In 'Export Files', output file name is selected for 'Export Classification Image' and 'Export Classification Vectors'. Fig. 39 shows Selecting of output filename. Click 'Finish' then classified data is displayed. Fig. 40 indicates Classified data.

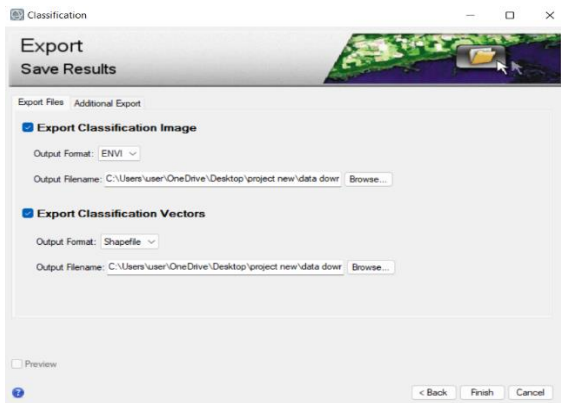


Fig. 39. Selecting output filename

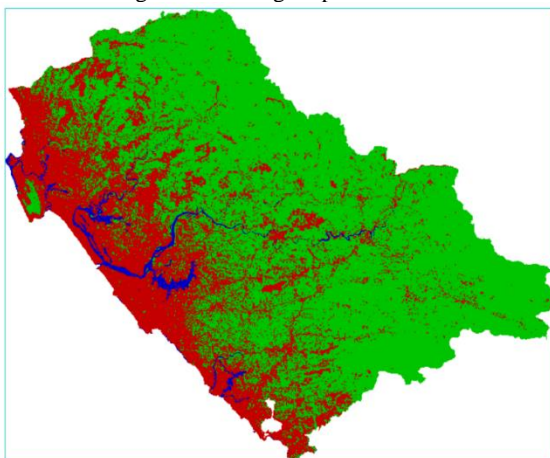


Fig. 40. Classified data

This map obtained after classification is then used to calculate the areas of certain classes of the study area.

STEP 11: Now in 'FILE' select 'Save As' and then 'Save As ERDAS IMAGINE' and save the file by choosing output file location. Fig.41 shows Saving file as ERDAS IMAGINE.

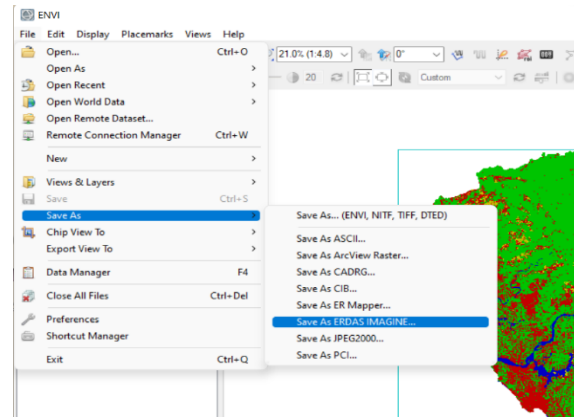


Fig. 41. Saving file as ERDAS IMAGINE.

E. Comparison

The final step is the comparison. The classified data for selected years can be compared to identify the change in land use and land cover mapping in Kannur district between the year 1991 and 2022. The data of the year 1991, 1998, 2013, 2018 and 2022 is prepared and Area calculation is done using ArcGIS and Excel, then compared to understand the change in land use and land cover. By this comparison the amount of vegetation loss, the rate of urbanization in particular areas etc. can be identified. i.e., we can identify the change in land cover and land use from 1991 to 2022 in Kannur district and the rate of urbanization can be understood.

1. Steps involved in Area Calculation

STEP 1: Start ArcMap 10.8.

STEP 2: Click on 'Catalog' and select 'Connect to Folder' and then choose the folder to which you want to connect. Fig. 42 shows how to connect to folder.

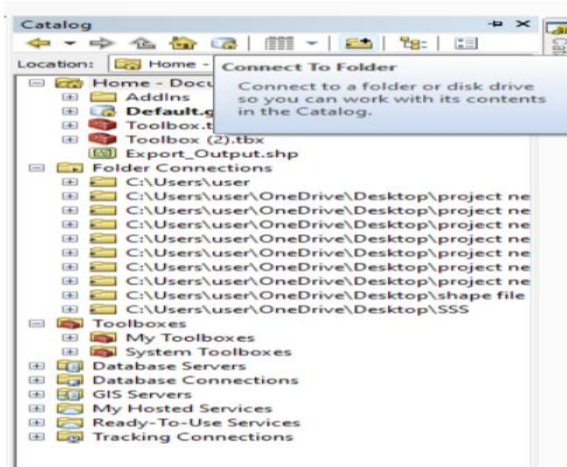


Fig. 42. Connecting to Folder.

STEP 3: Now in the 'Table of Contents', right click on 'Layers' and select 'Add Data' and add data by selecting the saved image file. Fig. 43 shows the Adding of Data to ArcGIS.

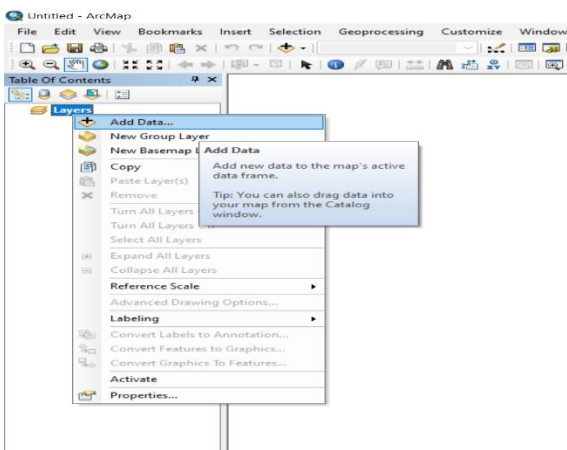


Fig. 43. Adding Data to ArcGIS

So, the image will be displayed in ArcMap.

STEP 4: The ENVI class names and color schemes may be different when you open in ArcGIS. So right click on the data in 'Layers' and select 'Layer Properties'. Fig. 44 shows Selecting of Layer Properties. In Layer Properties select 'Symbology' and then select 'Unique Values'. Now in the 'Value Field' select the option 'Value'. Fig. 45 shows Selecting Value Field.

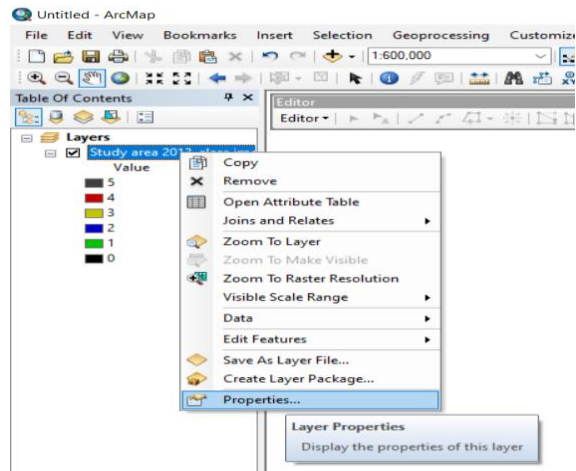


Fig. 44. Selecting Layer Properties.

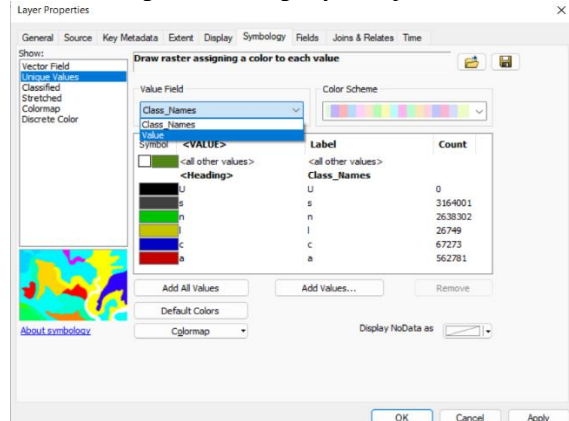


Fig.45. Selecting Value Field

Now clicking 'Apply', we will get the data displayed in 'Table of Contents' with Grid Values. Fig.46 shows the classes displayed with grid values.

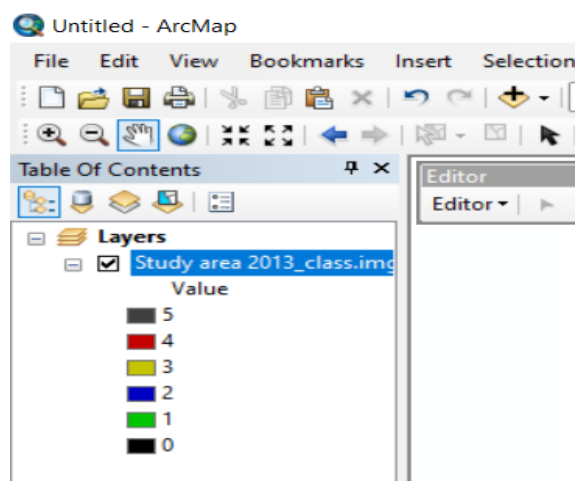


Fig. 46. Classes displayed with grid values.

STEP 5: Right click on the data in 'Layers' and select 'Open Attribute Table'. Fig. 47 shows the Opening Attribute Table.

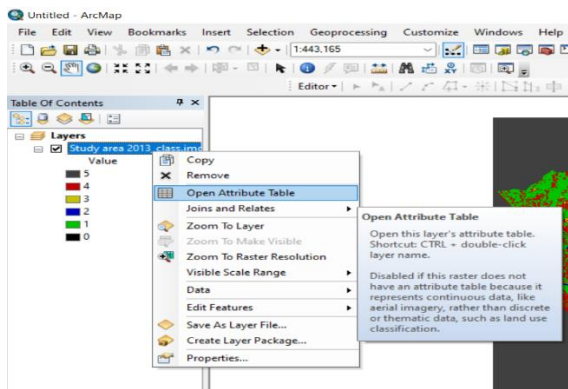


Fig. 47. Opening Attribute Table.

The table window will be appeared.

STEP 6: In 'Table Options', click on 'Add Field'. Fig. 48 shows Adding new field. In the appeared add field window give name as 'Class Name' and select 'Text' as type and click 'OK'.

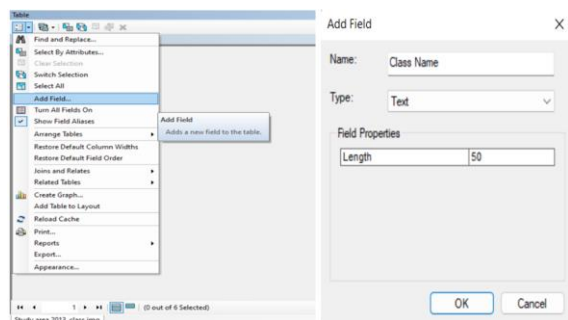


Fig. 48. Adding new field

STEP 7: Now name each class according to values which is displayed in 'Layers'. Fig. 49 shows the Entering of Class Names based on value.

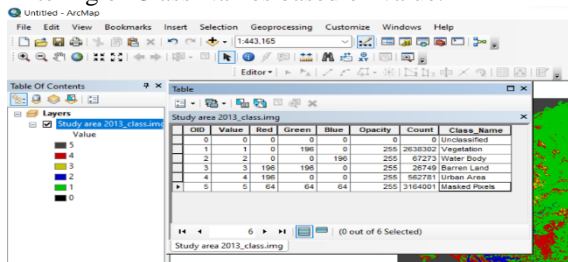


Fig. 49. Entering Class Names based on value

Care should be taken to provide correct class names according to corresponding values, as any mistake or change in class names will devastate the results.

STEP 8: For area calculation we want to convert the Raster file into Vector file. For this in 'Arc Toolbox' select 'Conversion Tools'. Fig.50 shows Selecting of conversion tools. Under this select 'From Raster' option and then select 'Raster to

Polygon'. Fig. 51 shows the Raster to Polygon window.

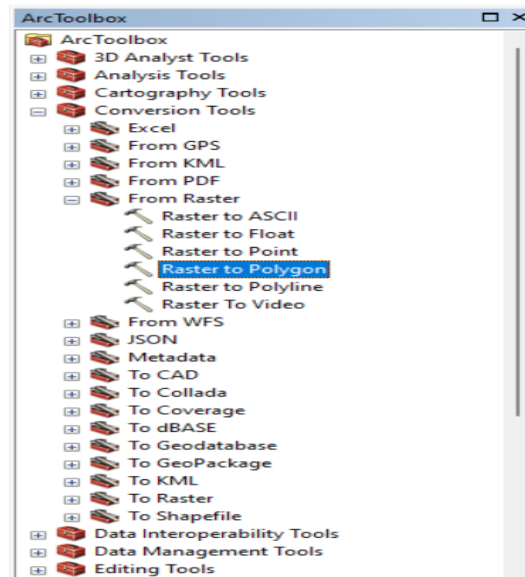


Fig. 50. Selecting conversion tools

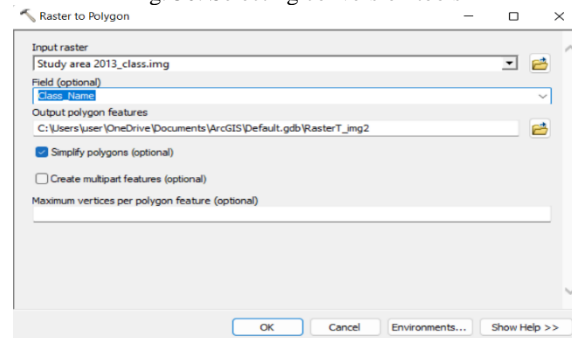


Fig. 51. Raster to Polygon window

In the displayed window the 'Input Raster' file is the image of our study area only. Select 'Class-Name' as Field. Browse the output file location and click 'OK'. The vector file will be displayed in 'Layers'. Fig.52 shows Vector data Displayed in Layers.

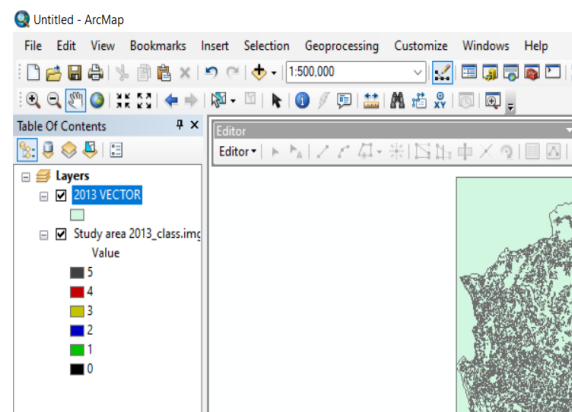


Fig. 52. Vector data Displayed in Layers.



STEP 9: Right click on the vector data in ‘Layers’. Select ‘Open Attribute Table’. Fig. 53 indicates the Attribute Table of vector data.

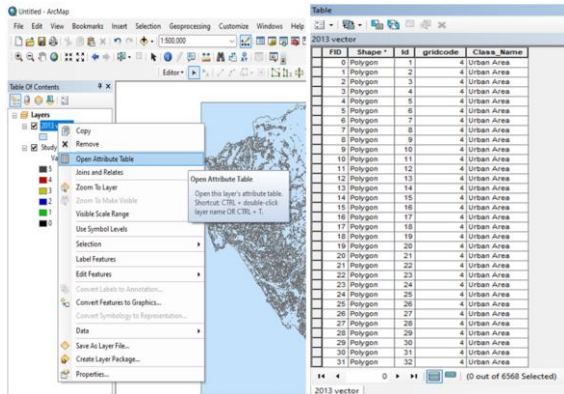


Fig. 53. Attribute Table of vector data

The attribute table only denotes the individual grid of different classes as separate and area covered by each class is not available. Hence it is to be found.

STEP 10: In ‘Table Options’, click on ‘Add Field’ and name field as “Area”. Fig. 54 shows Adding the New Field ‘Area’ and select ‘Type’ as “Double”. Now click ‘OK’.

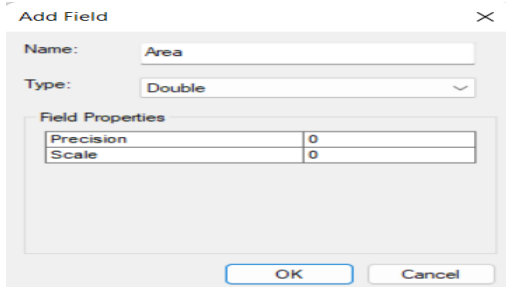


Fig. 54. Adding New Field ‘Area’

STEP 11: Now right click on ‘Area’, ‘Calculate Geometry’ option is there. Fig. 55 shows Selecting of ‘Calculate Geometry’. By clicking, ‘Calculate Geometry’ window appears. Fig. 56 indicates the Calculate Geometry Window.

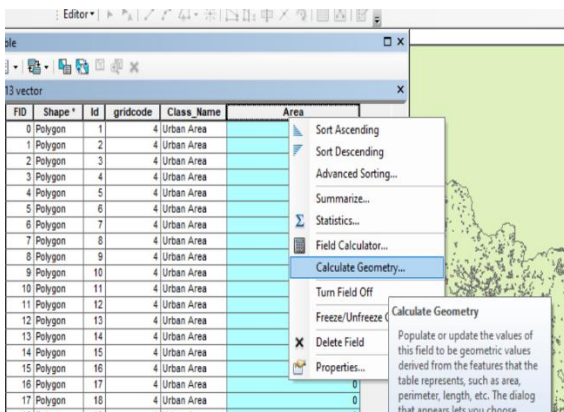


Fig. 55. Selecting ‘Calculate Geometry’

Select unit as “Square Kilometers [sq km]” and click ‘OK’. The area will be displayed as separate.

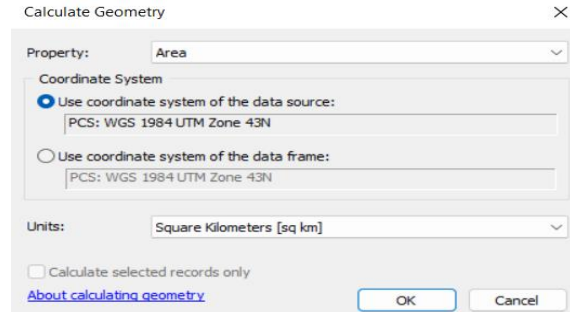


Fig. 56. Calculate Geometry Window.

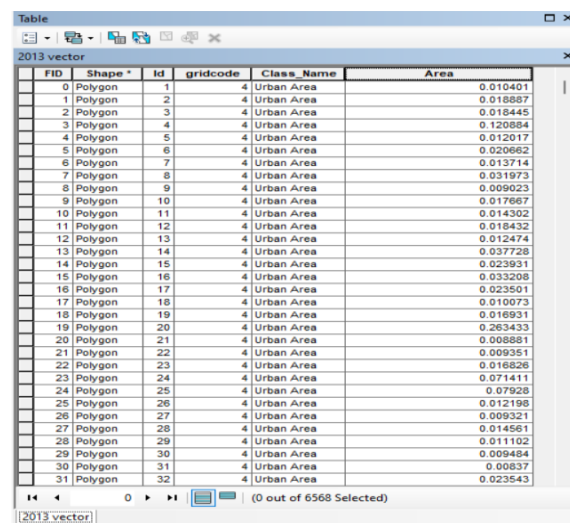


Fig. 57. Area Displayed as separate

Here the area of individual grids of different classes are obtained. the next step is to find the total area covered by each class.

STEP 12: To get total area covered by each class, we will convert this file into excel format. i.e. export all data into excel format. For this in ‘Table Options’ click ‘Export’. Fig. 58 shows Selecting Export option. Fig. 59 indicates Export Data window.

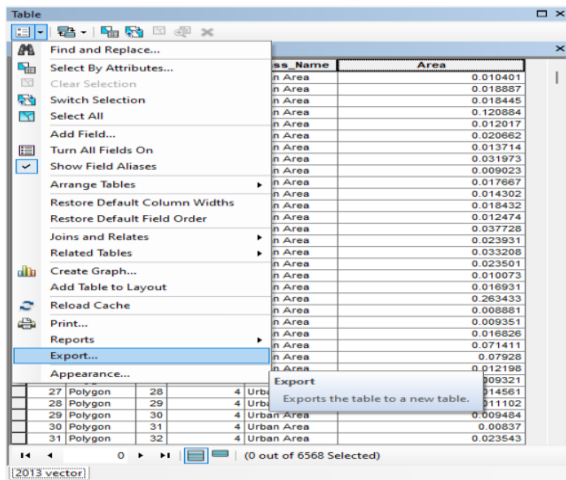


Fig. 58. Selecting Export option

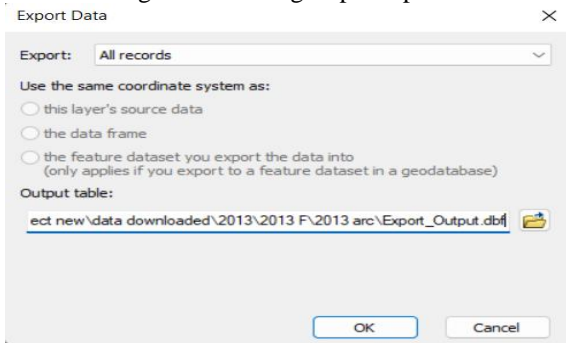


Fig. 59. Export Data window

In the appeared 'Export Data' window browse output table location. Now click 'OK', and the 'Saving Data' window appears. Fig.60 indicates the Saving Data window. Now select "dBASE Table" in 'Save as Type' option.

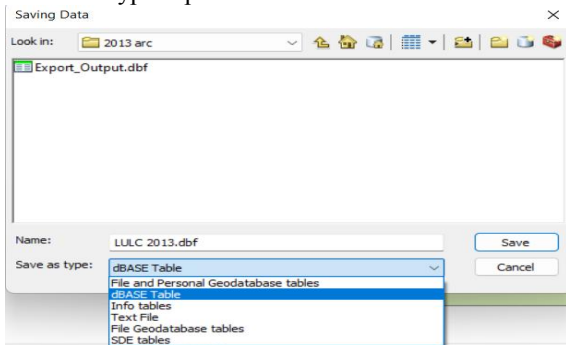


Fig. 60. Saving Data window

STEP 13: Now open Excel. Go to files and browse the data. Change to 'dBase Files' option. Fig. 61 shows Opening dBase File in Excel.

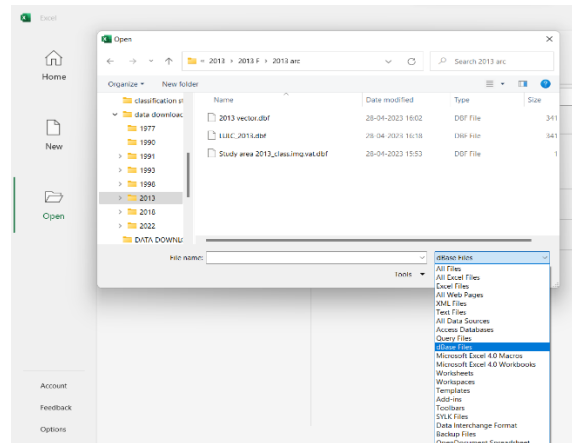


Fig. 61. Opening dBase File in Excel

Now select file and click 'Open'.

STEP 14: In 'Insert' select 'Pivot Table'. Fig. 62 shows Inserting of Pivot Table. The 'PivotTable from table or range' window appears as shown in Fig. 63.

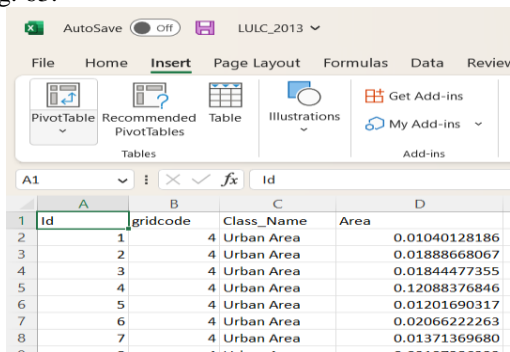


Fig. 62. Inserting Pivot Table

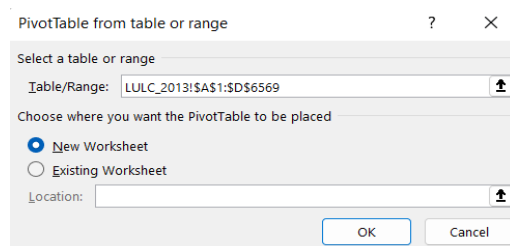


Fig. 63. PivotTable from table or range window.

Now click 'OK'. The 'Pivot Table Fields' appears as shown in Fig. 64. In 'Pivot Table Fields' select Class Name and Area. The Class Name will come in 'Rows' Table and Area to 'Values'.

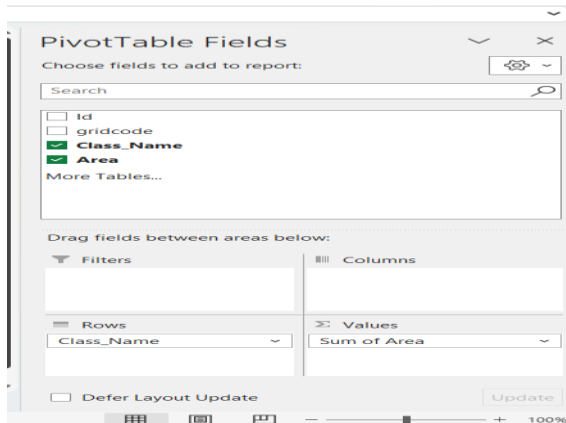


Fig. 64. Pivot Table Fields

Thus, we will get the sum. Fig. 65 shows the Sum of Area.

Row Labels	Sum of Area
Barren Land	23918032.86
Urban Area	503828252.6
Vegetation	2377136591
Water Body	60654355.46
Grand Total	2965537232

Fig. 65. Sum of Area

The sum of area of each class are obtained. For easy comparison to identify LULC change the percentage area of each class need to be found.

STEP 15: Now we will copy the value and paste in it nearby. Now click on 'AutoFit Column Width' in 'Format'. Fig. 66 shows Copying and pasting data and selecting Autofit column width.

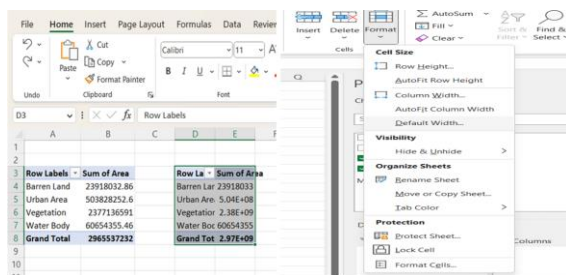


Fig. 66. Copying and pasting data and selecting Autofit column width

STEP 16: So, to calculate the percentage of each class create new column '%'. Enter '=' and select 'Sum of Area' of class divided by ('/') 'Total Area'. Fig. 67 shows Calculating Percentage of each class.

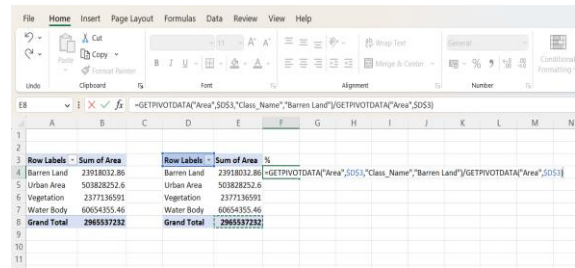


Fig. 67. Calculating Percentage of each class.

Do the same for all classes. Fig.68 indicates the Total percentage of land covered by each class.

Row Labels	Sum of Area	%
Barren Land	23918032.86	1%
Urban Area	503828252.6	17%
Vegetation	2377136591	80%
Water Body	60654355.46	2%
Grand Total	2965537232	

Fig. 68. Total percentage

The percentage of area covered by each class is obtained and by finding the same for all respective years of study we can easily compare and identify the LULC change.

III. RESULT

A. LULC classification of Kannur District - 1991

Fig. 69 shows the LULC Map of Kannur District of the year 1991

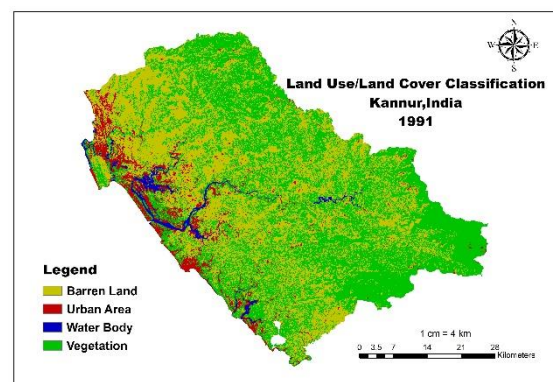


Fig. 69. LULC Map of Kannur District of the year 1991

LULC distribution of Kannur District in 1991 for different class are mentioned in Table 6.

Table - 6
LULC Distribution of Kannur District in 1991

Year	Sl No.	LULC Class	Area (m ²)	Area (%)
------	--------	------------	------------------------	----------



1991	1	Barren Land	1274341618	43
	2	Urban Area	174337397.9	6
	3	Vegetation	1463930690	49
	4	Water Body	52861814.96	2

Here the Barren Land covers 43% of total area, where as urban area takes up 6%, 49% is covered with vegetation and only the remaining 2% is contributed by Water body.

B. LULC classification of Kannur District - 1998

Fig.70 shows the LULC Map of Kannur District of the year 1998.

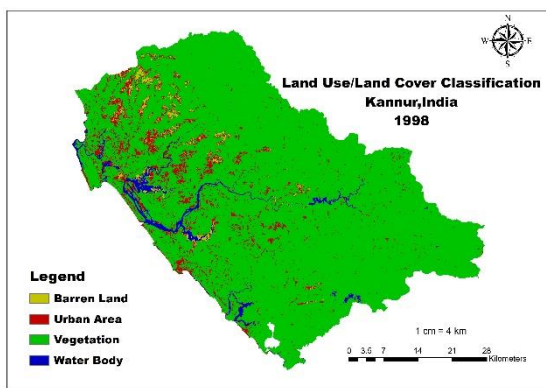


Fig. 70. LULC Map of Kannur District of the year 1998

The LULC Distribution of Kannur District in 1998 for different class are mentioned in Table 7.

Table - 7

LULC Distribution of Kannur District in 1998

Year	SI No.	LULC Class	Area (m ²)	Area (%)
1998	1	Barren Land	33927135.63	1
	2	Urban Area	187525420	6
	3	Vegetation	2675987721	90
	4	Water Body	68099554.78	2

Here the class vegetation covers the major part as it contributes 90% of total area. 6% is taken up by urban area and remaining 3% is covered by Barren Land and Water Body by 1% and 2% respectively.

C. LULC classification of Kannur District – 2013

Fig.71 shows the LULC Map of Kannur District of the year 2013.

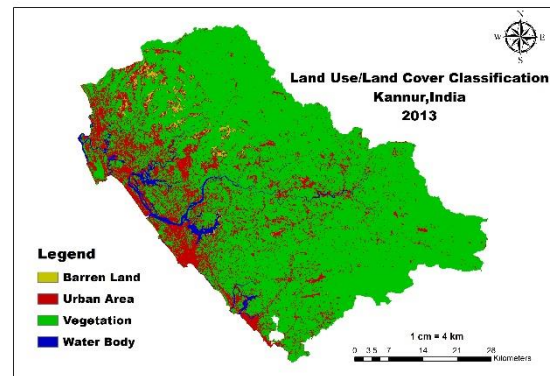


Fig. 71. LULC Map of Kannur District of the year 2013

The LULC Distribution of Kannur District in 2013 for different class are mentioned in Table 8.

Table - 8

LULC Distribution of Kannur District in 2013

Year	SI No.	LULC Class	Area (m ²)	Area (%)
2013	1	Barren Land	23918032.86	1
	2	Urban Area	503828252.6	17
	3	Vegetation	2377136591	80
	4	Water Body	60654355.46	2

Here the class vegetation covers the major part of total area which includes 90%. The urban area takes up 17% and 2% is occupied with Water Body. Only remaining 1% contribute.

D. LULC classification of Kannur District - 2018

Fig. 72 shows the LULC Map of Kannur District of the year 2018.

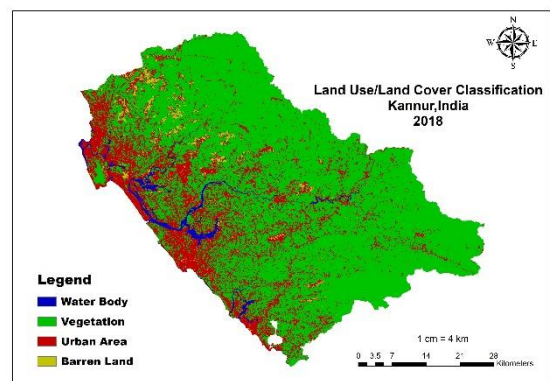


Fig. 72. LULC Map of Kannur District of the year 2018

The LULC Distribution of Kannur District in 2018 for different class are mentioned in Table 9.



Table - 9
LULC Distribution of Kannur District in 2018

Year	Sl No.	LULC Class	Area (m ²)	Area (%)
2018	1	Barren Land	46707844.36	2
	2	Urban Area	651000941.4	22
	3	Vegetation	2211990797	75
	4	Water Body	55838642.46	2

Here 75% of the total area is covered by vegetation, which contributes the major area. The Urban Area occupies 22% and remaining area is occupied by Water Body and Barren Land, each class covering 2% of total area.

E. LULC classification of Kannur District - 2022

Fig. 73 shows the LULC Map of Kannur District of the year 2022.

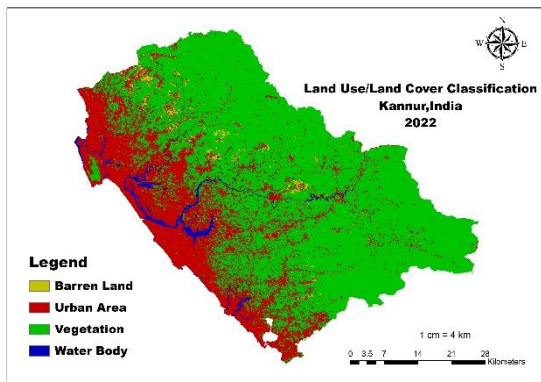


Fig. 73. LULC Map of Kannur District of the year 2022

The LULC Distribution of Kannur District in 2022 for different class are mentioned in Table 10.

Table - 10
LULC Distribution of Kannur District in 2022

Year	Sl No.	LULC Class	Area (m ²)	Area (%)
2022	1	Barren Land	37450481.52	1
	2	Urban Area	813759112.9	27
	3	Vegetation	2056970766	69
	4	Water Body	57358730.17	2

Here the class Vegetation covers the major part of total area, which is 69%. The Urban Area is occupying a total of 27% of total area. The remaining 3% is occupied by Water Body and Barren Land by 2% and 1% respectively.

IV. CONCLUSION

Land Cover indicates the physical land type such as forest or open water whereas Land Use documents how people are using the land. LULC is vital to investigate Land Use patterns and helping forecast future sustainable land management. Updated and precise LULC Maps are essential for sound planning, sustainable development, environmental monitoring, worldwide change, the estimation of forest degradation and also for monitoring of temporal dynamics of agricultural ecosystem, surface waterbodies etc.

This comprehensive study is done to examine the LULC Changes in Kannur District between 1991 and 2022. The LULC Maps were prepared by supervised classification in ENVI 5.8 using Landsat 5 (TM), Landsat 8 (OLI/TIRS) and Landsat 9 (OLI/TIRS) satellite data downloaded from USGS Earth Explorer site for the years 1991, 1998, 2013, 2018 and 2022. Area calculation is done using ArcMap 10.8 and Excel and area covered by each LULC Classes in respective year is found.

Table - 11
LULC Distribution of Kannur District between 1991 and 2022

Sl No	LULC Class	LULC Class Area (%) in Year				
		1991	1998	2013	2018	2022
1	Barren Land	43	1	1	2	1
2	Urban Area	6	6	17	22	27
3	Vegetation	49	90	80	75	69
4	Water Body	2	2	2	2	2

The study demonstrates that vegetation is the primary Land Use in the studied region. The maximum change is noticed from vegetation area which has increased to about 41% between 1991 and 1998 and then declined about 21% during 1998 and 2022. In case of Urban Area, it remains the same during 1991 and 1998 and raised by 21% between 1998 and 2022. The result shows that the vegetation is the major contributor in the growth of urban area, as the urban area has expanded mostly over these land use class. The presence of water body has also a significant contribution in urban area expansion.

While considering Barren Land it has a drastic decline during 1991 and 1998, which then has only slight changes between 1998 and 2022. At last, taking Water Body in consideration, it remains the same in area contributing only 2% of entire area between 1991 and 2022.

The study of Land Use Land Cover Change of Kannur District reveals that the development pattern is Irregular.



REFERENCES

- [1]. Can Bulent Karakus, Orhan Cerit, Kaan Sevki Kavak, (2015), "Determination of Land use/cover changes and land use potentials of Sivas city and its surroundings using Geographical Information Systems (GIS) and Remote Sensing (RS)", *Procedia Earth and Planetary Science*.
- [2]. Ernest Biney, Ebenezer Boakye, (2021), "Urban sprawl and its impact on land use land cover dynamics of Sekondi-Takoradi metropolitan assembly, Ghana", *Environmental Challenges*.
- [3]. Hsiao-chien Shih, Douglas A. Stow, Kou-Chen Chang, Dar A. Roberts & Konstadinos G. Goulias, (2021), "From land cover to land use: Applying random forest classifier to Landsat imagery for urban land use change mapping", *Geocarto International*.
- [4]. Hsiao-chien Shih, Douglas A. Stow, Yu Hsin Tsai, (2018), "Guidance on and comparison of machine learning classifiers for Landsat-based land cover and land use mapping", *International Journal of Remote Sensing*.
- [5]. James Magidi, Fethi Ahmed, (2018), "Assessing urban sprawl using remote sensing and landscape metrics: A case study of City of Tshwane, South Africa (1984-2015)", *The Egyptian Journal of Remote Sensing and Space Sciences*.
- [6]. Md Mahadi Hasan Seyam, Md Rashedul Haque, Md Mostafizur Rahman, (2023), "Identifying the land use land cover (LULC) changes using remote sensing and GIS approach: A case study at Bhaluka in Mymensingh, Bangladesh", *Case Studies in Chemical and Environmental Engineering*.
- [7]. Mohd Waseem Naikoo, Mohd Rihan, Mohammad Ishtiaque, Shahfahad, (2020), "Analyses of land use land cover (LULC) change and built-up expansion in the suburb of a metropolitan city: Spatio-temporal analysis of Delhi NCR using landsat datasets", *Journal of Urban Management*.
- [8]. Muhammad Salem, Naoki Tsurusaki, Prasanna Divigalpitiya, (2020), "Land use/land cover change detection and urban sprawl in the peri-urban area of greater Cairo since the Egyptian revolution of 2011", *Journal of Land Use Science*.
- [9]. N. C. Gautam, G. Ch. Chennaiah, (1985), "Land-use and land-cover mapping and change detection in Tripura using satellite LANDSAT data", *International Journal of Remote Sensing*.
- [10]. Parvaiz A. Bhat, Mifta Ul Shafiq, Abaas A. Mir, Pervez Ahmed, (2017), "Urban sprawl and its impact on landuse/land cover dynamics of Dehradun City, India", *International Journal of Sustainable Built Environment*.
- [11]. Prabuddh Kumar Mishra, Aman Rai, Suresh Chand Rai, (2020), "Land use and land cover change detection using geospatial techniques in the Sikkim Himalaya, India", *The Egyptian Journal of Remote Sensing and Space Sciences*.
- [12]. Shaojuan Xu, Manfred Ehlers, (2022), "Automatic detection of urban vacant land: An open-source approach for sustainable cities", *Computers, Environment and Urban Systems*.