A MINI PROJECT

ON

"Watershed Analysis and LULC change detection at Chirang District using ARC GIS"

Submitted in Partial Fulfillment for the Requirements for the award of Degree of

MASTERS OF TECHNOLOGY (CIVIL ENGINEERING)

UNDER

ASSAM SCIENCE AND TECHNOLOGY UNIVERSITY

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SESSION: 2023-2025

SELF DECLARATION

The work contained in the report **"Watershed Analysis and LULC change detection at Chirang District using ARC GIS"** has been carried out by me under the supervision of **Dr. BHARATI MEDHI DAS**, Professor, Department of Civil Engineering, Assam Engineering College, Jalukbari. The project is submitted in partial fulfillment of requirements for the award of the degree of "Master of Technology in Civil Engineering" under specialization on Water Resources Engineering to the Department of Civil Engineering, Assam Engineering College, Jalukbari , Guwahati-781013, Assam.

The matter embodied in this dissertation has not been submitted to any other institute for the award of any other degree. I have followed the guidelines provided by the Department of Civil Engineering, Assam Engineering College, Jalukbari, Guwahati-781013, Assam. Whenever materials from other sources are used, due acknowledgement is given to them by citing them in the text of this project and giving their details in the references.

This is to certify that the above statement made is correct to the best of my knowledge.

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The content of this report has not been submitted to any other university for the award of any degree.

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CERTIFICATE FROM THE HEAD OF THE DEPARTMENT

It is to certify that the project report entitled **“Watershed Analysis and LULC change detection at Chirang District using ARC GIS”** is hereby accorded our approval as a study carried out and presented in a manner in their 3rd semester courses for acceptance in partial fulfilment for the award of Master of Technology in Civil Engineering under specialisation on Water Resources Engineering degree for approval does not necessarily endorse or accept every statement made, opinion expressed or conclusion drawn as recorded in the report. It only signifies the acceptance of the project report for the purpose for which it is submitted.

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ABSTRACT

The GIS based remote sensing has been accepted widely as an as an effective tool to study complex problems associated with water resource management. It enables precise mapping of watersheds, assessment of water quality, study of land use-land cover aiding in flood risk assessment, mitigation and resource allotment in case of natural hazards. The present study aims to examine the watershed attributes and analyse the changes in land use land cover (LULC) within Manas River Basin located in Chirang district of Assam by the help of Arc GIS.

The watershed analysis of Manas river basin is done using various steps like downloading DEM (Digital Elevation Model) for study area, creating basin, generating stream networks, displaying flow accumulation, watershed delineation, generating contour lines and estimating storage capacity of watershed at variable heights. The outputs of the various parameters can be visualized using symbology and labeling options in Arc GIS. The LULC (Land use land cover) analysis was carried out using maximum likelihood supervised classification for three different time periods. Classification was done on classes like water bodies, forest, agriculture, built up, barren land and flood plains.

The results from the watershed analysis provides insights into drainage pattern, storage capacity and stream networks aiding in the assessment of potential flood risks and management. The LULC analysis presented the trends of changes in land use due to urban growth, agriculture expansion and forest depletion. These changes can cause significant impact in the environment, ecology, geography and economy. The findings highlight the importance of GIS based approach while dealing with challenges present within the realm of water resources engineering.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

A watershed is an area that is capable of draining all the water that lands on it and its surroundings. Watershed analysis involves the processes of using DEMs (Digital elevation Models) and raster operations to delineate watersheds, derive topographic features such as stream networks, stream order (E. Horton, 1945) and estimating storage capacities. Earlier watershed delineation was done by hand delineation and catchment area was obtained based on the information available on topography of that area (William, 2000). Nowadays with remote sensing based GIS application watershed delineation can be done without hurdles and delay. ArcGIS facilitates this through its specific spatial analysis tools, by incorporating DEMs, hydrological data and other spatial data layers to define watershed boundaries with high precision. The stream order of a river basin can provide vital information about the hydrological and ecological characteristics of the basin. Higher order streams indicates larger channel with more water flow and are formed due to convergence of lower order streams. This aids in identification of flood risk zones and assessment of water quality and habitat topography. Watershed storage capacities at different elevations can also be estimated using a supplementary spatial analyst tool. It generates tables and charts of elevations and corresponding storage capacities at various elevation increments.

Land Use/Land Cover maps can be prepared in ArcGIS through several techniques like Supervised Classification, Unsupervised Classification, and Hybrid Classification etc. Supervised Classification uses training data for known classes and assigns pixel to certain class. Various methods are available like Maximum Likelihood Classification, Support Vector and Random forest within supervised classification in order to prepare LULC maps. Land Use/Land Cover (LULC) change detection by maximum likelihood classification (MLC) based on supervised classification in ArcGIS includes categorizing pixels in multi-temporal images on the basis of their spectral signatures. MLC assumes that the statistics for each class in the image are normally distributed and calculates probability of each pixel belonging to each class. After examining the probabilities, the pixel is assigned to the class with the highest likelihood.

By examining the watershed parameters and analyzing its effects in changing the land use and land cover of a particular region one can avail substantial information to plan out effective watershed management techniques without compromising with the rising economic demands of the region. The present study aims to perform watershed analysis and land use land cover change detection of a particular region using ArcGIS.

1.2 OBJECTIVES OF THE STUDY

The main objectives of the study are listed below:-

- To obtain a high quality DEM for the study area and ensure that it is properly georeferenced with other spatial data layers.
- Deriving the stream network and obtaining stream orders in the study area basin.
- Delineate the watershed basin that contributes to the water flow.
- Estimate the storage capacities based on different elevations.
- Prepare Land use/Land cover (LULC) maps of the study area in different years.
- Detect the changes occurred in each classes and prepare charts showing their change.

CHAPTER 2

LITERATURE REVIEW

Horton et al. (1945) introduced the initial concept of stream order based on tributary numbers, establishing foundational laws of drainage composition. This foundational work quantifies the hierarchical structure of river systems, influencing hydrological studies by linking stream size to basin shape, drainage density, and flow characteristics.

Strahler et al. (1952), refined this into a more universally applicable system, where stream order increases at each confluence, setting the standard for hydrologic stream classification. Stream order is pivotal in delineating watersheds, offering a framework to understand the hierarchical structure of river networks, crucial for hydrology. This review synthesizes the evolution, application, and implications of stream order within watershed studies

Islam et al. (2004) compared traditional hand delineation with GIS-based methods, concluding that digital methods are superior in terms of time efficiency and potentially accuracy. He compared manual delineation on topographic maps with automated GIS methods, finding that while both methods can achieve similar results, automated methods are far more efficient and less prone to human error.

Majumder et al. (2011), conducted a study focusing on how alterations in Land Use/Land Cover (LULC) influence hydrological cycles, with a special emphasis on the effects of urbanization. Their research examined how converting natural landscapes into urban areas increases impervious surfaces, leading to higher runoff coefficients. This change significantly affects peak flow rates, thereby increasing flood risks. By integrating LULC data with hydrological modeling, they provided insights into managing water resources and mitigating urban flood risks.

Hwang et al. (2016,) in their study titled "Impact of land use and land cover change on soil erosion in South Korea," investigated how changes in LULC affect soil erosion rates using the Revised Universal Soil Loss Equation (RUSLE) model. The study found significant increases in soil erosion rates associated with the conversion from forest to agricultural or urban land uses

S. Aryal and B. K Shrestha et al. (2017) conducted a study on the evaluation and application of the Soil and Water Assessment Tool (SWAT) model to assess the impact of climate change on the hydrology of the Himalayan River Basin, specifically the Tamor River Basin in Nepal. Their research focused on understanding how climate variability influences water resources, essential for agricultural use and hydropower. They used SWAT to simulate basin hydrology under different climate scenarios, examining changes in streamflow under RCP4.5 and RCP8.5 scenarios, highlighting the vulnerability of Himalayan water resources to climate change.

Lahon et al. (2014) and numerous other researchers have utilized Geographic Information Systems (GIS) with Digital Elevation Models (DEMs) for precise watershed delineation. This approach allows for the calculation of morphometric parameters and the development of stream networks necessary for hydrological analysis.

CHAPTER 3

DESCRIPTION OF THE STUDY AREA

3.1 INFORMATION OF THE STUDY AREA

The Manas River Basin has a considerable impact on the Chirang district of Assam, India, as it is a part of the large Brahmaputra river system. The Manas River originates in Tibet and runs through Bhutan before entering India, finally meeting with the Brahmaputra near Jogighopa. The rivers in Chirang add to the district's biodiversity and biological richness by flowing along the Bhutan border and through Manas National Park, a UNESCO World Heritage Site noted for its outstanding biodiversity.

The present project is based on a study area in Chirang District comprising Manas River basin. The study area polygon is composed of 870 km^2 area and its perimeter is 120km. The Manas River also has a significant impact on the region's climate, supporting a subtropical environment defined by warm and humid summers and dry, chilly winters, with its flow impacted by both monsoon rains and Himalayan runoff.

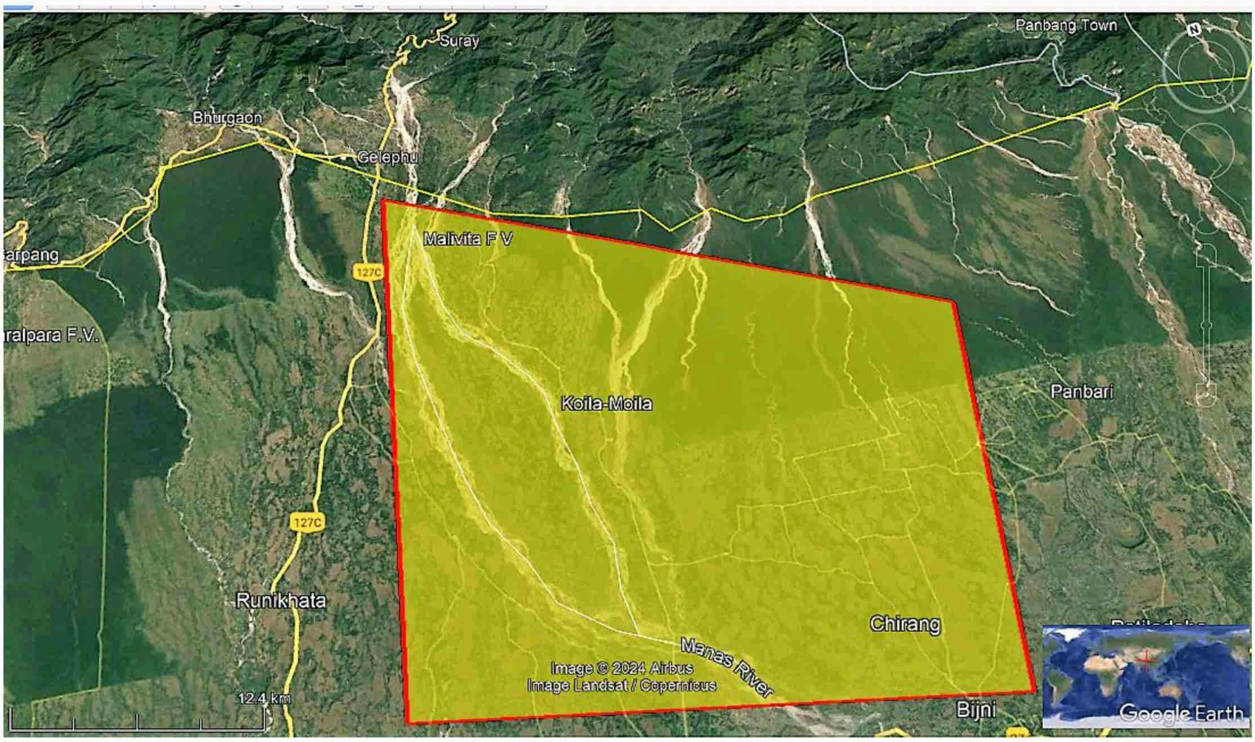


Fig 3.1 Google Earth image showing the study area based in Chirang District.

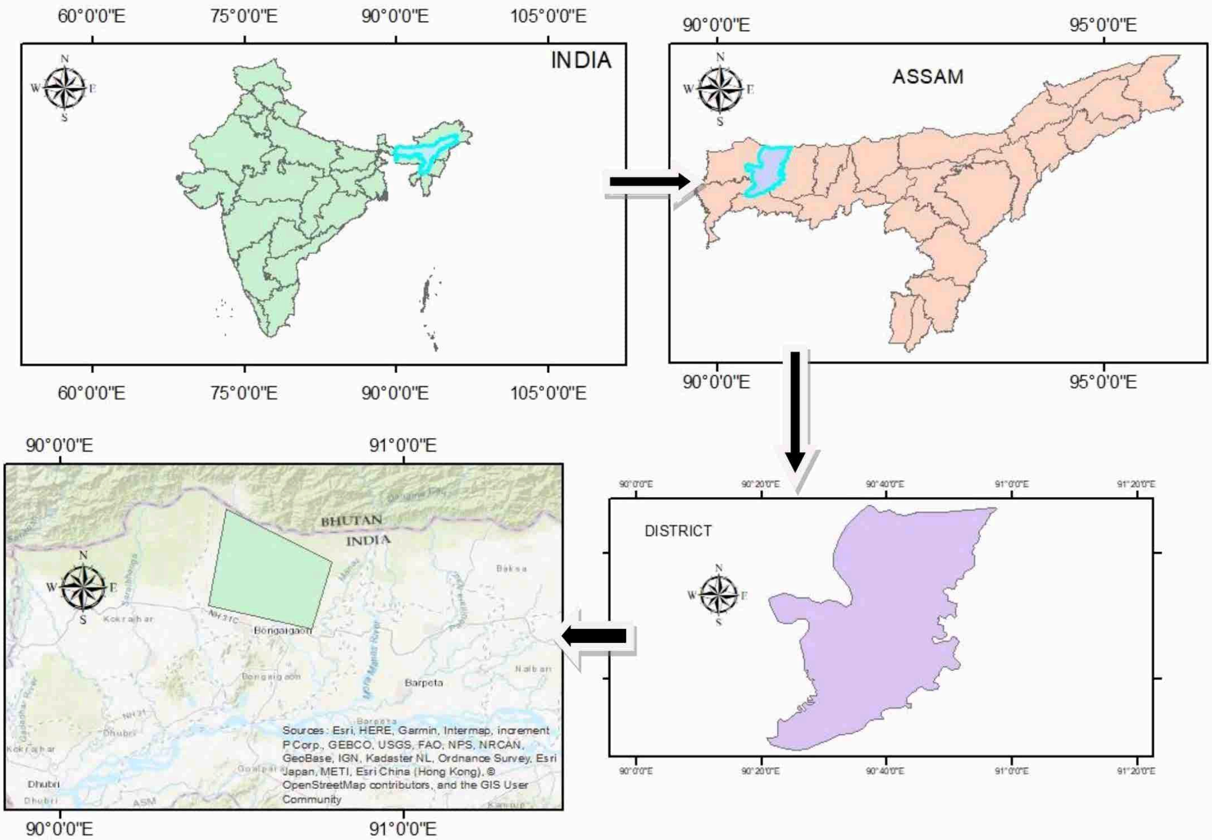


FIGURE 3.2 Study area in ArcGIS layout a)INDIA b)ASSAM c)BONGAIGAON & CHIRANG d) Selected study area

The flood problems in Chirang district are primarily due to a combination of natural and human-induced factors. Geographically, Chirang is located in the flood-prone Brahmaputra River basin, making it inherently susceptible to floods. Heavy monsoon rains, which are common in this region, lead to an overflow of rivers like the Manas, Beki, and Pahumara, which are tributaries of the Brahmaputra.

The situation is worsened by the release of water from the Kurichu Dam in Bhutan, which often leads to a sudden increase in water levels downstream in Assam. Additionally, deforestation in the upper catchments accelerates soil erosion, increasing sediment load in the rivers which can raise riverbeds, reducing their capacity to hold water.

Human activities, such as improper land use, construction on floodplains, and inadequate drainage systems, also contribute significantly. The lack of effective river training works and embankment maintenance allows rivers to change course or breach their banks during high water levels. Climate change has further complicated the scenario by increasing the intensity and frequency of rainfall, leading to flash floods and prolonged inundation. Together, these factors result in recurrent and severe flooding, impacting agriculture, infrastructure, and the local population's livelihood in Chirang district.

CHAPTER 4

THEORITICAL BACKGROUND

4.1 GENERAL

A watershed is an area of land where all water, whether from rain, snowmelt, or underground sources, drains to a common outlet such as a river, lake, or ocean. The process of delineation involves mapping out these areas based on topography. Elevation data, often derived from digital elevation models (DEMs), is crucial as water flows downhill following the path of least resistance, shaped by the landscape's contours. Using GIS (Geographic Information System) software, hydrologists can calculate flow direction, which indicates how water would move across the surface. From this, flow accumulation maps are created, showing areas where water accumulates, leading to the identification of streams and rivers.

In ArcGIS, the concept of "stream order" refers to a hierarchical classification system used to describe the size and complexity of streams within a drainage network. This system was originally developed by Robert E. Horton in the 1940s. The basic idea is to assign a numerical order to streams based on their tributaries:

- First-order streams are the smallest, having no tributaries. They are typically headwater streams.
- Second-order streams are formed when two first-order streams merge.
- Higher-order streams result from the joining of streams of the same order. For example, a third-order stream is created when two second-order streams join, and so forth.

First order streams are typically found in the highest elevations where water first starts to flow. They are responsible for starting the drainage pattern of a river system and contribute significantly to the overall water quality and ecology of whole watershed basin. Second order streams are formed when two first order streams meets together. Presence of second order streams represents increase in size, complexity and volume of watershed. Further increase in stream indicates larger and more significant waterways with significant volume affecting its nature and behavior in the surrounding ecosystem.

4.2 USES OF STREAM ORDER

Examining stream order in ArcGIS provides significant information which are crucial for watershed management, urban planning, hydrological and environmental monitoring. Here are some applications of stream order :

- Watershed management: Stream order helps to identify the areas of a river network that are important for watershed management. By identifying higher order of streams which have larger flow, efforts for conservation and sustainable development projects can be undertaken.
- Ecological Assessment: diverse stream orders are frequently associated with diverse ecological groups. Lower-order streams may provide unique habitats for specific species, whereas higher orders may sustain a variety of aquatic ecosystems.
- Water Quality Management: Understanding where and how streams merge allows planners to identify places for water quality monitoring, particularly where contaminants may accumulate or dilute.
- Land Use Planning: Stream order influences decisions on where to build infrastructure such as bridges or dams, as well as where to focus conservation efforts to maintain ecological integrity.
- Flood Management: Higher-order streams indicate higher water volumes, directing where flood barriers or mitigation methods should be strengthened.
- Navigation and Transportation: Study on stream order can be used to help plan out transportation infrastructures such as roads and bridges that cross rivers and streams. By understanding the stream order, engineers can design structures that are safe and effective for crossing the waterway.

4.3 Watershed delineation

Watershed delineation is the act of establishing the borders of a drainage basin such that all water from rain, snowfall, or other sources flows into a single outlet, such as a river, lake, or ocean. A Digital Elevation Model (DEM) is used to map the landscape's topography. Tools use this information to compute flow direction, which indicates how water will move across the terrain. Flow accumulation then determines potential water pathways by adding the amount of water that would travel through each site. A stream network can be created by defining a stream threshold. Finally, delineation tools trace back from a specific outlet point to determine the area's boundaries, where all runoff will converge.

Watershed delineation techniques have evolved from manual to digital. Initially, it used hand-drawn boundaries on topographic maps, which was prone to human mistake. With the development of computers in the 1980s, automated systems based on Digital Elevation Models (DEMs) arose. These algorithms determine flow direction and accumulation, allowing applications such as ArcGIS or QGIS to accurately identify watershed boundaries. Recent developments include high-resolution satellite data, which improves accuracy and detail. This trend has made watershed delineation faster, more consistent, and less subjective, hence improving environmental management, flood prediction, and water resource planning.

Watershed delineation requires:

- Digital Elevation Model (DEM): Provides the terrain's elevation data.
- GIS Software: Tools like ArcGIS, QGIS, or GRASS for spatial analysis.
- Flow Direction Tool: Determines water flow paths.
- Flow Accumulation Tool: Identifies potential stream networks.
- Watershed Delineation Tool: Defines basin boundaries from a pour point.
- Hydrology Extensions: Enhance capabilities with specific hydrologic functions.
- Threshold Setting: Manually or algorithmically defining what constitutes a stream based on flow accumulation.

Modern techniques also leverage remote sensing data and cloud computing for more detailed and dynamic analyses.

4.4 Uses of Watershed delineation:

Watershed delineation has numerous practical applications across various fields, enhancing our ability to manage natural resources, mitigate environmental impacts, and plan for sustainable development. Here are key uses:

Water Resource Management:

- Water Supply Planning: Understanding watersheds helps in assessing water availability, planning reservoir locations, and managing water distribution systems.
- Irrigation Planning: Delineation aids in designing efficient irrigation networks by pinpointing natural drainage patterns.

Flood Management:

- Flood Risk Assessment: By knowing where water flows, areas prone to flooding can be identified for mitigation measures like levees, floodplain zoning, or natural flood management strategies.

Environmental Protection:

- Pollution Control: Tracking how pollutants move through watersheds helps in pinpointing pollution sources, designing containment strategies, and protecting water quality.
- Habitat Conservation: Watersheds often correspond to critical habitats; delineation helps in conservation planning to protect biodiversity.

Land Use Planning:

- Urban and Rural Development: It informs where development should occur to minimize impact on water resources or to optimize water flow management.
- Zoning and Land Use Regulation: Helps in setting appropriate land use policies to protect sensitive areas.

Monitoring:

- Long-term ecological monitoring can be structured around watershed boundaries for coherent data collection and analysis.
- Emergency Response: Knowing the watershed helps in planning evacuation routes, emergency shelters, and resource allocation during flood events or water contamination incidents.

4.5 Land Use and Land cover maps (LULC)

A Land Use Land Cover (LULC) map is a thematic map that represents the distribution of different land use and land cover types over a geographical area. It serves as a critical tool for understanding how land is utilized by humans and the natural cover of the Earth's surface. Here's an in-depth look at what a LULC map entails:

Definition and Purpose:

Land Use: Refers to human activities or economic functions associated with a specific piece of land, like agriculture, urban development, or recreation.

Land Cover: Describes the physical material at the surface of the Earth, such as vegetation, water bodies, bare soil, or artificial structures.

LULC maps are designed to provide a snapshot of how these elements are distributed across landscapes, offering insights into environmental conditions, human impact, and planning needs.

Types of LULC Maps:

- Scale: Can range from local, where detailed classifications are possible, to global, providing a broad but less detailed categorization.
- Classification Systems: Various systems exist like the Anderson Land Use and Land Cover Classification System or more recent ones like the CORINE Land Cover for Europe, each with specific classes tailored to regional characteristics or intended use.

LULC maps are fundamental in bridging the gap between environmental science, policy, and practical land management, offering a visual and analytical tool for decision-making across various sectors

4.6 Land Use and Land cover maps (LULC) applications

Land Use Land Cover (LULC) maps have a wide array of applications across multiple disciplines, reflecting their utility in both environmental management and socio-economic planning. Here are some key applications:

1. Environmental Management:

- Wildlife Corridors: Mapping can show connectivity between habitats, aiding in the design of wildlife passages or green corridors.
- Land Degradation Assessment: By comparing LULC over time, areas undergoing degradation can be pinpointed for restoration efforts.

2. Urban and Regional Planning:

- Zoning: Provides a foundation for zoning laws, ensuring that development is aligned with land suitability and environmental impact assessments.
- Infrastructure Planning: Determines optimal locations for new constructions based on existing land use, minimizing environmental impact.

3. Water Resource Management:

- Watershed Analysis: Understanding land use within watersheds helps manage water quality, predict runoff, and plan for water conservation.
- Flood Risk Management: Identifying areas prone to flooding by examining land cover types like impervious surfaces or wetlands.

4. Disaster Risk Reduction:

- Hazard Mapping: By analyzing land cover, maps can indicate areas at higher risk from natural disasters like landslides, wildfires, or floods.
- Emergency Response: Post-disaster LULC maps aid in damage assessment and guide relief efforts.

CHAPTER 5

METHODOLOGY

5.1 Watershed analysis

Here are the basic steps followed for watershed analysis using Arc GIS software:

1. Collection of data: - Digital elevation model (DEM) is downloaded from USGS. DEM should be in raster format.
2. Fill and correct DEM: - Use the Fill tool to remove sinks or depressions where water would not drain. Ensure preprocessing of DEM which includes projecting the DEM into common output coordinate system.
3. Create Flow direction: - Use the corrected DEM to generate flow direction by selecting flow direction from "Spatial analyst" toolbar in Arc toolbox.
4. Select watershed basin: - Under "Spatial analyst" toolbar select "Basin" to generate delineated basins and select input flow direction raster. Convert the basin raster to polygon and extract the largest or preferred basin.
5. Flow accumulation: - Flow accumulation raster is generated from the "Spatial analyst" toolbar, select "Hydrology" and choose "Flow accumulation".
6. Raster calculator: - Use raster calculator to generate streams network output raster which display streams with desired flow accumulated value.
7. Stream order: - Under "Spatial analyst" toolbar choose "Stream Order" and select the stream network raster as the input, select STRAHLER method to assign stream orders in the network. Convert the raster to vector format.
8. Extract the watershed: - Extract the watershed basin with stream order from the DEM file using "Extract by Mask" from toolbar and analyse the stream order from attribute table.
9. Estimate storage capacity:- Estimate storage capacities of the study area at various elevations using Supplementary Spatial Analyst tool.

1. <u>Collection of data</u>:-

To download DEMs from the USGS, use Earth Explorer or The National Map Downloader. Search for your area, select "Digital Elevation" data sets like SRTM or NED, choose the resolution, and download the data in formats like GeoTIFF. Ensure that the DEM file is in raster format. Make sure that the cloud coverage is negligible and study area falls within the selected DEM by observing its footprint. If the study area falls between two DEMs we need to mosaic the two DEMs using mosaic tool and then extract the study area.

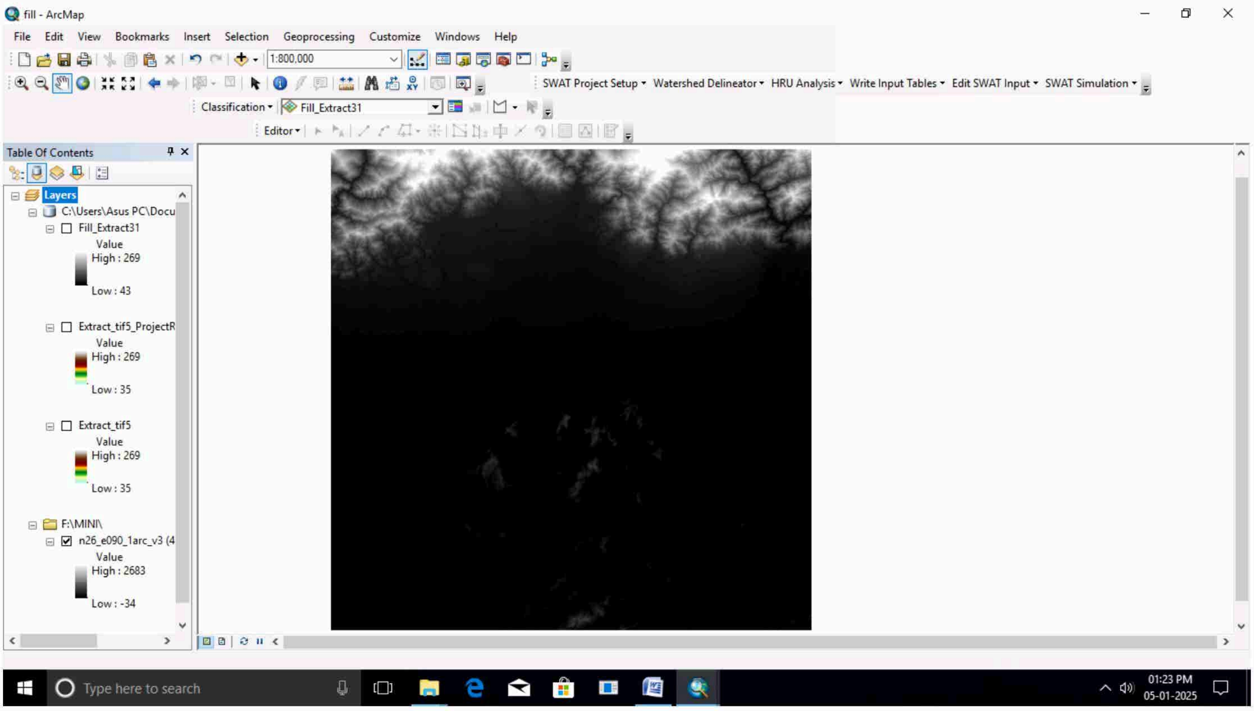


Figure 5.1: DEM file downloaded from USGS earth explorer

2. <u>Fill and Correct DEM</u>:-

The "Fill" tool in ArcGIS is used to remove depressions or 'sinks' in Digital Elevation Models (DEMs).Sinks are areas in a DEM where the elevation drops below the surrounding terrain, creating a 'hole' where water should flow but can't because of the data's topography. The Fill tool elevates these points to the lowest pour point around them, ensuring there's a path for water to flow out. Filling sinks corrects errors in elevation data which might occur due to data collection inaccuracies, noise, or problems with interpolation methods used to create the DEM. This leads to a more accurate representation of the terrain.

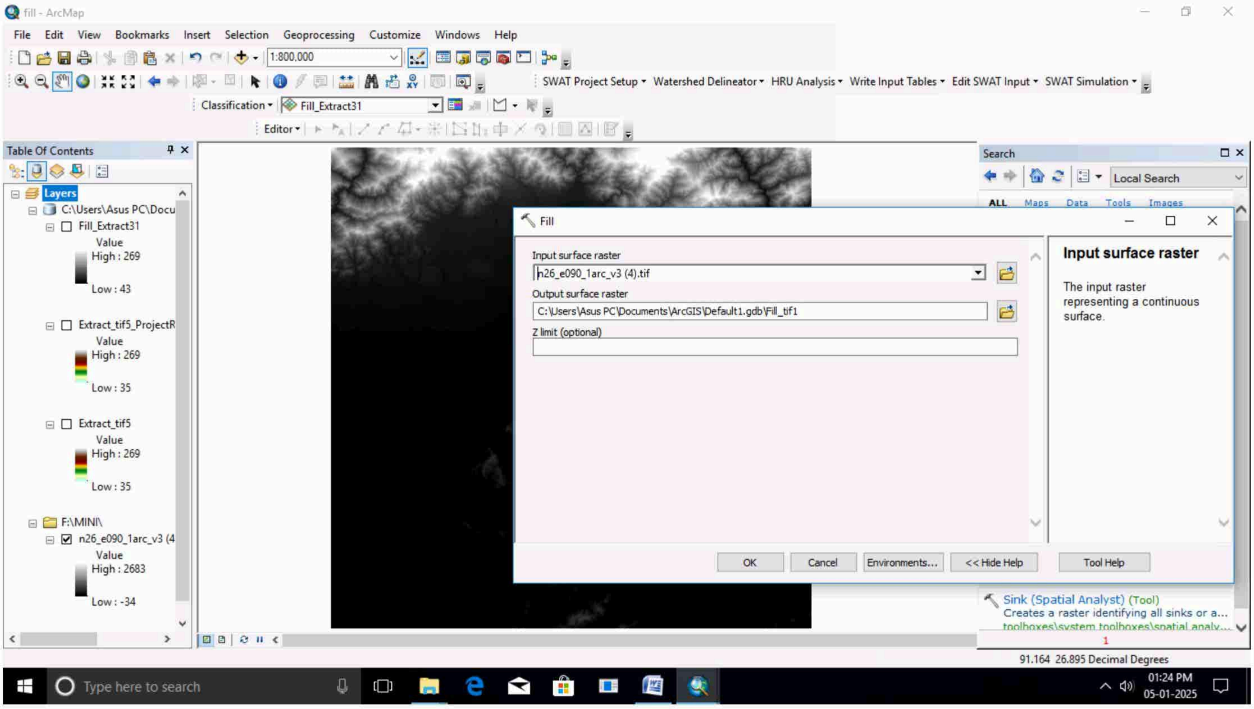


Figure 5.2: Fill DEM file

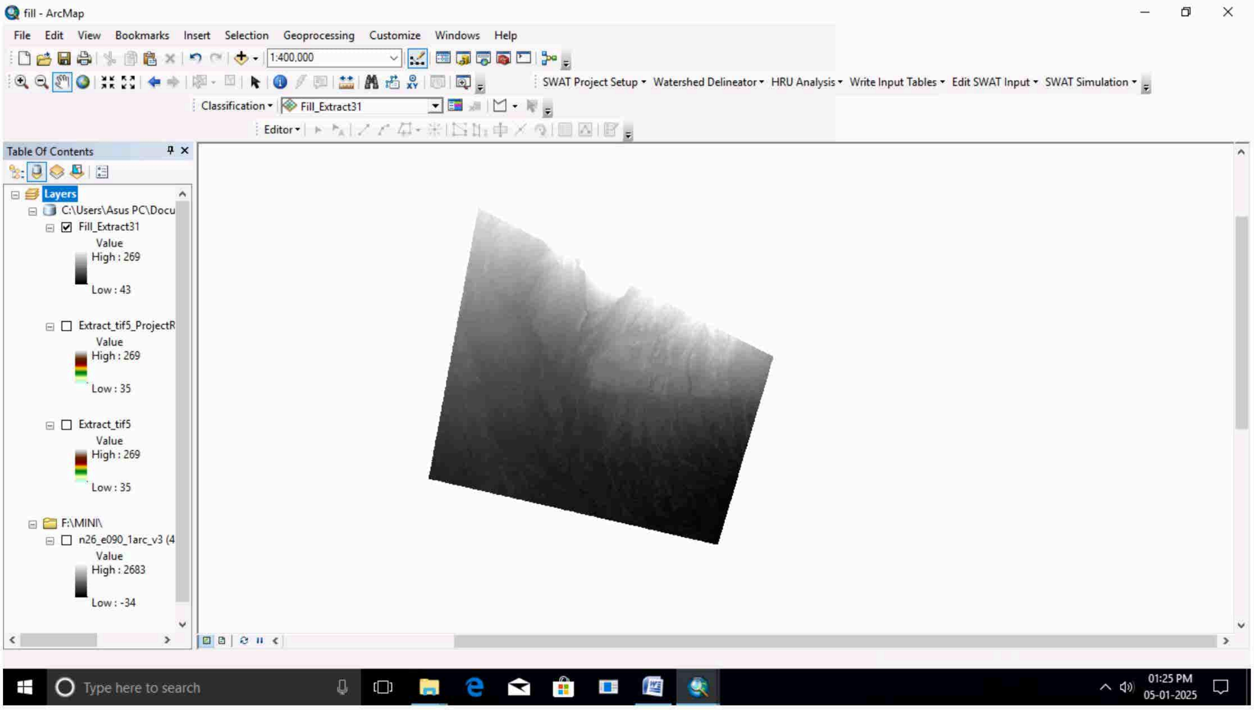


Figure 5.3: Extracting study area after filling and projecting to output coordinate system

3. <u>Create flow direction raster</u>:-

In ArcGIS, flow direction refers to the path water would naturally take across a landscape based on the topography. It's a critical component in hydrological analysis, determining how water moves from higher to lower elevations. Flow direction is typically calculated from a digital elevation model (DEM), where each cell in a grid receives a direction value based on its steepest downslope neighbor. This data is used for various applications like watershed delineation, stream network generation, and flood modeling. Understanding flow direction helps in managing water resources, planning drainage systems, and assessing environmental impacts.

The flow direction raster typically uses a specific coding where each direction corresponds to a number (e.g., D8 method where 1 to 8 represent directions from east, southeast, south, etc., in a clockwise manner).Understanding this coding is crucial for interpreting the results correctly.

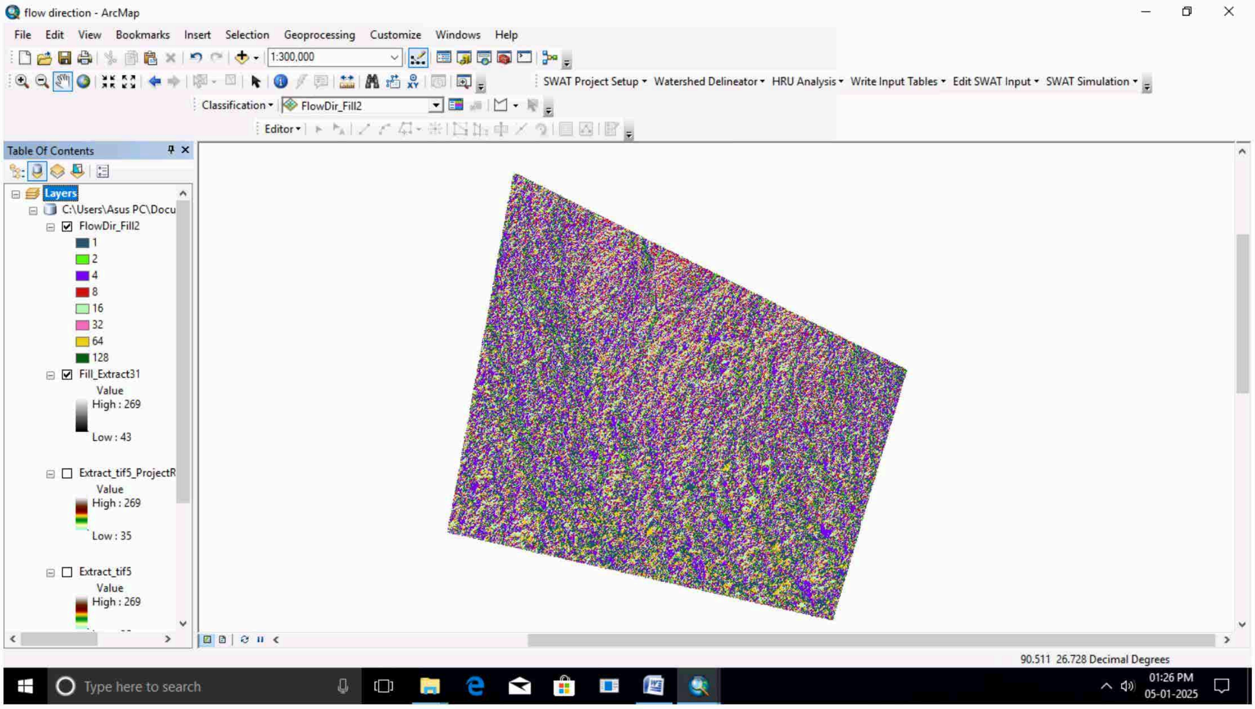


Figure 5.4: Flow direction of study area

4. <u>Create and select basin:-</u>

After creating flow direction raster the study area is divided into number of basins using basin tool under hydrology. Convert the basin raster into polygon and select any one basin polygon for further analysis. The Basin tool in ArcGIS, part of the Spatial Analyst extension, delineates drainage basins from a flow direction raster. It identifies ridge lines between basins and assigns cells to basins based on flow paths to pour points or sinks. The tool requires a D8 flow direction raster, often created using the Flow Direction tool. Outputs are raster datasets where each basin is uniquely colored, showing areas contributing to a single outlet. This tool is crucial for hydrological analysis, helping to understand surface water movement and aiding in water resource management and environmental planning

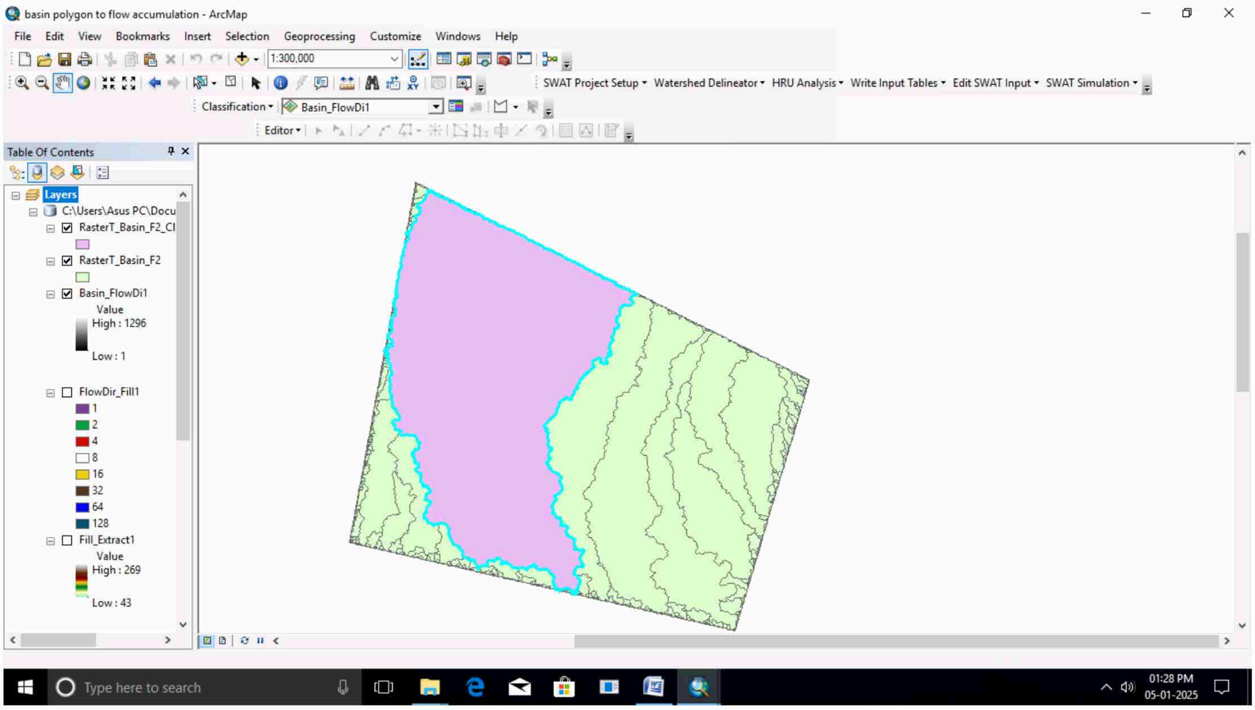


Figure 5.5: Selecting basin from study area

5. <u>Create flow accumulation raster: -</u>

A flow accumulation raster visually represents how water flows across a landscape based on elevation data. Each cell in this raster shows the total number of cells (or area) upstream that contribute flow to that cell. High values indicate areas where water accumulates, often highlighting natural or potential stream channels, drainage networks, and areas prone to runoff or flooding.

After generating flow direction raster navigate to hydrology section and select flow accumulation toolbar under spatial analyst tool. Choose the previous flow direction raster as the input and select any desired output location. While watershed delineation it is necessary to check that every step is completed with keeping the output coordinated system to common projected output coordinate system.

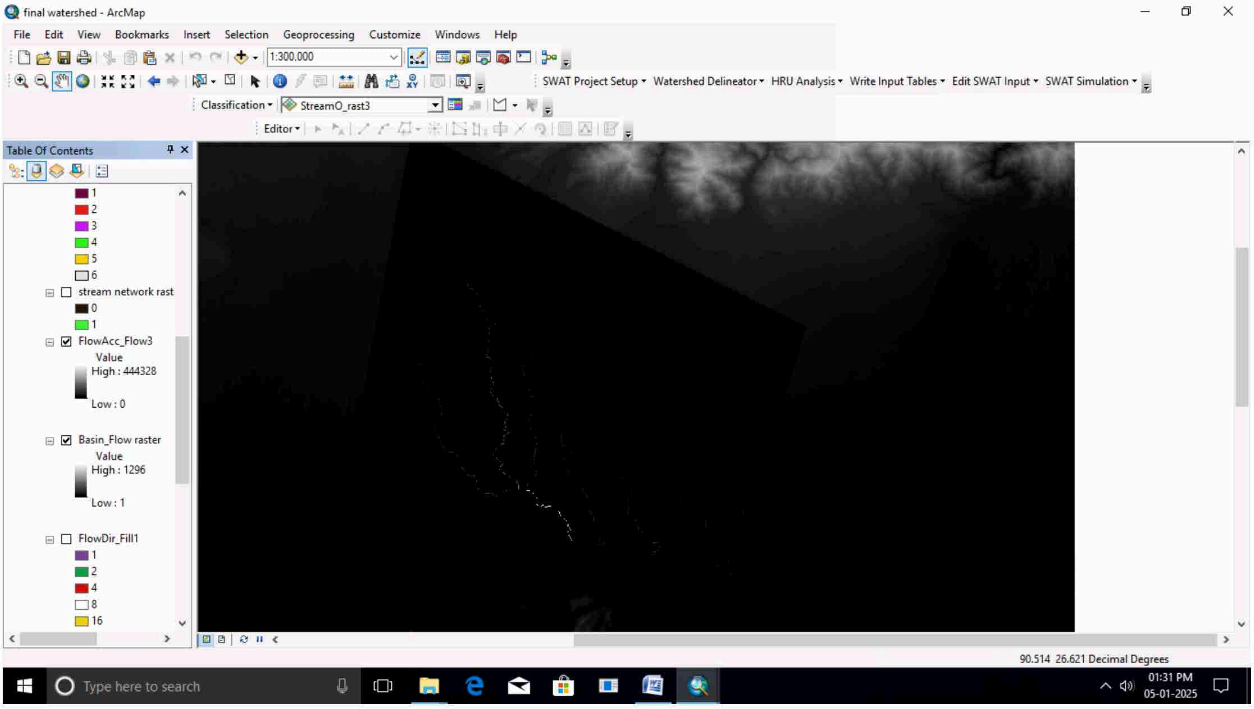


Figure 5.6: Flow accumulation in study area basin

6. <u>Raster Calculator</u>:-

Before generating stream orders and networks it is necessary to define at which flow accumulation value stream orders will be created. Under spatial analyst toolbar navigate into map algebra and select raster calculator. The Raster Calculator tool allows you to create and execute a Map Algebra expression that will output a raster. It buiilds and executes a single Map Algebra expression using Python syntax in a calculator-like interface.The Raster Calculator tool is intended for use in the application only as a GP tool dialog box or in ModelBuilder. It is not intended for use in scripting and is not available in the ArcPy Spatial Analyst module.

Use the Layers and variables list to select the datasets and variables to use in the expression. Numerical values and mathematical operators can be added to the expression by clicking the respective buttons in the tool dialog box. A list of commonly used conditional and mathematical tools is provided, allowing you to easily add them to the expression. Multiple geoprocessing tools and operations can be combined in a map algebra expression using standard Python syntax. When typing tool names, be sure to check the tool name syntax. If the capitalization is incorrect, the expression will be invalid and fail to execute because Python is case sensitive.

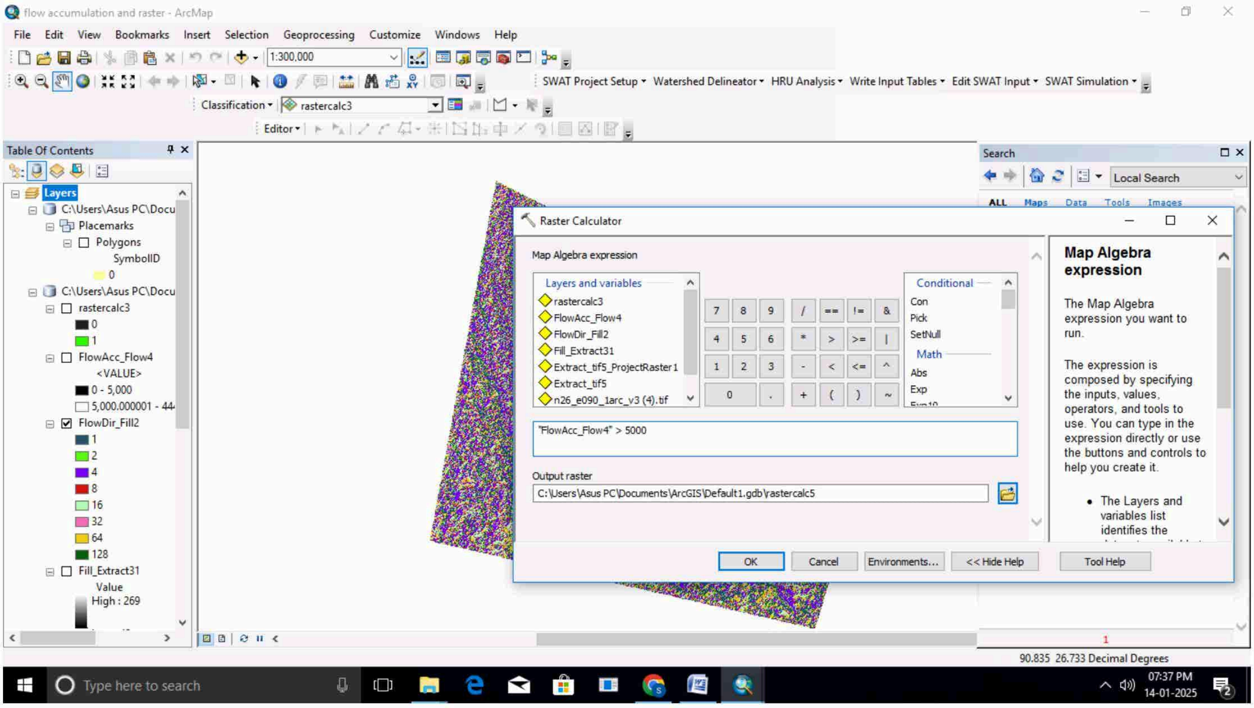


Figure 5.7: Using raster calculator

7. <u>Stream order:</u>

In ArcGIS, stream order is a method to classify the hierarchy of streams within a watershed. It's based on the Strahler Stream Order system where the smallest, unbranched tributaries are designated as first-order streams. When two first-order streams join, they form a second-order stream. Two second-order streams joining create a third-order stream, and so on. However, if a higher-order stream meets a lower-order stream, the order remains that of the higher stream.

The Strahler method classifies streams by order. First-order streams are the smallest, unbranched tributaries. When two first-order streams converge, they form a second-order stream. Higher orders require the confluence of streams of the same or higher order. This hierarchy aids in hydrological analysis for watershed management. Based on previous raster calculated raster file as an input we have created four orders of streams in the study area basin.

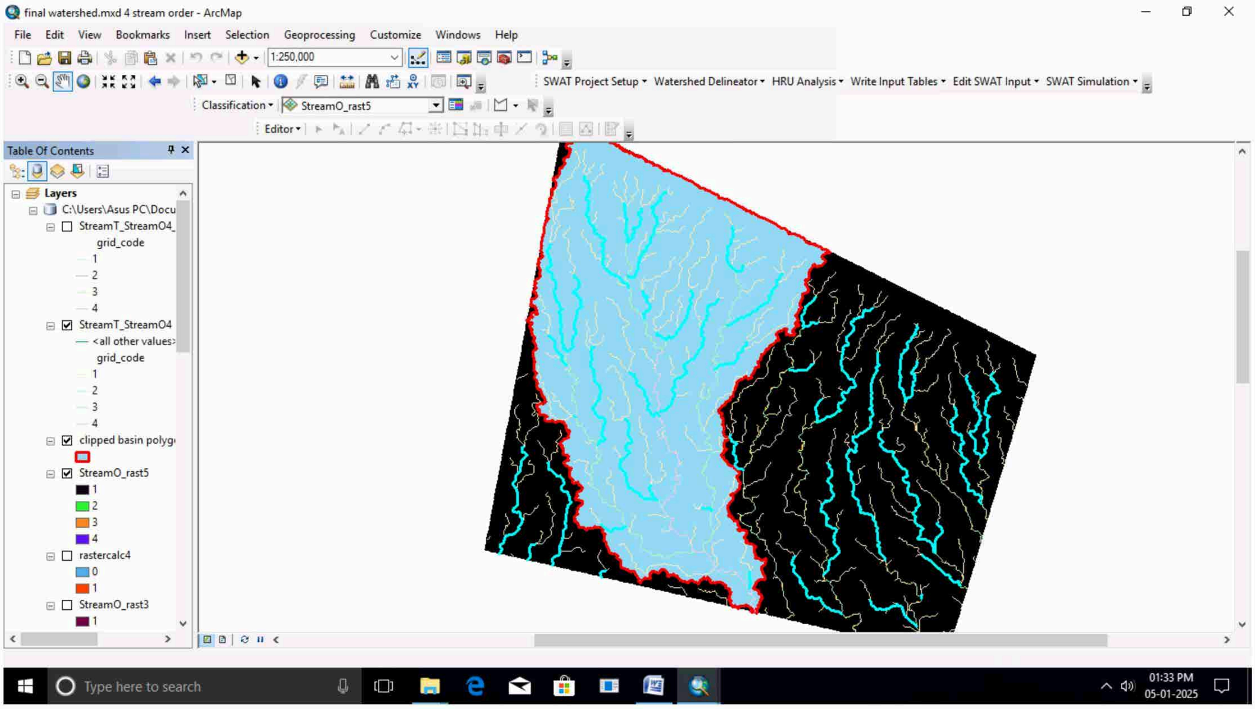


Figure 5.8: Stream order of basin

8. Extract the delineated watershed:-

The delineated watershed basin is extracted from the DEM file along with stream networks labeled with their respective orders. Labeling can be done by modifying the properties of the raster watershed and do necessary changes in the labeling.

Analysis and study of stream order can be done with the help of attribute table from the output file. For proper understanding from attribute table and adding new fields to attribute table editing can be done from the editor toolbar. Using field calculators do necessary formulations to obtain desired value in acceptable terms like km, km^2.

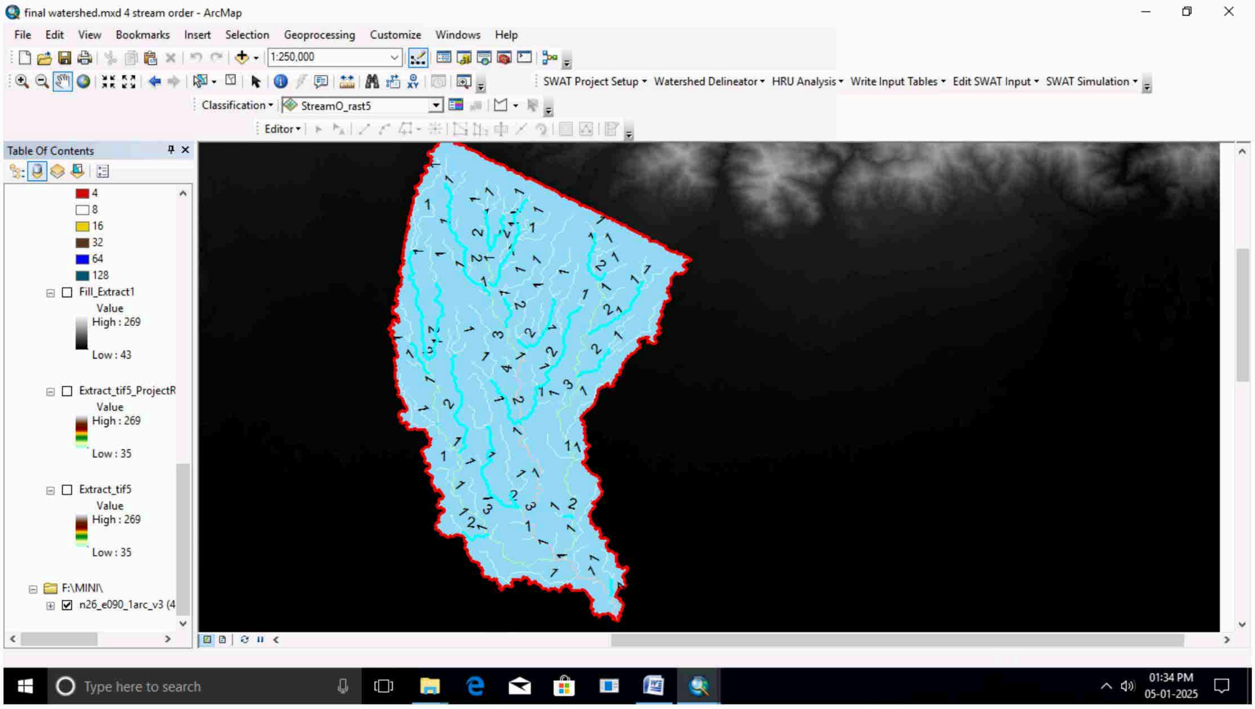


Figure 5.9: Delineated watershed basin with stream order.

<u>10. Estimate storage capacity</u>:-

T he Spatial Analyst Supplementary Tool for Storage Capacity in ArcGIS is designed to calculate and analyze the storage capacity of reservoirs or detention basins based on surface elevations. Available within the Spatial Analyst extension, this tool generates a table and potentially a chart that detail elevations and corresponding storage volumes for an input surface raster. The tool computes surface area and total volume at various elevation increments, which is crucial for hydrological studies, flood routing, and water management. For each zone specified in the analysis, such as a reservoir, the tool calculates these metrics independently. If zones aren't specified, the tool uses the entire analysis extent as one zone. Users can set parameters like minimum and maximum elevations, the type of increment, and increment size to tailor the analysis to specific needs. This tool is especially useful for creating elevation-storage relationships, which are fundamental for understanding how much water a basin can hold at different water levels.

Introduced to streamline what was previously a manual process, this tool saves time and increases accuracy in reservoir capacity assessments. It's particularly beneficial for those managing water resources, planning infrastructure, or conducting environmental studies where precise storage capacity data is essential.

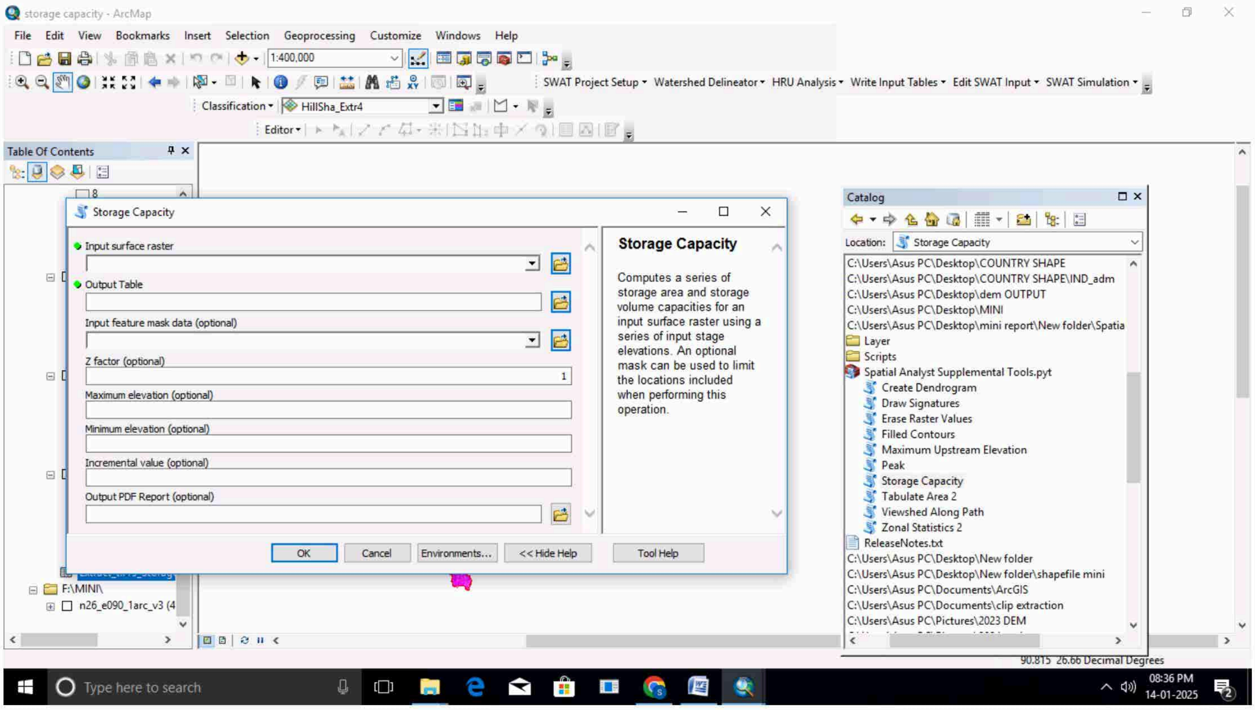


Figure 5.10: Estimating storage capacities using supplementary spatial analyst tool.

5.2 LULC Change detection

Here are the basic steps for LULC change detection using Arc GIS software:-

1. Data Collection: - Landsat 8 images of study area for three different time periods i.e 2015, 2019 and 2023 downloaded from USGS earth explorer.
2. Pre-processing:- Perform radiometric corrections and geometric corrections if necessary to ensure image is usable.
3. Extraction of study area:- Study area is extracted from landsat image by "Extract by Mask" tool under "Spatial Analyst Tools" from Arc Toolbox.
4. Image Classification:- Select Image classification in the tab and create training samples by manually drawing polygons.
5. Signature file:- Create and save signature file of the classes in the training sample manager.
6. Classification: - Under "Spatial Analyst Tools" from Arc Toolbox choose "Maximum Likelihood Classification" and input your raster and signature file that is created.
7. Post-Processing:- Prepare validation dataset and create accuracy assessment points to generate points for validation. Use "Accuracy Assessment" to assess the classification's accuracy.
8. Visualization: - Adjust Symbology tab for better visualization of different classes and create layout to design your map.
9. Change Detection:- Analyse the attribute tables of each year's LULC map and prepare tables and charts showing their change.

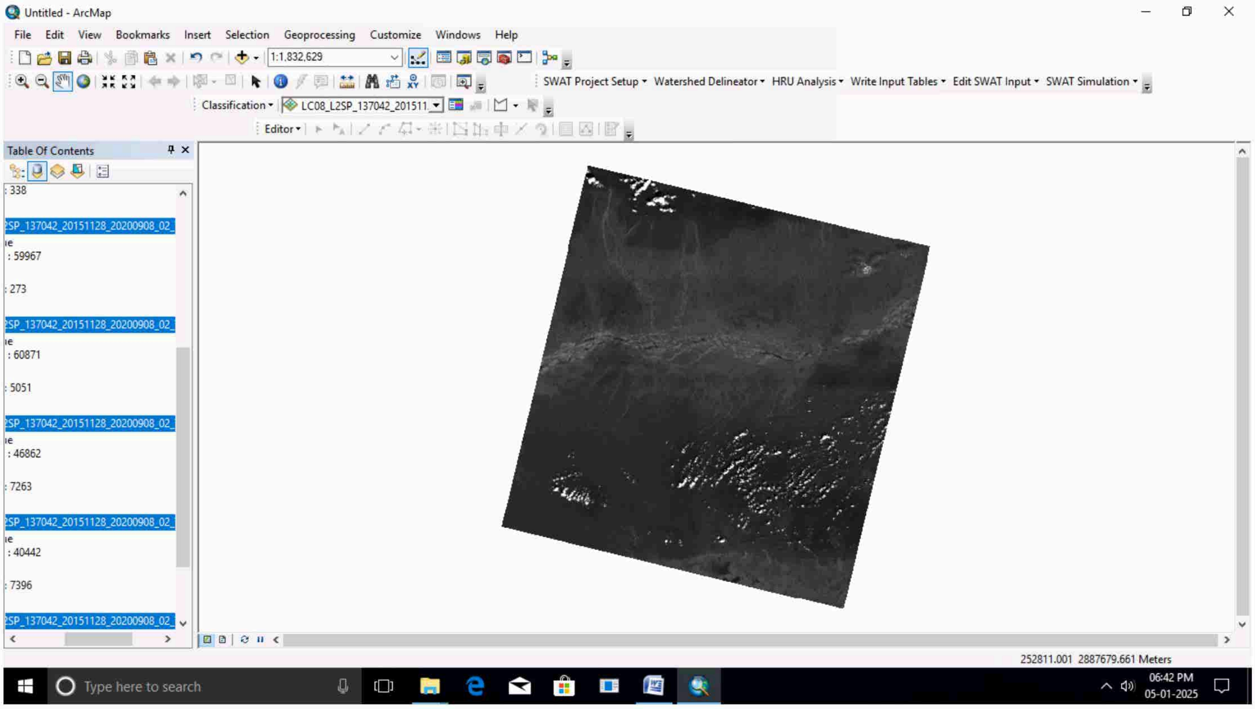


Figure 5.11:- Downloading landsat images from USGS earth explorer

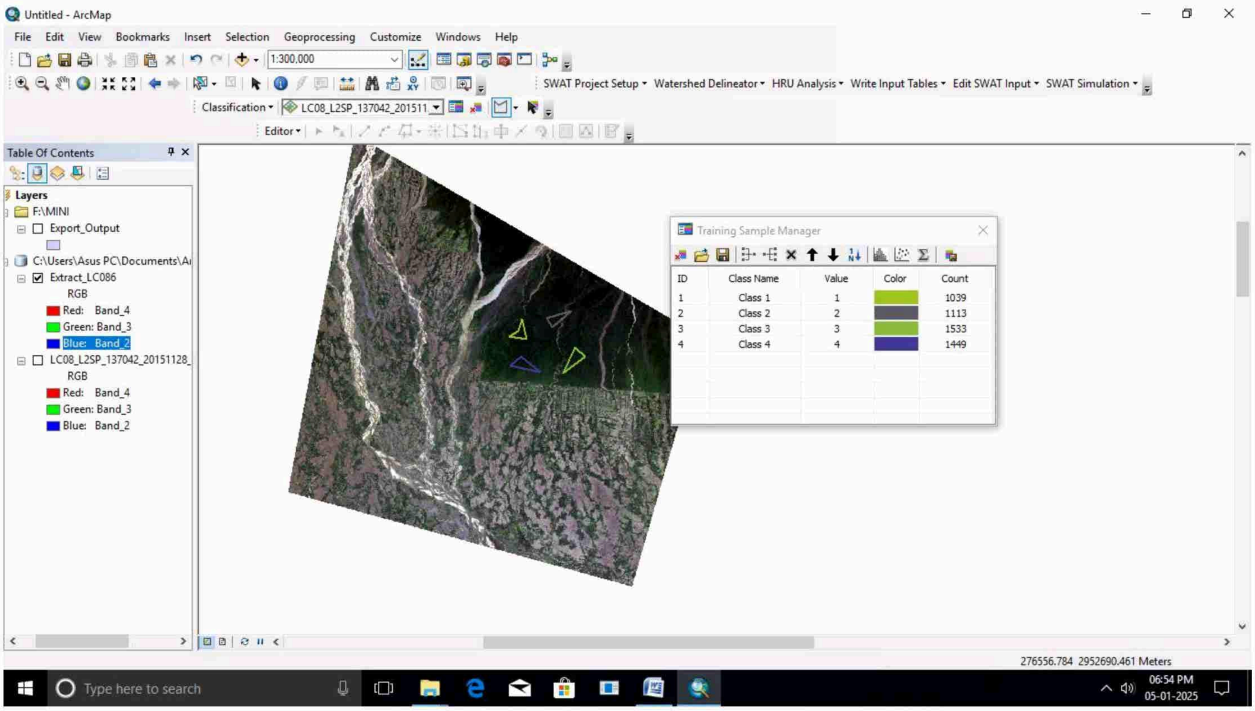


Figure 5.12:- Creating training samples from study area in LULC 2015

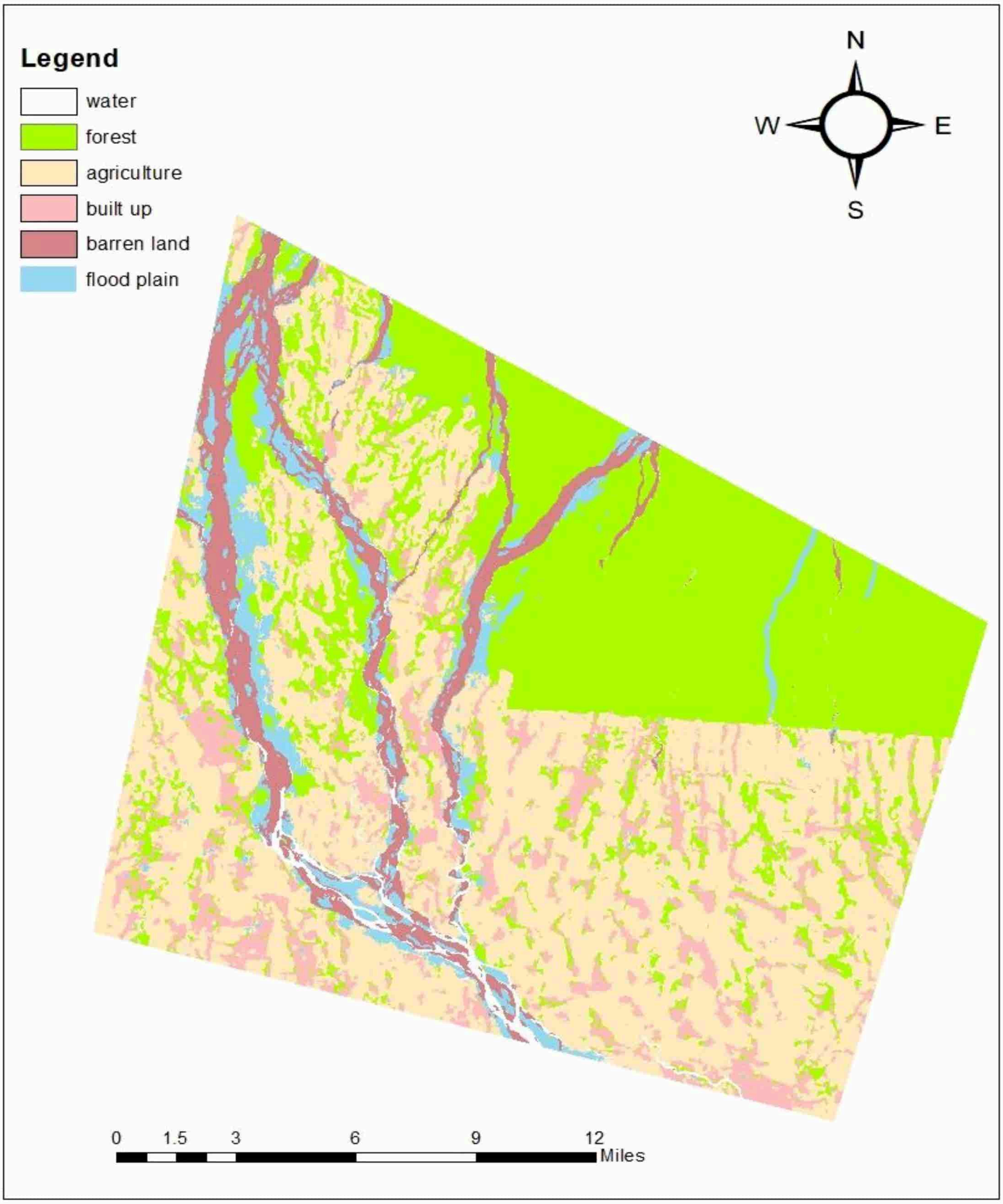


Figure 5.13:- LULC map of study area 2015

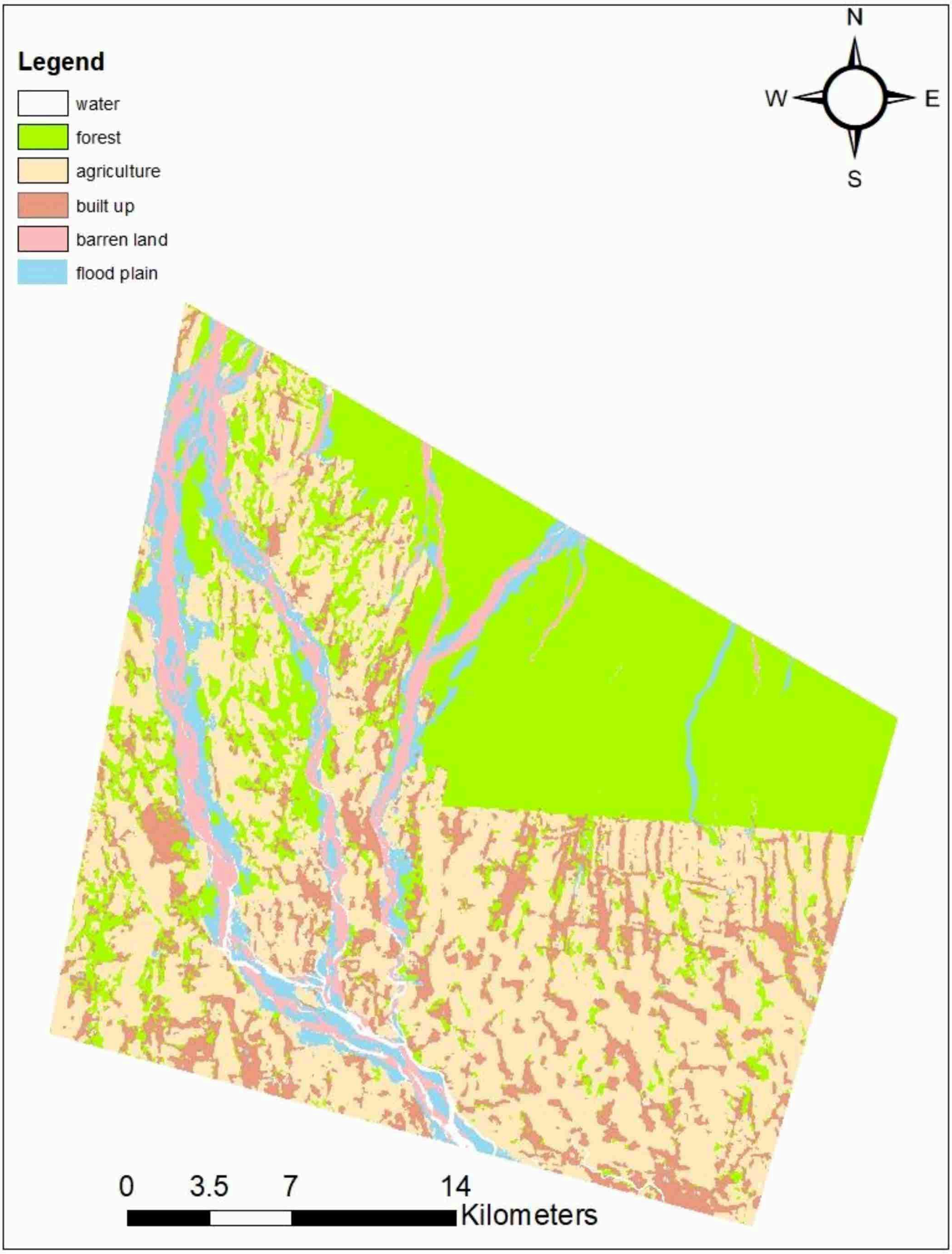


Figure 5.14: LULC map of study area 2019.

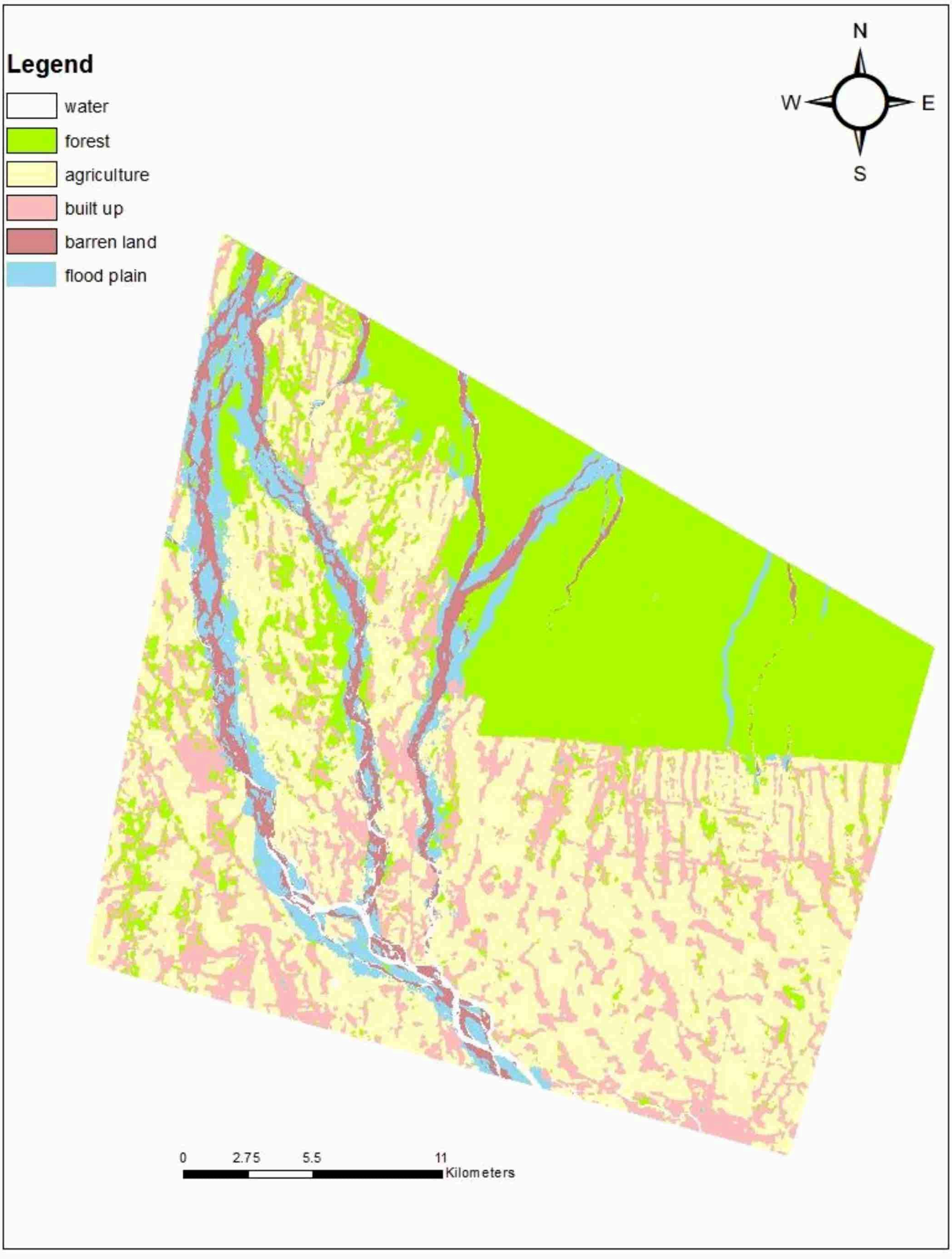


Figure 5.15: LULC map of study area 2023

CHAPTER 6

RESULTS AND DISCUSSION

6.1 Stream order

After watershed analysis it was found that there are upto four order of streams in the study area. First order streams are numerous and are generated in the upper reach of the basin while higher order streams are generated in the lower region of the basin. Two first order streams merge to form one second order stream. Again two second order streams merges to form one third order stream so on upto fourth order stream. It is to be noted that if two different order streams joins then the larger will flow forward without increase in order. There are total 211 numbers of streams and sum of total length of all the streams is 422.82 km.

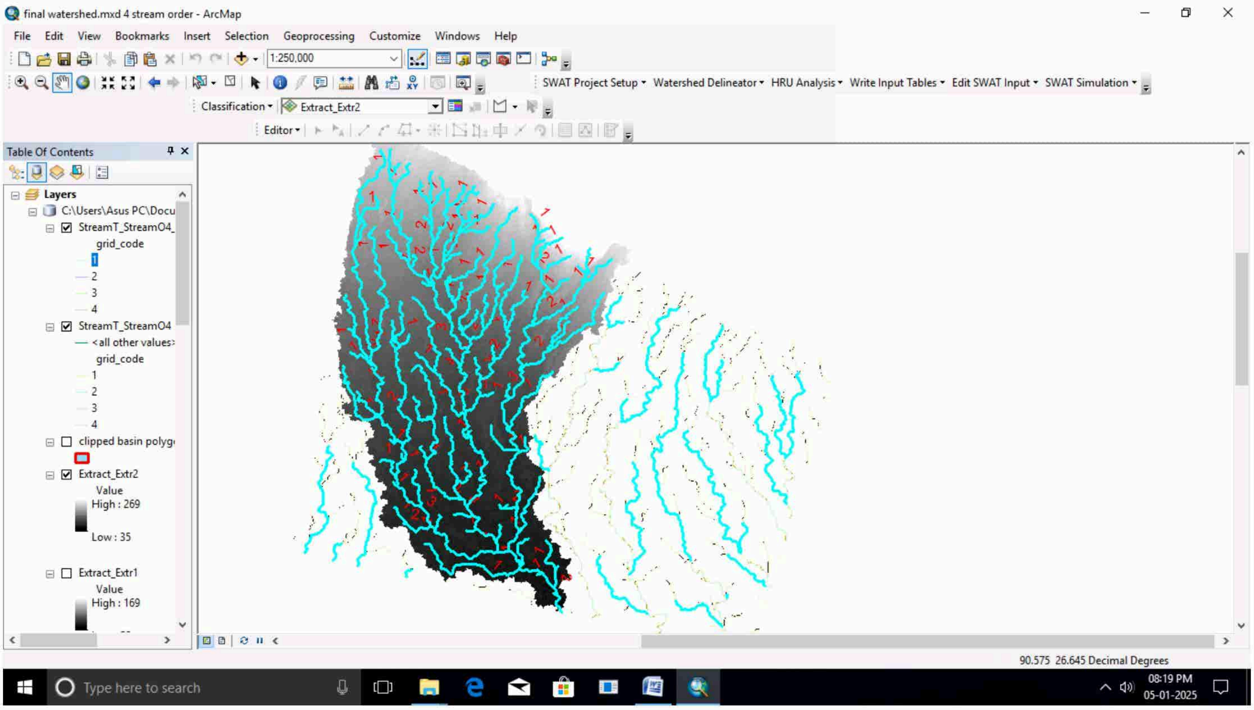
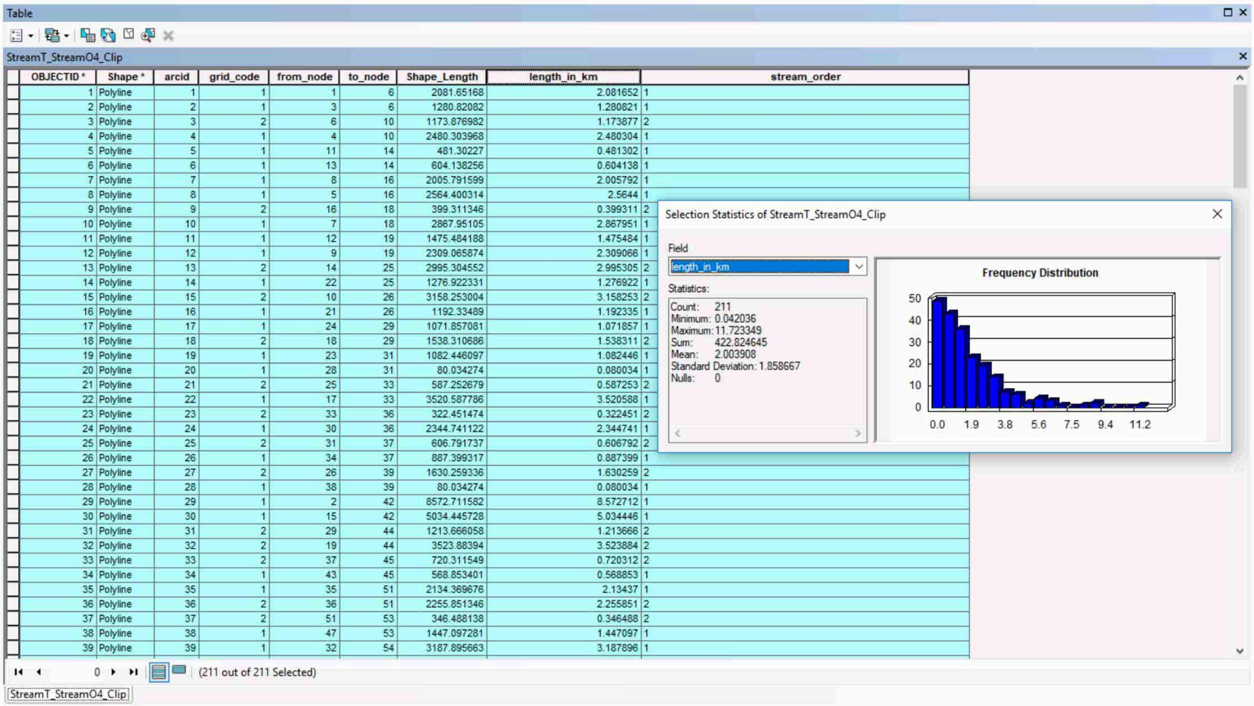


Figure 6.1: Stream order numbering



Table

StreamT_StreamO4_Clip

OBJECTID *	Shape *	arcid	grid_code	from_node	to_node	Shape_Length	length_in_km	stream_order
1	Polyline	1	1	1	6	2081.65168	2.081652	1
2	Polyline	2	1	3	6	1280.82082	1.280821	1
3	Polyline	3	2	6	10	1173.876982	1.173877	2
4	Polyline	4	1	4	10	2480.303968	2.480304	1
5	Polyline	5	1	11	14	481.30227	0.481302	1
6	Polyline	6	1	13	14	604.138256	0.604138	1
7	Polyline	7	1	8	16	2005.791599	2.005792	1
8	Polyline	8	1	5	16	2564.400314	2.5644	1
9	Polyline	9	2	16	18	399.311346	0.399311	2
10	Polyline	10	1	7	18	2867.95105	2.867951	1
11	Polyline	11	1	12	19	1475.484188	1.475484	1
12	Polyline	12	1	9	19	2309.065874	2.309066	1
13	Polyline	13	2	14	25	2995.304552	2.995305	2
14	Polyline	14	1	22	25	1276.922331	1.276922	1
15	Polyline	15	2	10	26	3158.253004	3.158253	2
16	Polyline	16	1	21	26	1192.33489	1.192335	1
17	Polyline	17	1	24	29	1071.857081	1.071857	1
18	Polyline	18	2	18	29	1538.310686	1.538311	2
19	Polyline	19	1	23	31	1082.446097	1.082446	1
20	Polyline	20	1	28	31	80.034274	0.080034	1
21	Polyline	21	2	25	33	587.252679	0.587253	2
22	Polyline	22	1	17	33	3520.587786	3.520588	1
23	Polyline	23	2	33	36	322.451474	0.322451	2
24	Polyline	24	1	30	36	2344.741122	2.344741	1
25	Polyline	25	2	31	37	606.791737	0.606792	2
26	Polyline	26	1	34	37	887.399317	0.887399	1
27	Polyline	27	2	26	39	1630.259336	1.630259	2
28	Polyline	28	1	38	39	80.034274	0.080034	1
29	Polyline	29	1	2	42	8572.711582	8.572712	1
30	Polyline	30	1	15	42	5034.445728	5.034446	1
31	Polyline	31	2	29	44	1213.666058	1.213666	2
32	Polyline	32	2	19	44	3523.88394	3.523884	2
33	Polyline	33	2	37	45	720.311549	0.720312	2
34	Polyline	34	1	43	45	568.853401	0.568853	1
35	Polyline	35	1	35	51	2134.369676	2.13437	1
36	Polyline	36	2	36	51	2255.851346	2.255851	2
37	Polyline	37	2	51	53	346.488138	0.346488	2
38	Polyline	38	1	47	53	1447.097281	1.447097	1
39	Polyline	39	1	32	54	3187.895663	3.187896	1

0 (211 out of 211 Selected)

StreamT_StreamO4_Clip

Table 6.1 : Attribute table showing different orders of streams and its length in km

S.NO	Stream Order	Count stream order	Sum of stream length (KM)
0	1	106	227.45
1	2	54	105.96
2	3	31	61.21
3	4	20	28.19

Table 6.2 : Table showing overall stream lengths of different orders.

6.2 Total Area of River Basin

The total area of river basin is 392.60 km^2 and its length is 127.311 km

Table

clipped basin polygon

OBJECTID *	Shape *	Id	gridcode	Shape_Length	Shape_Area	length_in_km	Area_in_km2
1	Polygon	116	116	127311.890662	392603994.64819	127.311891	392.603995

1 (0 out of 1 Selected)

clipped basin polygon

Table 6.3: Attribute table showing length and area of basin

6.3 Watershed storage capacity

The main theoretical principle behind the Spatial Analyst Supplementary Tool for Storage Capacity calculation is based on cumulative volume and area calculations using a raster dataset that represents the elevation of the landscape. Here's how it works in theoretical terms:

- **Raster Data Representation**: The landscape is represented by a grid of cells (raster), where each cell's value represents the elevation at that point.
- **Calculating Volume**: Elevation Intervals: The tool works through the raster in steps, usually at defined intervals of elevation (e.g., every meter or foot).
- **Surface Area at Each Elevation**: For each elevation level, it counts how many cells are at or below that height. This gives you the surface area of water (in planimetric units like square meters or feet) if water were to be at that elevation. This is essentially calculating the area of a "contour" at each elevation.
- **Volume Calculation**: Volume at Each Elevation: For each elevation step, the tool

calculates the volume added between the current elevation and the previous one. It does this by summing up the volumes of small prisms or pyramids (depending on the method) for each cell.

- **Cumulative Volume**: The total volume at any given elevation is the sum of all these incremental volumes, starting from the lowest elevation up to the current one.

By breaking down the landscape into these manageable grid units and applying volume calculation methods, the tool provides an estimate of storage capacity which is vital for practical applications in water management and environmental planning.

Table

Extract_tif15_StorageCapacit

OBJECTID *	Elevation	Area	Volume
1	150	315924844.559078	16159638558.493982
2	175	361729162.899451	24688598619.811058
3	200	382600424.322595	34072938921.094791
4	225	388482582.01978	43720451219.81163
5	250	392012047.805201	53484694351.781769
6	267	392570052.580199	60155606347.63224

0 (0 out of 6 Selected)

Extract_tif15_StorageCapacit

Table 6.4: Attribute table watershed storage capacities at different elevations.

6.4 LULC Change detection

Land use- land cover maps of study area of three different years i.e, 2015, 2019 and 2023 and has been prepared and supervised classification is done through maximum likelihood classification method. Six different classes has been classified which are: Water bodies, forest, agriculture, built up, barren land and floodplains. Changes in area of each class over the years has been analysed through attribute table and presented through charts and table.

It has been found that built up area or urban area has increased dramatically throughout the time period meanwhile forest area has decreased substantially. Increase in flood inundation at this region in recent years can be caused due to decrease in forest area and increase in urban land or built up area. Increase in flood plains area throughout this time period showcases the growing flood hazard caused due to urban expansion.

CLASSES	2015		2019		2023	
	Sum of Area(km^2)	Total Area (%)	Sum of Area(km^2)	Total Area (%)	Sum of Area(km^2)	Total Area (%)
WATER	10.98	1.26	9.9128	1.14	11.472	1.33
FOREST	292.3865	33.63	290.4511	33.40	257.3353	29.59
AGRICULTURE	356.3789	40.994	342.6005	39.40	345.6102	39.74
BUILT UP	94.09	10.82	117.017	13.46	148.436	17.07

BARREN LAND	63.701	7.33	52.063	5.98	41.4531	4.76
FLOOD PLAINS	52.1	5.99	57.5888	6.62	65.024	7.47
Total Area(km^2)	869.633	100	869.633	100	869.633	100

Table 6.5: Table showing change in area for each class in three different years.

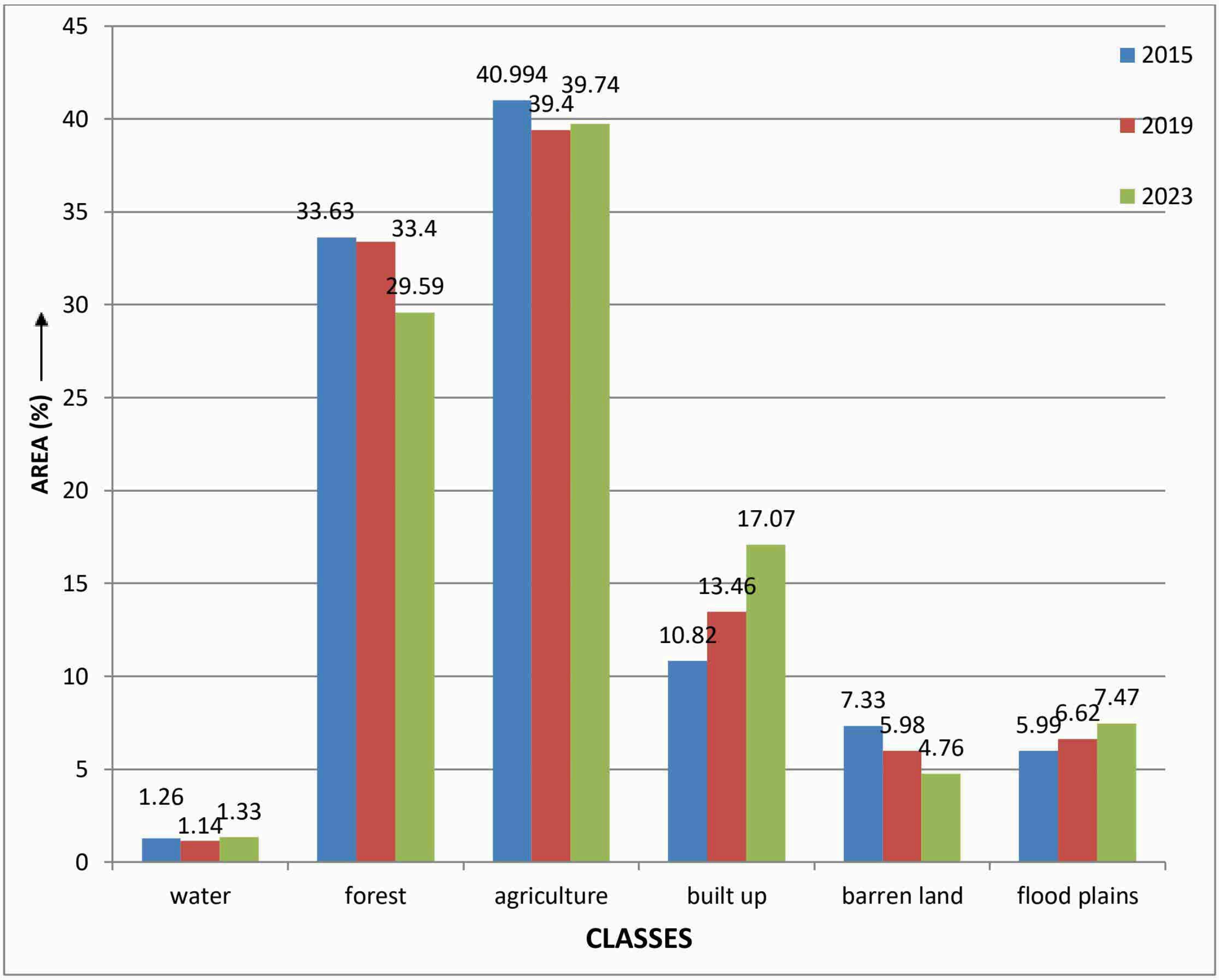


Figure 6.2: Chart showing changes in area(%) for each class

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION

Watershed analysis is a fundamental step in watershed management using remote sensing. Understanding watershed borders allows us to better predict where water will concentrate following heavy rains, leading to more effective flood control techniques. It also helps to manage erosion, as streams within a watershed can substantially modify terrain. Watershed delineation informs policymaking by establishing defined, natural bounds for regulation. This is critical for protecting water rights, reducing pollution, and ensuring that development does not harm water system.Stream order is vital for understanding river systems' structure and function. It categorizes streams based on their hierarchy, influencing ecological diversity, water quality, and flow dynamics. This classification aids in water resource management, flood risk assessment, and environmental planning. It's crucial for predicting water availability, managing sediment, and guiding conservation efforts. Stream order also informs policy-making, land use planning, and educational initiatives, providing a framework for studying riverine landscapes' complexity.

Land Use Land Cover (LULC) classification is essential for understanding how land is utilized and its natural cover, which directly impacts environmental management, urban planning, and policy-making. It provides critical data for assessing ecosystem health, biodiversity, and changes over time due to human activity or natural processes. LULC classifications are used for water management, predicting flood risks, planning infrastructure, and mitigating climate change effects. They help in monitoring deforestation, urbanization, and agricultural expansion, informing conservation strategies and sustainable development.

Chirang District in Assam has seen a rise in flood and erosion problems due to a variety of sources. Flooding is exacerbated by heavy, often unpredictable rains and overflowing rivers such as Aie, Beki, and Manas. Erosion has increased, particularly along riverbanks, due to the enormous sediment load carried by these rivers, resulting in significant land loss each year. Climate change has most likely contributed by modifying weather patterns, resulting in more heavy rainfall. The present study showcases the rise in urban land use and degradation in vegetation can be attributed to the cause of occurrence of flood and erosion in recent years. By understanding the hydrological characteristics and understanding the stream order it is possible to develop better water management strategies in these region.

7.2 FUTURE SCOPE

Watershed delineation and Land Use Land Cover (LULC) classification will become increasingly important in the future due to technological improvements, environmental challenges, and regulatory needs. Here some potential future development in the use of watershed analysis and land use land cover classification:

- Advancements in technology, including remote sensing and GIS, enable more accurate and detailed watershed delineation. Hyperspectral and multispectral imaging will improve LULC classification by providing more detailed data on land surface characteristics.
- With climate change influencing precipitation patterns and land development, watershed delineation will be critical in predicting flood hazards and water supply. LULC classification will be critical for monitoring changes such as deforestation and urbanization, both of which have a direct impact on hydrological cycles.
- There's potential for community involvement in data collection and validation, using apps and platforms for real-time updates on land use, which can refine LULC classifications.
- Flood risk assessment using more advanced applications like ArcGIS Pro, Hec-Ras and improved satellite imagery softwares will ensure better land use land cover classification and better understanding of hydrological characteristics of a region.
- Improved LULC maps will help to value ecosystem services and manage natural resources for resilience to environmental change, such as carbon sequestration, water filtering, and biodiversity conservation.
- Tools and data will be more readily available for educational purposes, raising public knowledge and participation in environmental stewardship.

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