

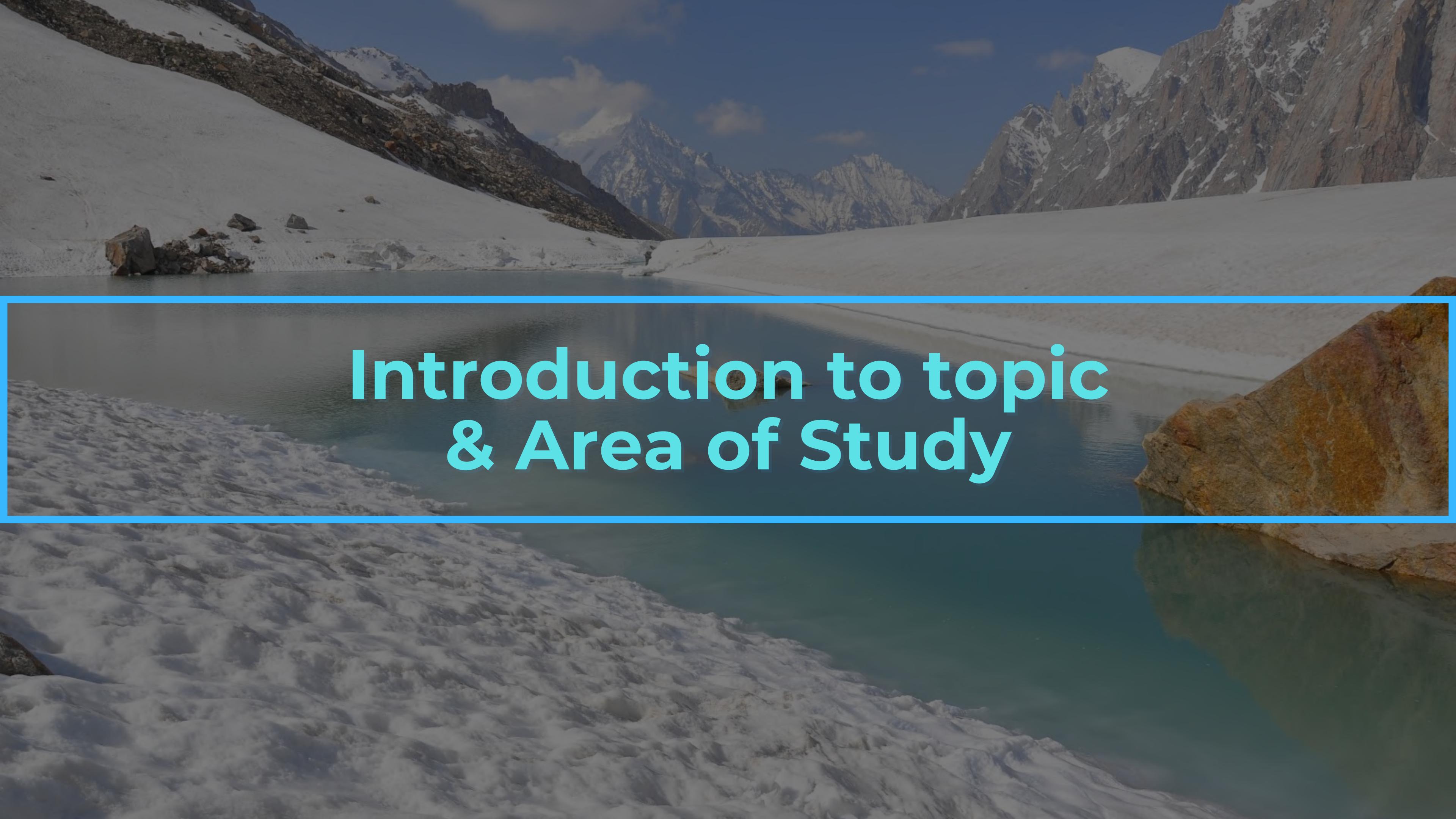


Watershed Delineation & Morphometric Analysis

Study Location- **Chandra Basin**

Presented By-

- Aditya Naik
- Nishant Kumar
- Digvijay Singh Rathore
- Manish Kori

The background image shows a vast, clear blue lake nestled among towering mountains. The mountains are partially covered in snow, with rocky outcrops visible. The sky above is a mix of blue and white clouds.

Introduction to topic & Area of Study

Background:

- Several studies have revealed that the Himalayan region is displaying accelerated heterogeneous mass loss and glacier melting as climate change leading to a rise in temperatures wreaks havoc.
- More the melting of glaciers more is the generation of streams of water. As water flows through the troughs, it carves out new channels for water to flow.

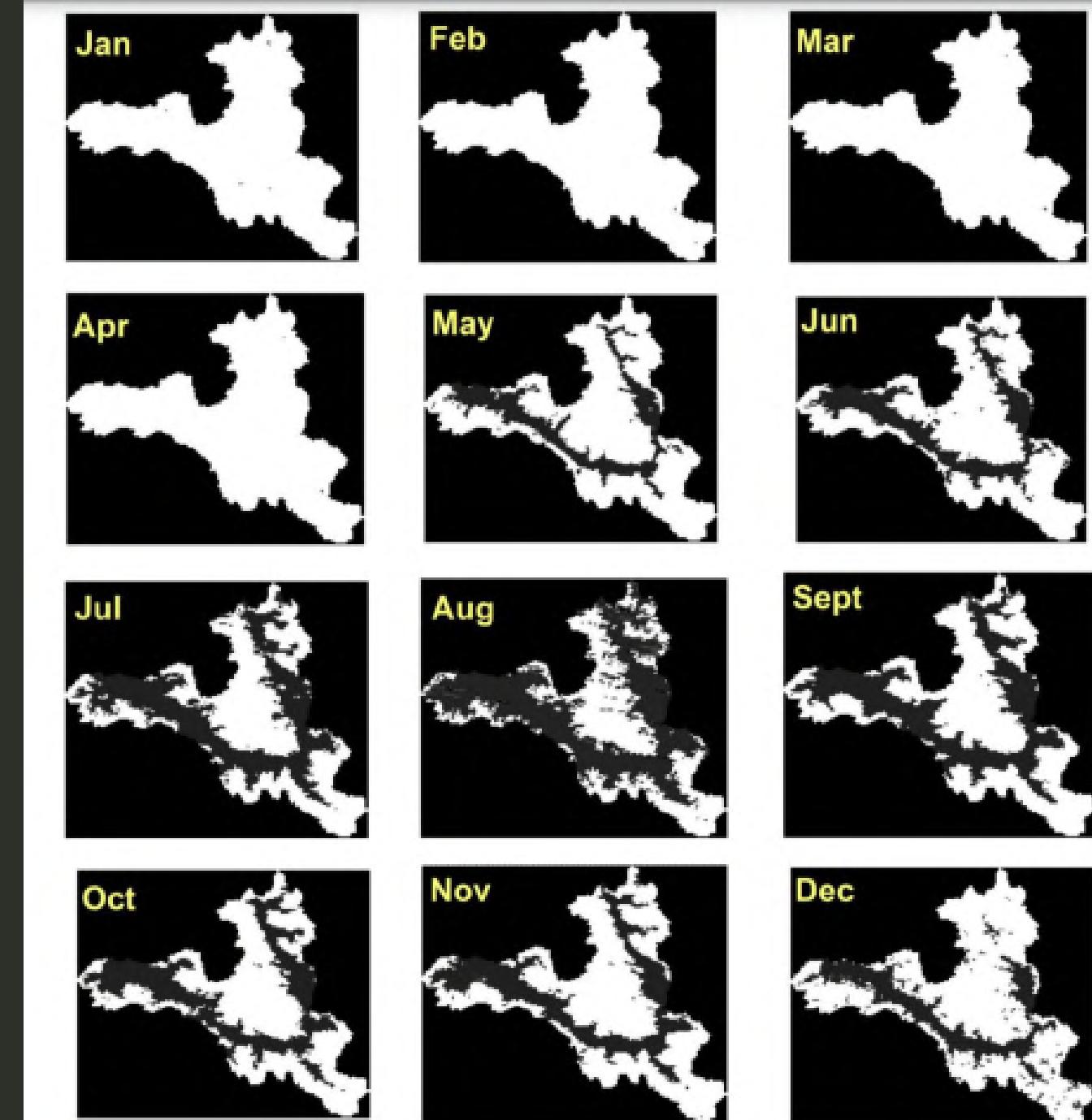
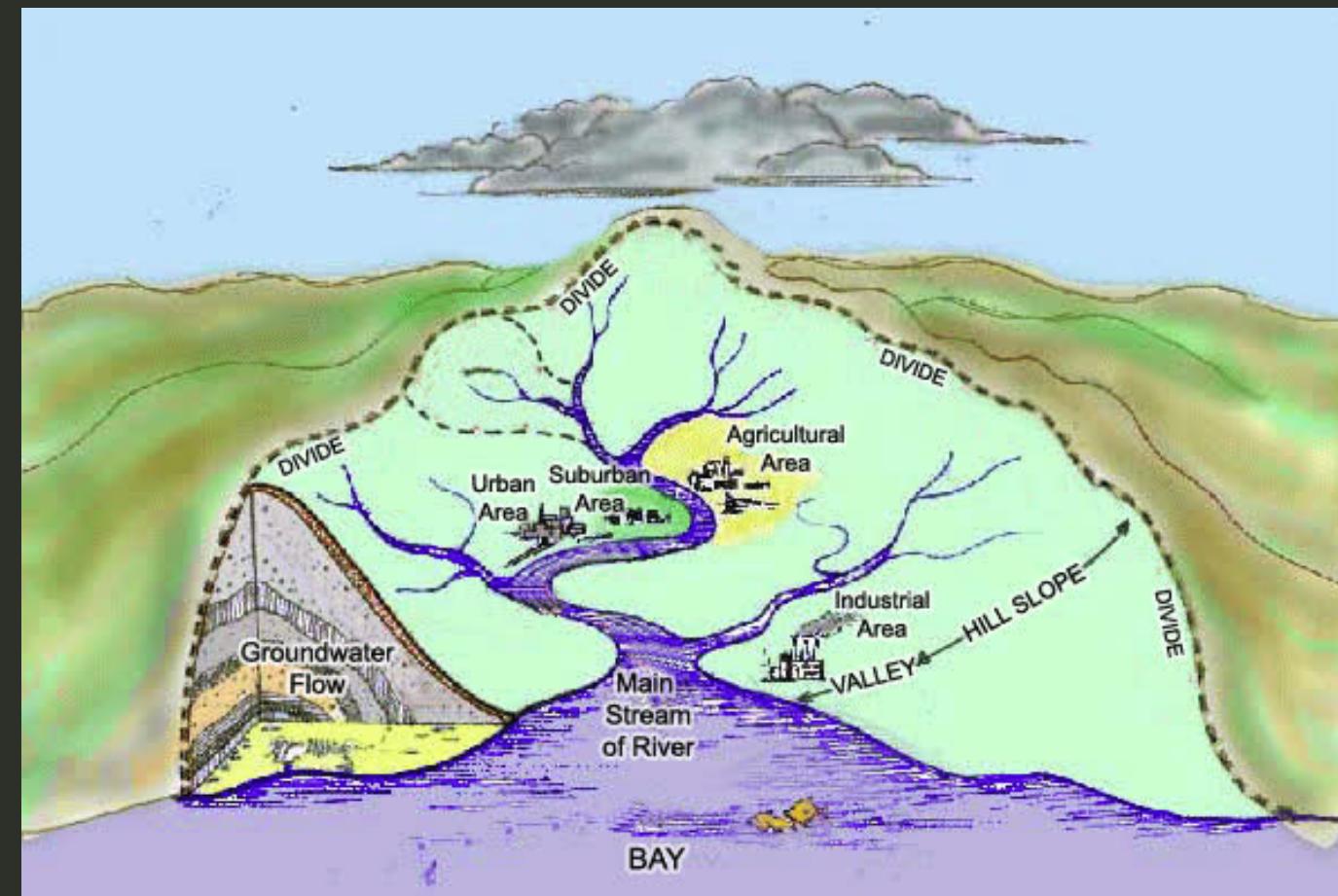


Fig. 3 Mean snow cover of Chandra basin, Western Himalaya between 2000 and 2015

What is a Watershed & Morphometry

- A Watershed is an area or ridge of land that separates waters flowing to different rivers, basins, or seas.
- Where precipitation collects and drains off into a common outlet, such as into a river, bay, or other body of water.
- It is basically a drainage basin of associated tributaries.

Note
This study only deals with surface water flow and doesn't consider aquifers and groundwater percolation





What is a Watershed & Morphometry

- Morphometric analysis is a quantitative measurement and mathematical analysis of landforms.
- It plays a significant role in understanding the geohydrological characteristics of a drainage basin in relation to the terrain feature and its flow patterns.
- It helps Aquatic resource managers to retrieve information about the characteristics of watersheds
- Furthermore, they need this information for multiple watersheds within states or larger regions.

- **Horton 1945**
- **Miller 1953**
- **Schumm 1956**
- **Strahler 1964**

Morphometric Analysis		Formula	References
Aspects	Parameters		
(A) Linear	(1) Stream Order (u)	Hierarchical rank	A.N. Strahler (1969)
	(2) Bifurcation Ratio (R_b)	$R_b = N_u/N_{u+1}$ Where, N_u = No. of streams of 'u' order N_{u+1} = No. of streams of next higher order.	R.E. Horton (1945)
	(3) Sinuosity Index (SI)	$SI = O_L/E_L$ Where, O_L = observed (actual) path of a stream, E_L = expected straight path of same stream.	S.A. Schumm (1963)
(B) Areal	(1) Drainage Density (D_d)	$D_d = L_k/A_k$ Where, L_k =Total length of all stream segments of a basin, A_k = Total area of the Basin	R.E. Horton (1945)
	(2) Form Factor (F)	$F = A/L^2$ Where, A = Basin area L = Basin length	R.E. Horton (1932)
	(3) Circularity Index (C)	$C = 4\pi A/p^2$ Where, A = Basin area P = Basin Perimeter	V.C. Miller (1953)
	(4) Elongation ratio (R_e)	$R_e = (2\sqrt{A}/P)/L_b$ Where, A = Basin area, L_b = Basin length	S.A. Schumm (1956)
(C) Relief	(1) Relative Relief (R_R)	$R_R = (\text{Maximum altitude}-\text{Minimum altitude})$	Smith(1935)
	(2) Slope (θ)	$\theta = \tan^{-1}(N \times i/K)$ where, N = No. of contour crossing per mile/kilometer i = Contour interval, K = Constant (3361 for mile grid & 636.60 for kilometer grid)	Wentworth (1930)
	(3) Dissection Index (DI)	$DI = R_R/A_R$ Where, R_R =Relative Relief A_R =Absolute Relief	Dov Nir (1957)
	(4) Hypsometric Integral (HI)	$HI = (h/H)/(a/A)$ Where, h = absolute relief, H = highest relief in the area; a = area of absolute relief (h) A = Total basin area	A.N. Strahler (1952)

Study Area and its Importance

This project work focuses on Chandra river basin in Western Himalaya. The total area of Chandra basin lies between $77^{\circ} 0' 0''\text{E}$ and $77^{\circ} 50' 00''\text{ E}$ and $32^{\circ} 00' 0''\text{ N}$ and $33^{\circ} 10' 00''\text{ N}$, with the altitude varying from 2800 m to almost 6600 m.

Though the river Chandra flows through a region of almost no vegetation and no human settlement, it has an important place due to-

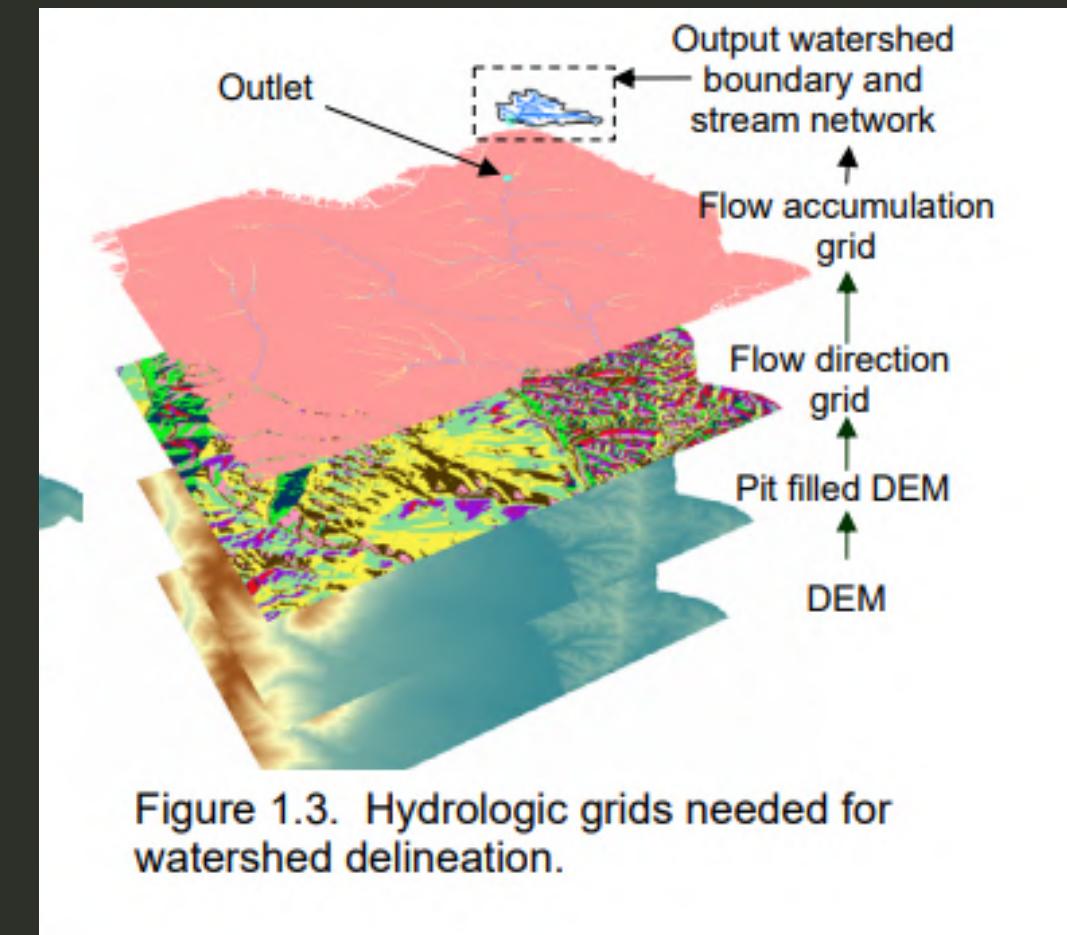
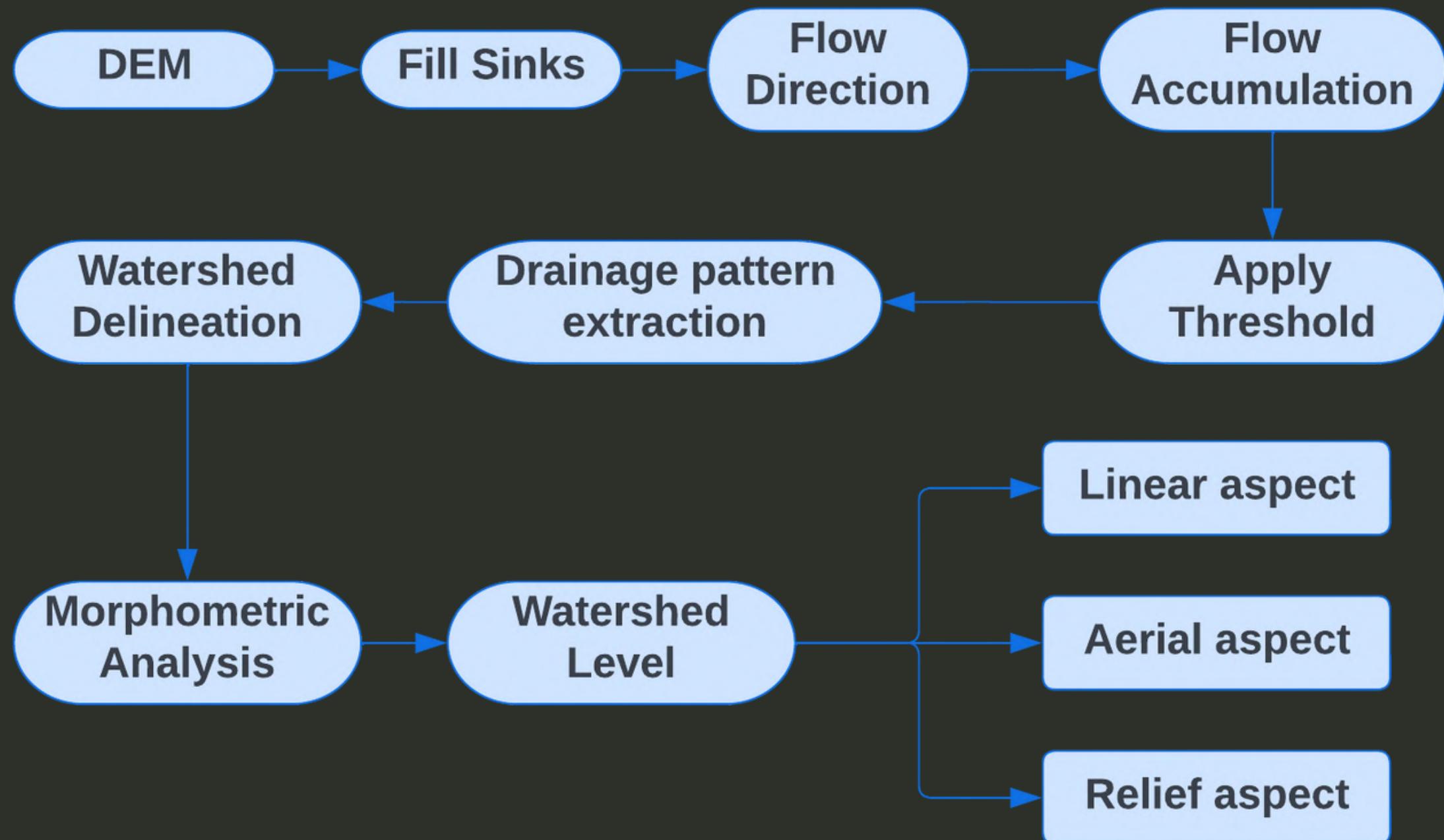
- River Chandra merges with river Bhaga to flow as Chandrabhaga or Chenab.
- River Chenab is among most important river of the country flowing through the fertile regions of Punjab and empowering many Dams.
- The Chandra river is almost perennial



The background image shows a wide, calm lake or river in the foreground, with a dense line of trees and bushes along its edge. In the distance, there are rolling hills and mountains under a clear blue sky.

Step 1: Watershed Delineation

Methodology





DEM data procurement through Bhuvan

We acquired CartoDEM version-2 R1 data from the Cratosat-1 satellite for this project.

Steps:

Bhuvan>>Cratosat data>>select tile>>Download data

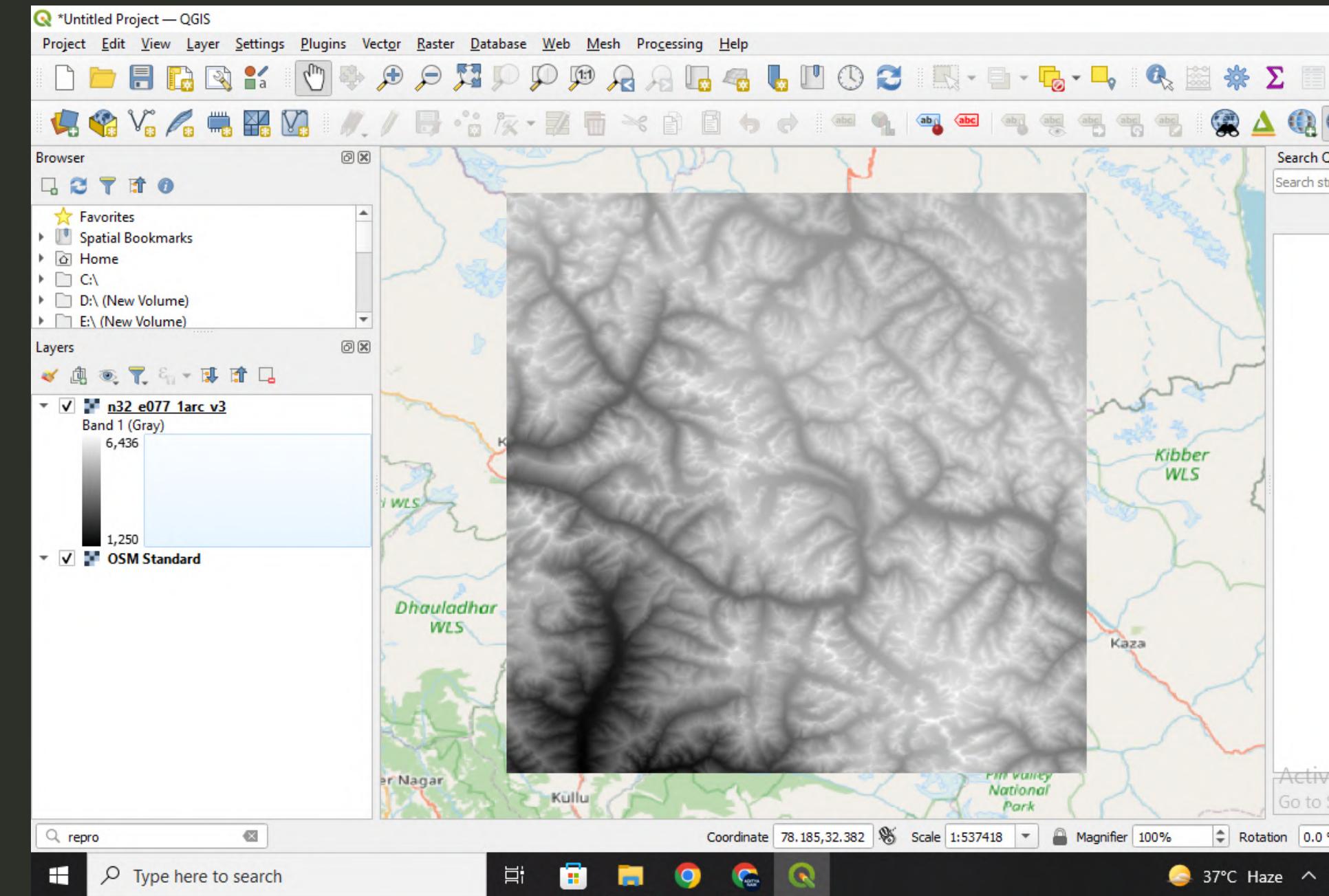
Dataset Name: C1_DEM_16b_2005-2014_V2R1_77E32N_I43X

The screenshot shows the Bhuvan Open Data Archive interface. On the left, there's a sidebar with a search bar, a 'Select Category' dropdown set to 'Satellite/Sensor', and a 'Select SubCategory' dropdown set to 'Cartosat-1'. Below these are 'Select Product' dropdowns set to 'CartoDEM Version-2 R1' and a note about the dataset being derived from the Cartosat-1 stereo payload. There are also links to 'Technical Documents' like the brochure and user handbook. On the right, a large map of India is displayed with a grid overlay. A specific tile in the top-left corner of the grid is highlighted with a red border, indicating it has been selected. At the bottom of the map, there's a scale bar labeled 'KILOMETERS' with values 0, 100, and 200, and a text overlay 'Activate Windows Go to Settings to activate Windows.'

The screenshot shows a 'Metadata' dialog box for 'Metadata of Tile No:I43X'. The dialog is divided into several sections:
I. Data Identification Information:
1. Name of the Dataset: C1_DEM_16b_2005-2014_V2R1_77E32N_I43X
2. Theme: Terrain
3. Keywords: Cartosat-1, DEM, Stereo data, India, ISRO, NRSC
4. Access Constraints
5. Use Constraints
6. Purpose of creating data
7. Data Type: Elevation
8. Edition: Second
9. Status: Completed: Production of the data has been completed
II. Contact Information:
1. Contact Person: Group Director,NDC
2. Organisation: National Remote Sensing Centre
3. Mailing Address: Balanagar
4. City/Locality: Hyderabad
5. Country: India
6. Contact Telephone: 040-23884422/23
7. Contact Fax: 040-23878158
8. Contact Email: gndc@nrsc.gov.in
III. Geographic Location:
1. Spheroid / Datum: GCS, WGS-1984
IV. Coverage:
1. Upper left: X = 77E, Y = 33N
A 'Close' button is at the bottom right of the dialog.

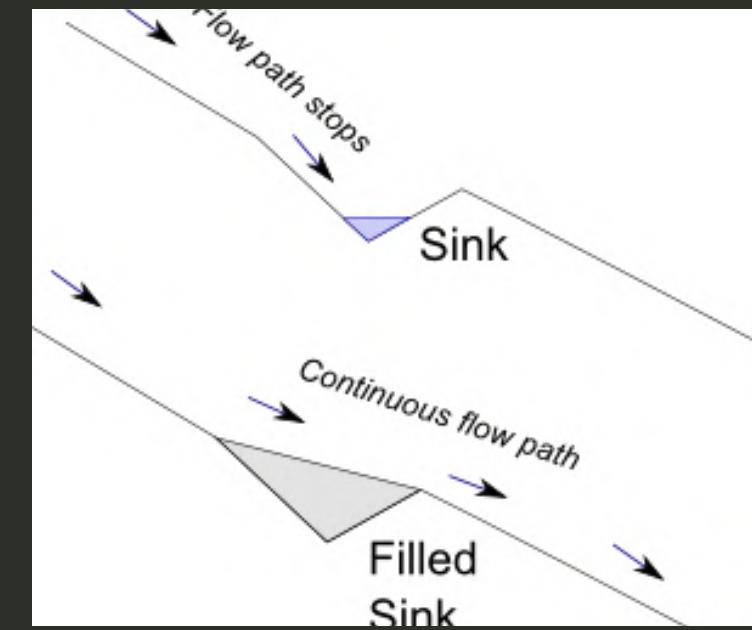
Opening and Reprojecting DEM file

- Open DEM file in QGIS v3.22 (Directly drag and drop in layers panel)
- Reproject DEM
- We re-project our DEM to the appropriate projection, in our case we can use WGS 84/EPSG 4326. Raster>>Projections >> Warp (Reproject)>> WGS 84 for target CRS.
- We used QuickMapService plugin to add background map



Tool: Fill Sinks

- The Fill Sinks tool by Wang & Liu produces a DEM free of depressions (AKA sinks) that would capture the flow of water, hence, conserving the waterflow in our data.
- Set minimum slope = 0.01
- This Algorithm (Wang & Liu) generates 3 outputs.



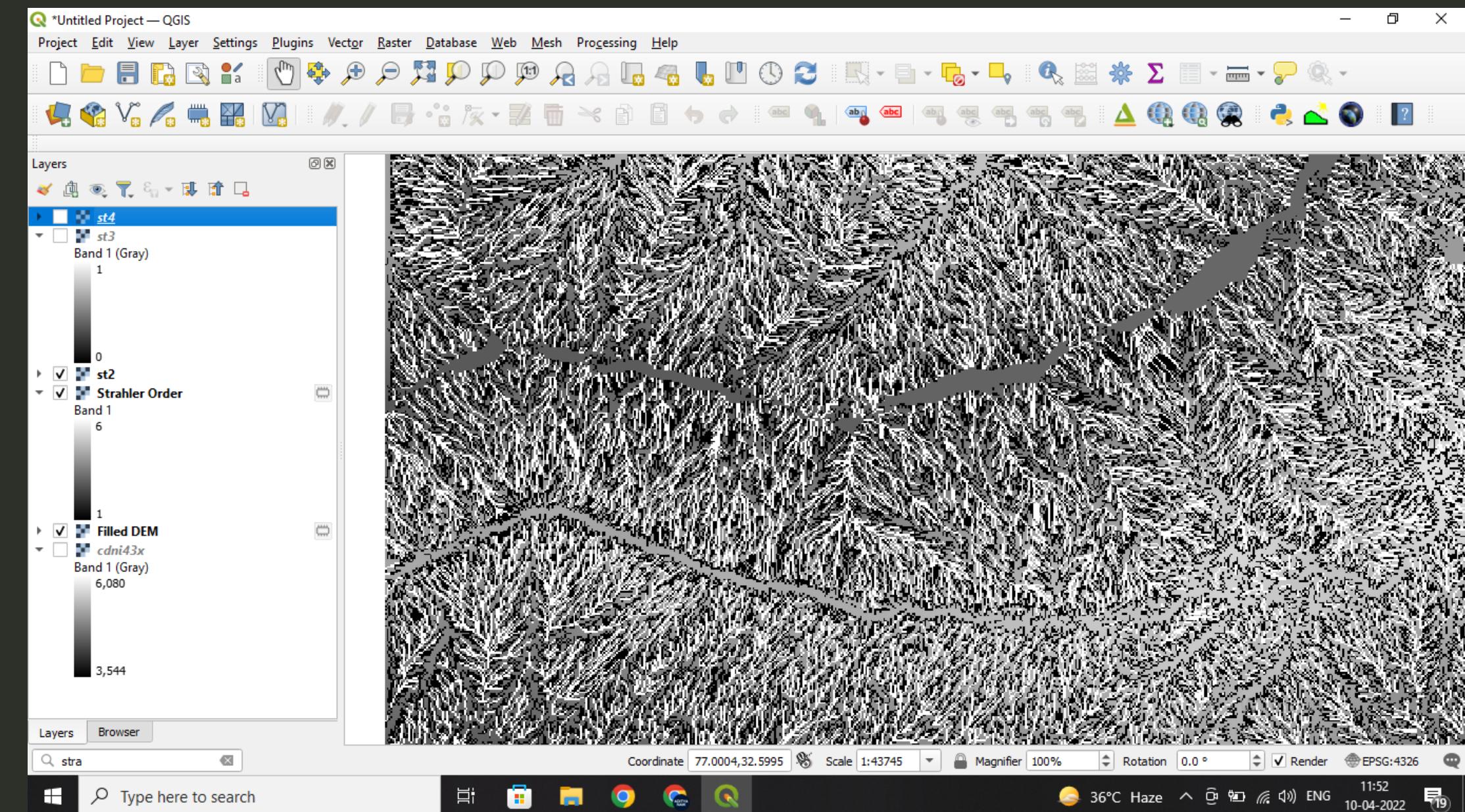
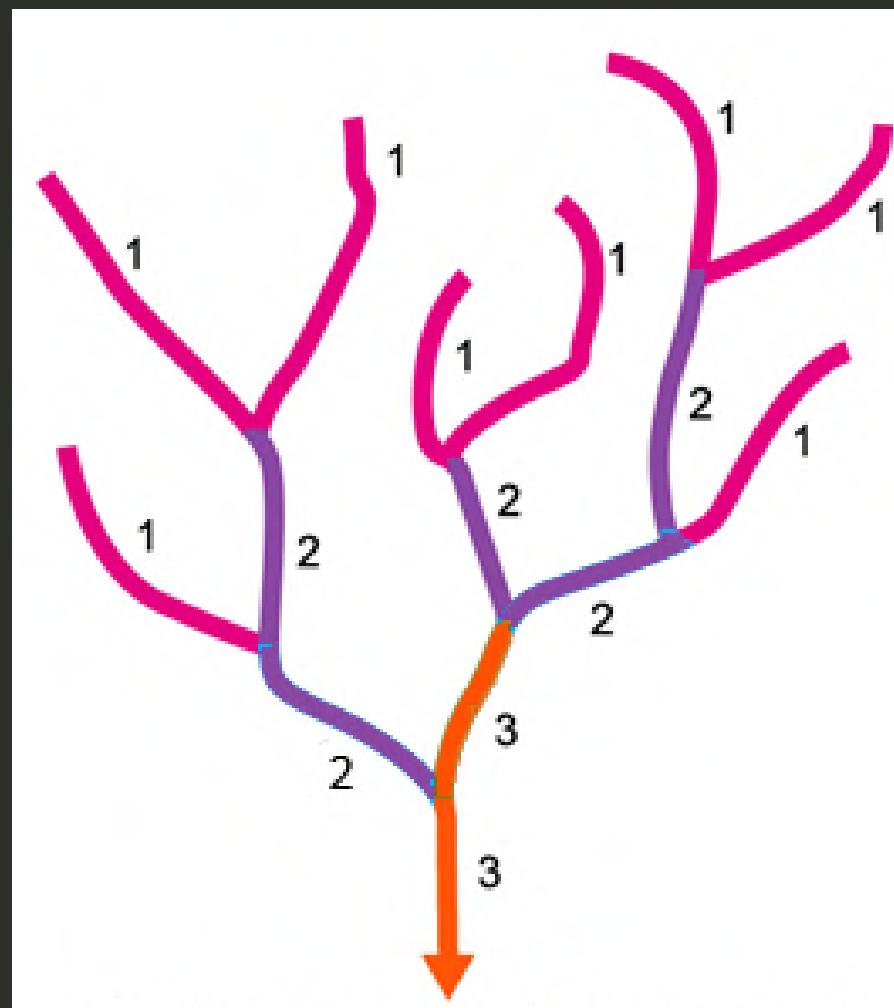
Filled DEM

Flow Direction

Basin Boundaries

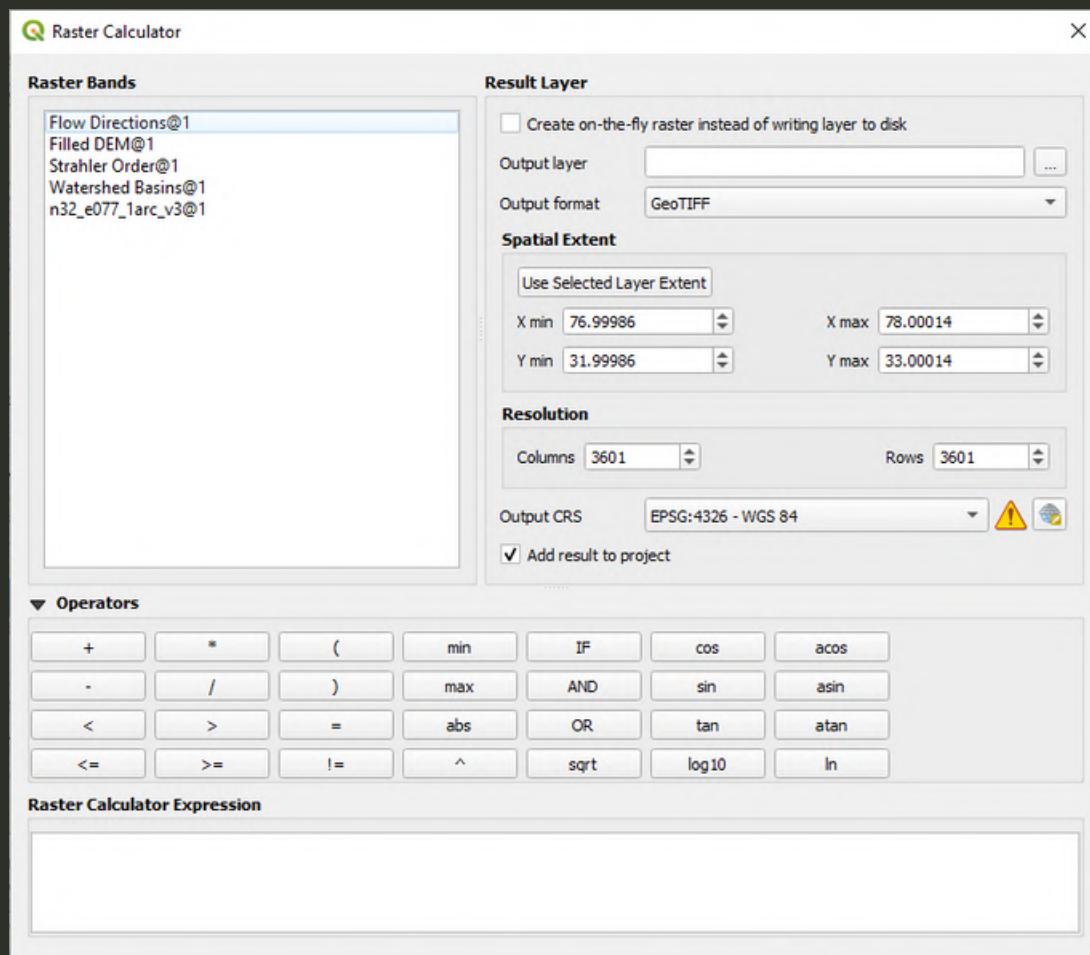
Tool: Strahler Order

- Toolbox > SAGA > Terrain Analysis-Channels > Strahler Order
- Raster > Raster Calculator
- Set desired strahler order

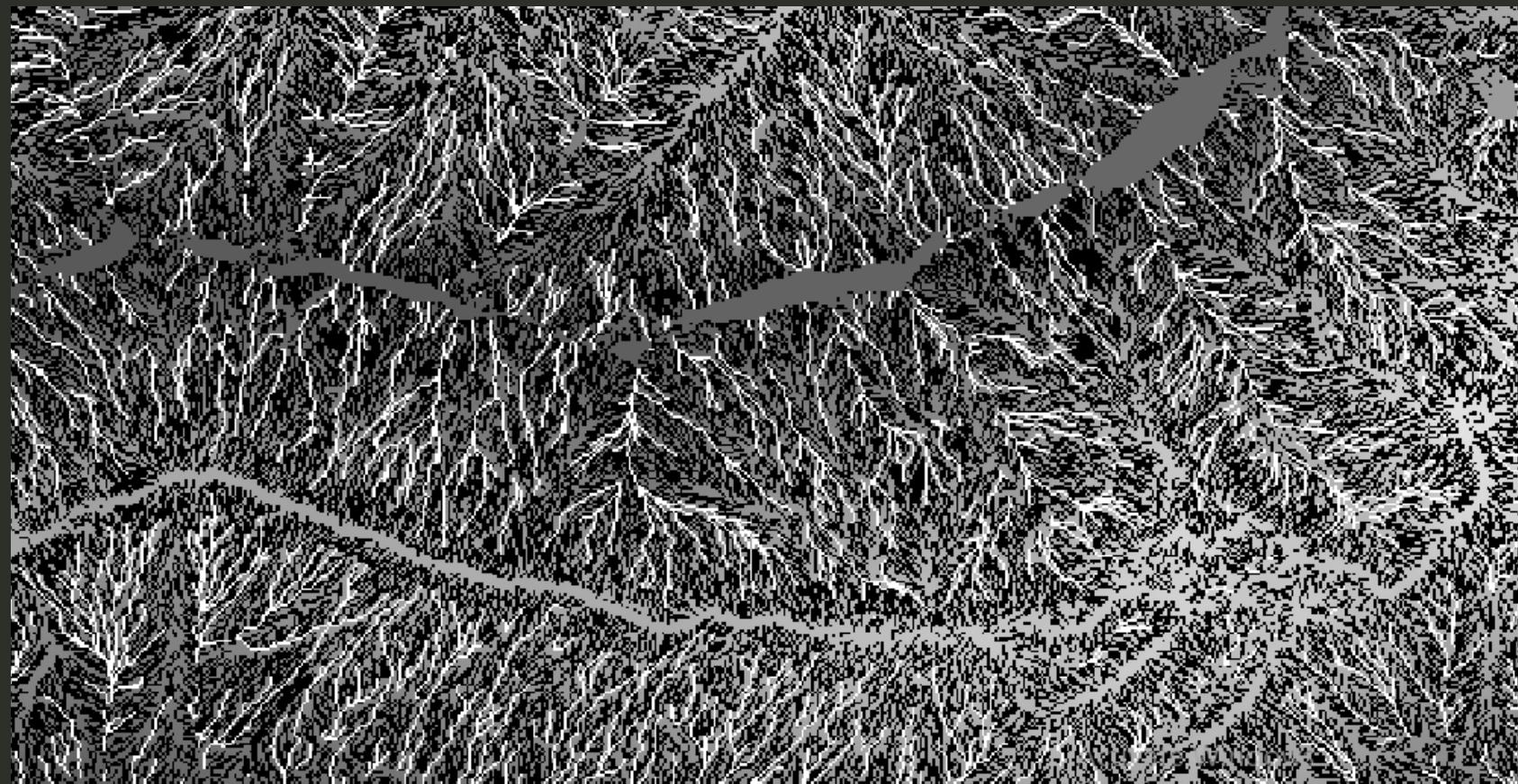


Tool: Strahler Order

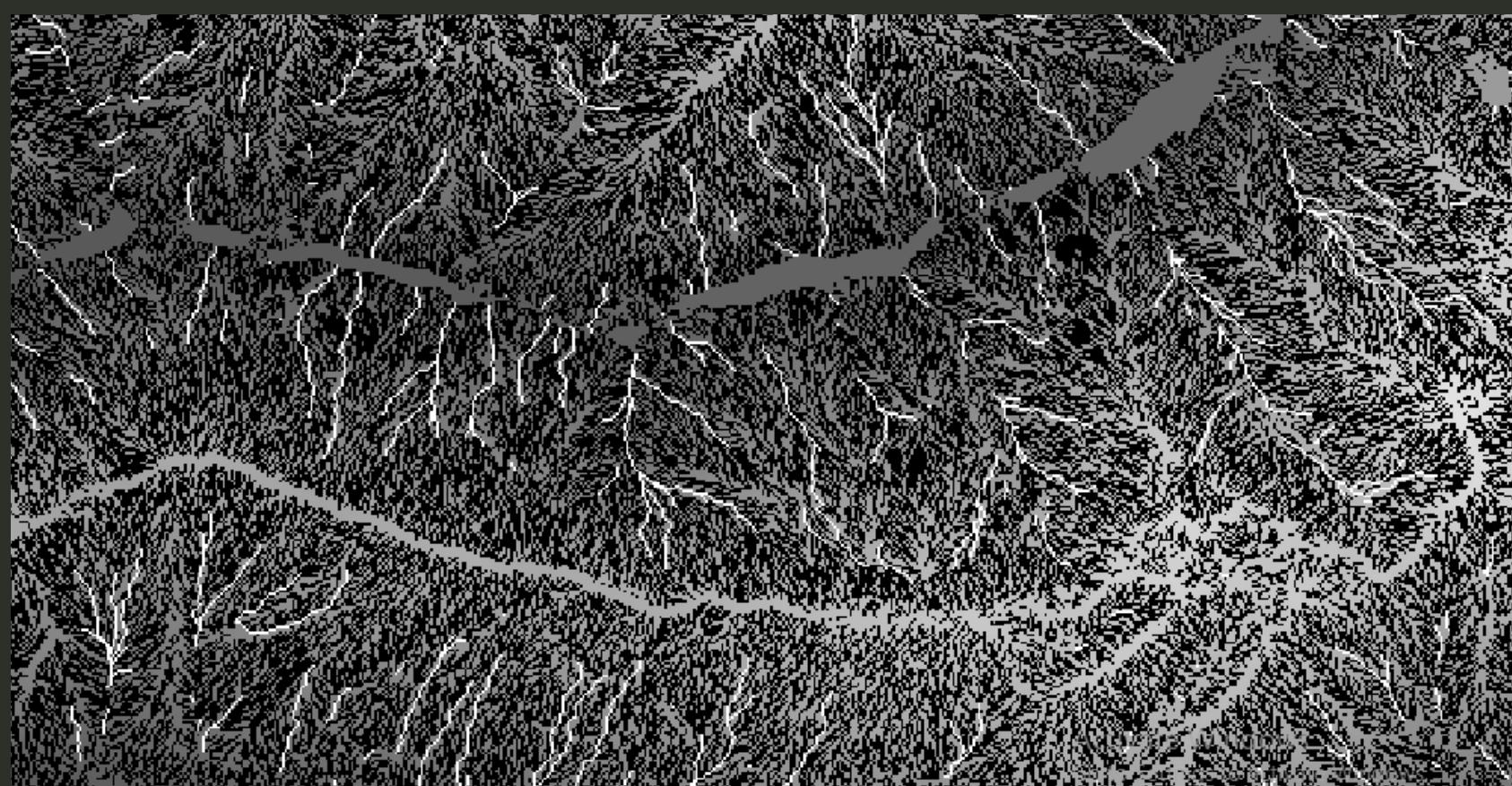
- Toolbox > SAGA > Terrain Analysis- Channels > Strahler Order
- Raster > Raster Calculator
- Set desired strahler order



Raster Calculator



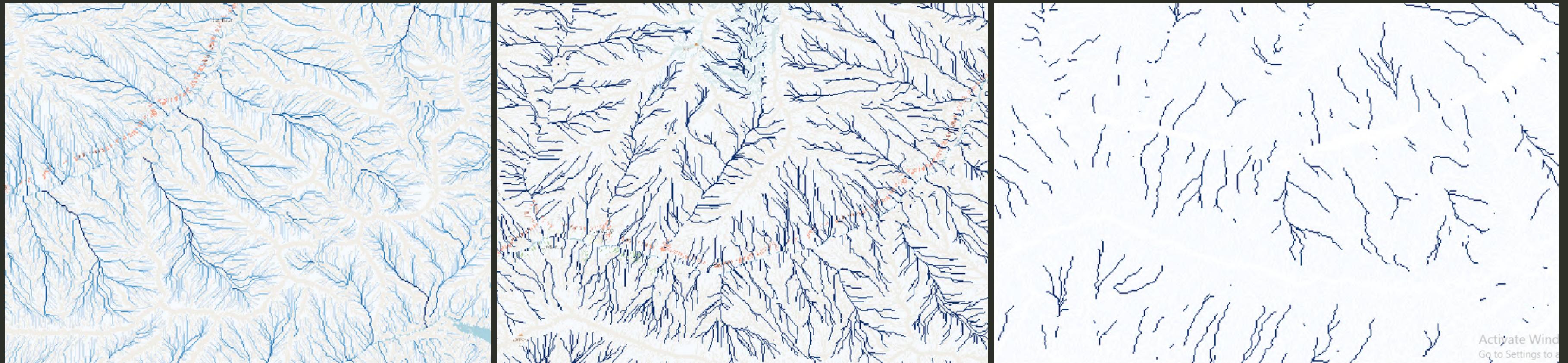
Streams with strahler order > 3



Streams with strahler order > 4

Let us Colourise the streams

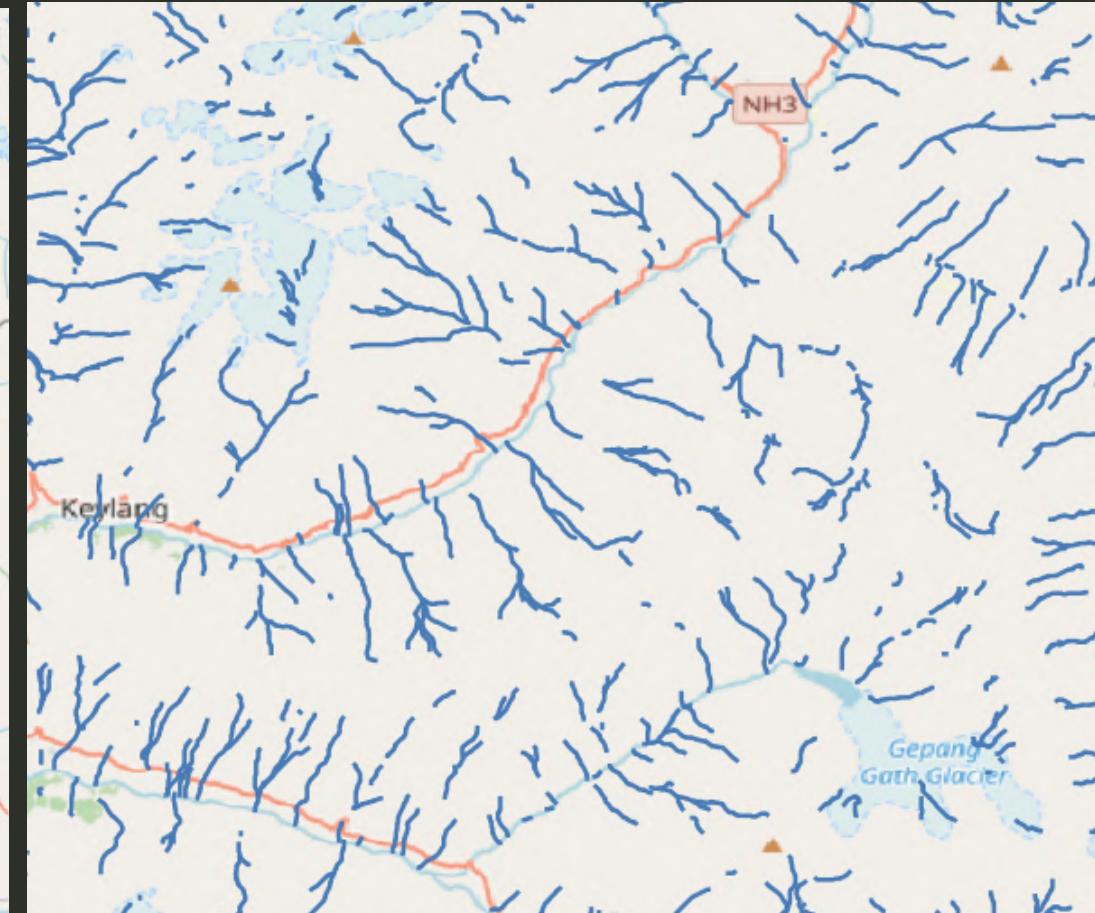
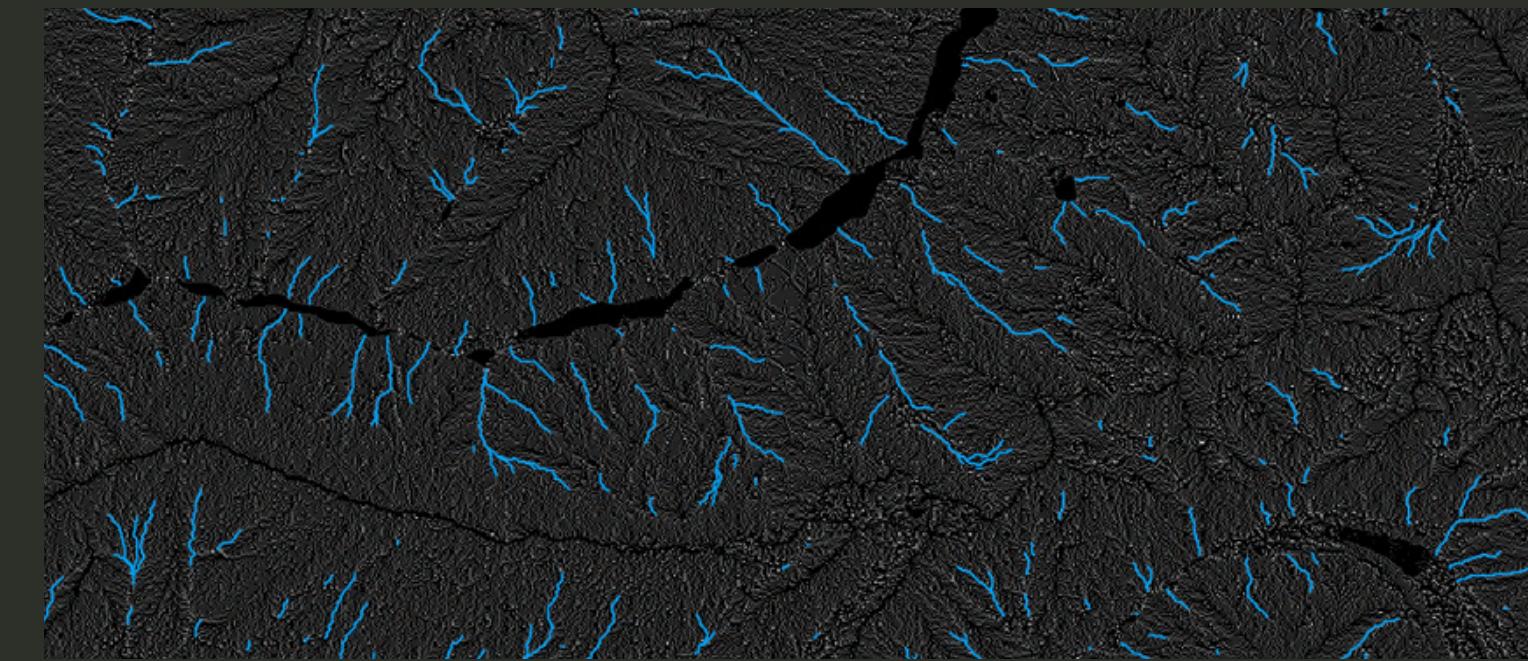
- Layer Properties>> Symbology>> Singleband Pseudo Colour
- Then select colour values
- Then Transparency



Increasing Strahler order

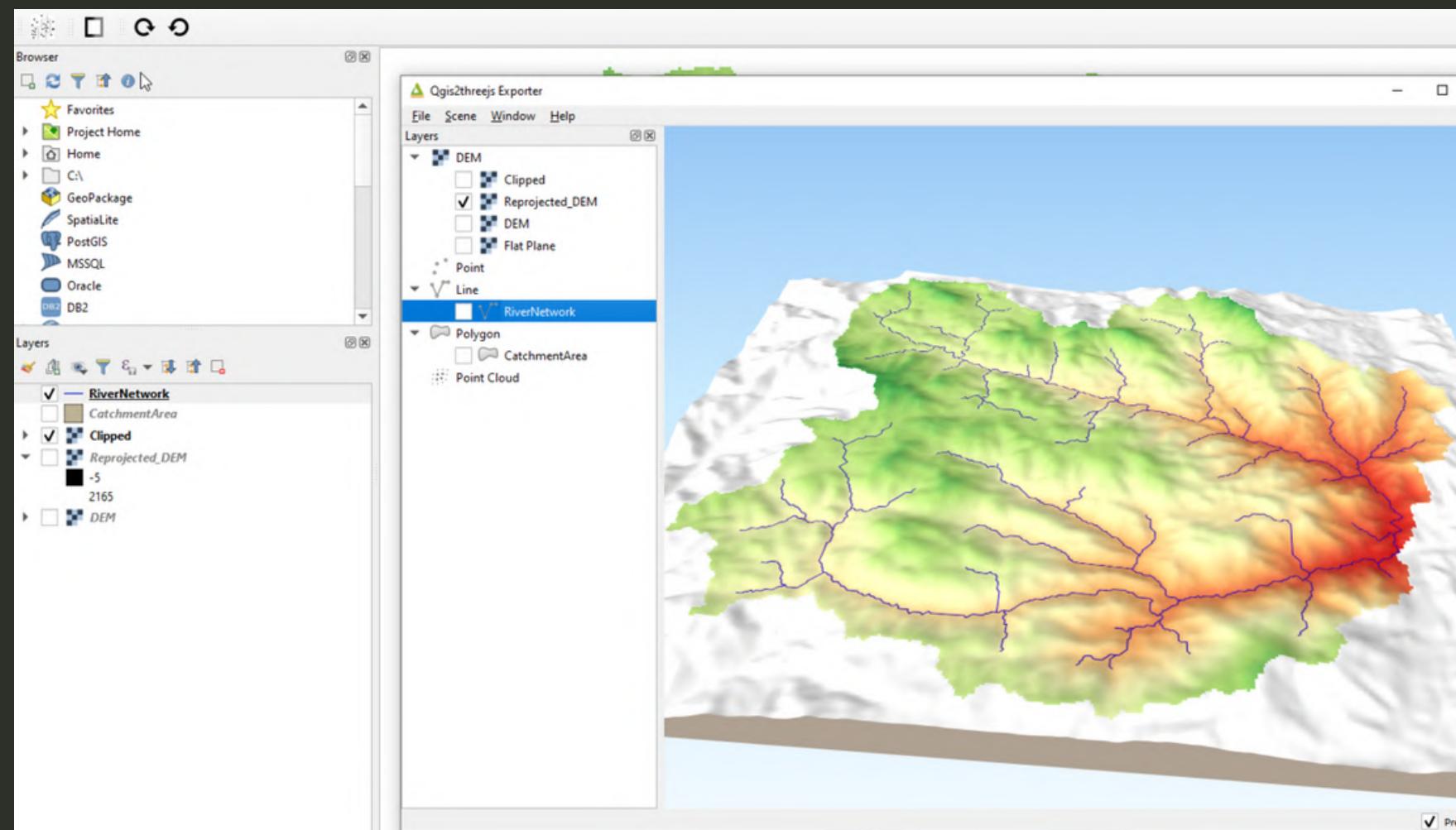
Vectorise the Streams

- Toolbox > Saga > Terrain Analysis- Channels > Channel Network and Drainage Basins
- Select elevation as Filled DEM

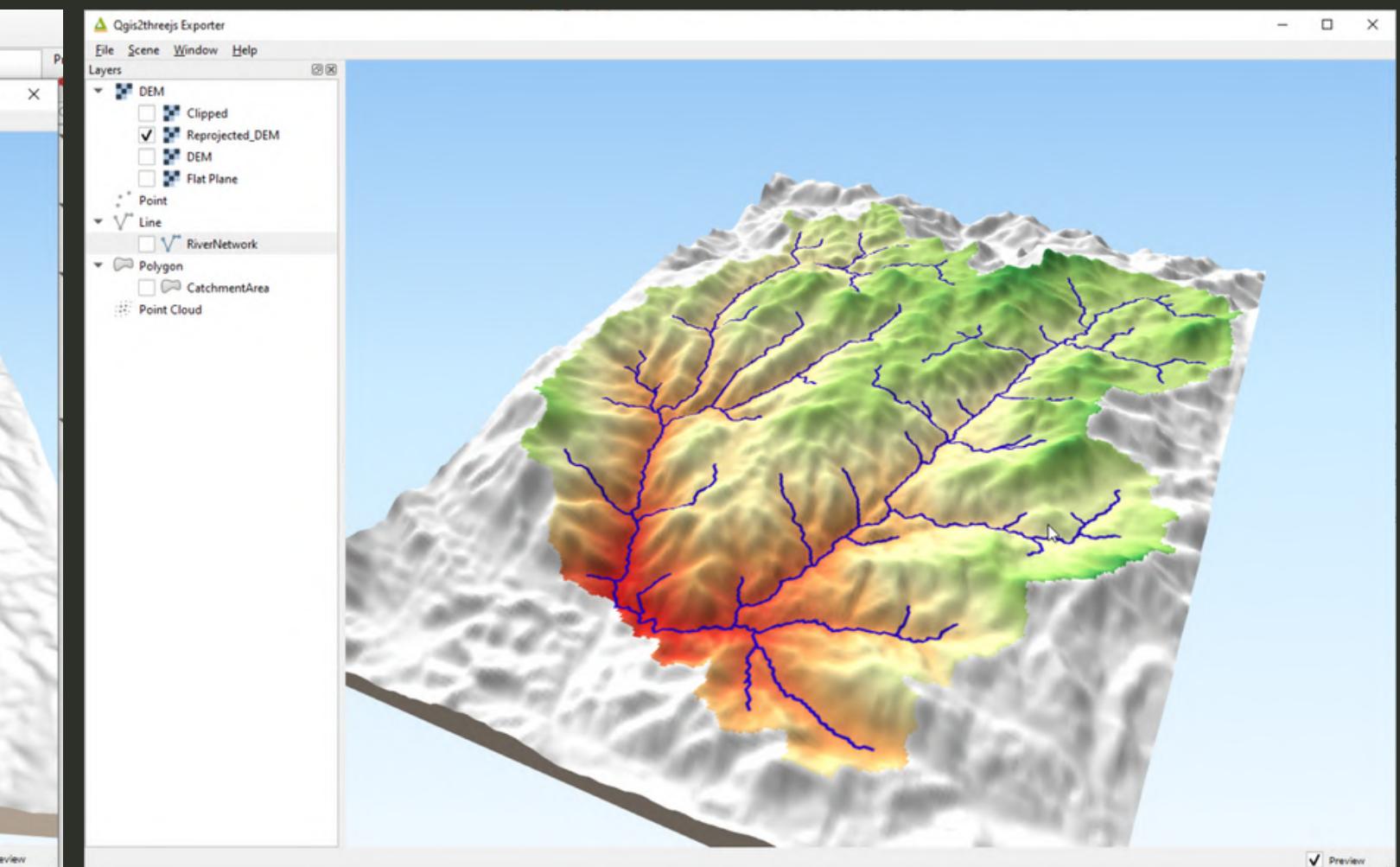


3D Modelling

- Install a Plugin **Qgis2threejs** that will aid in 3D modelling
- Select the reprojected DEM, Shape file of streams and clipped basin



Colourise Clipped Area

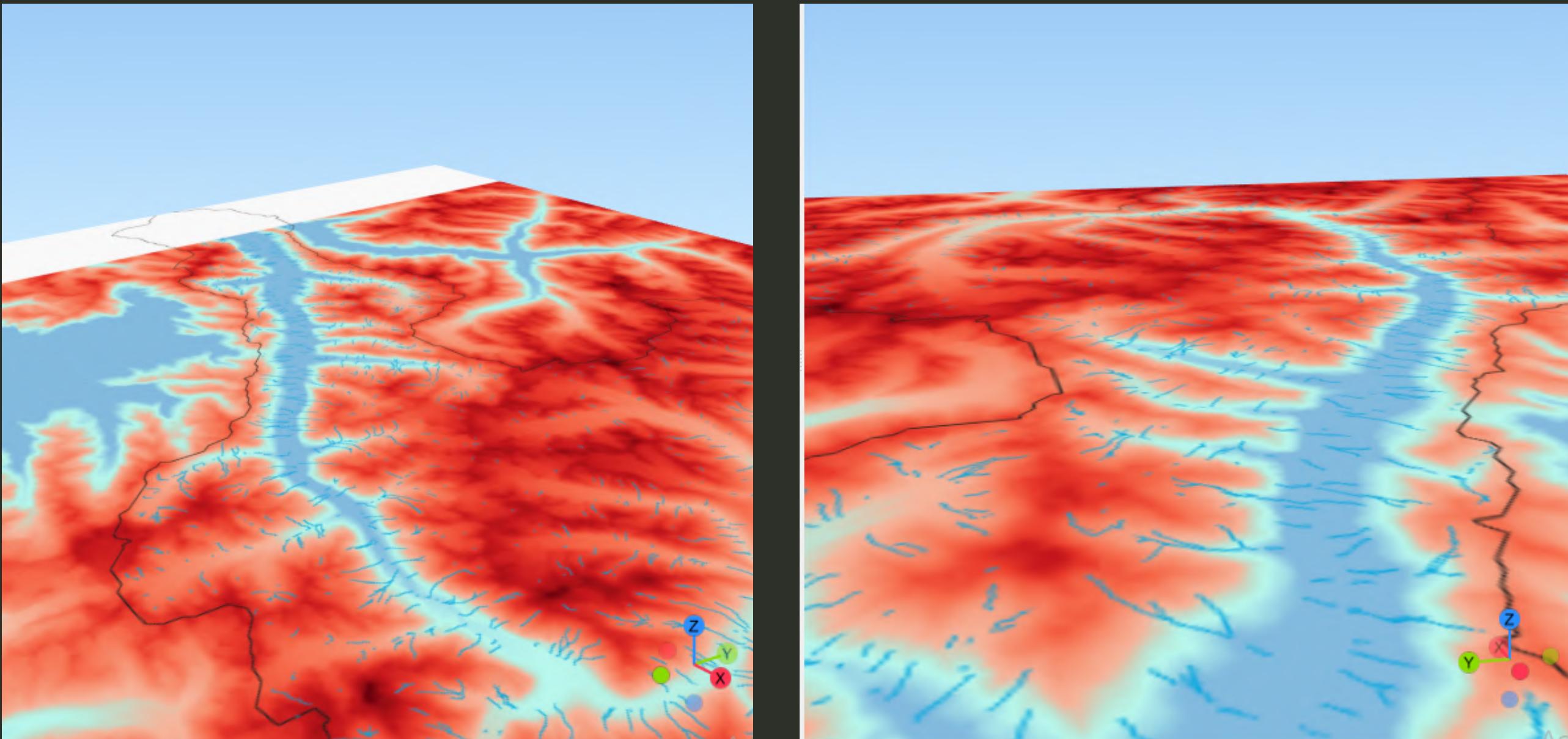


Model it using Qgis2threejs

3D Modelling

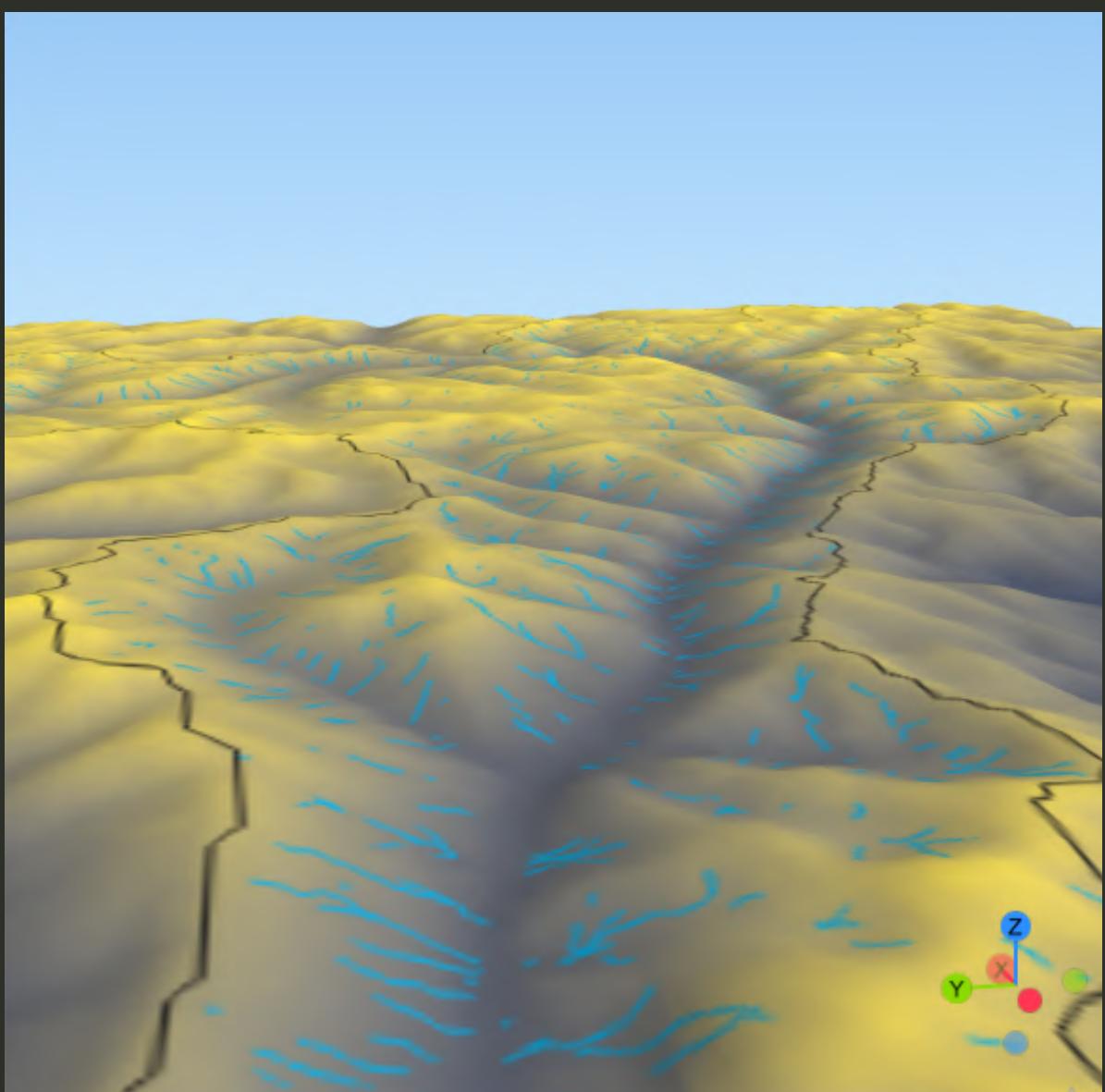
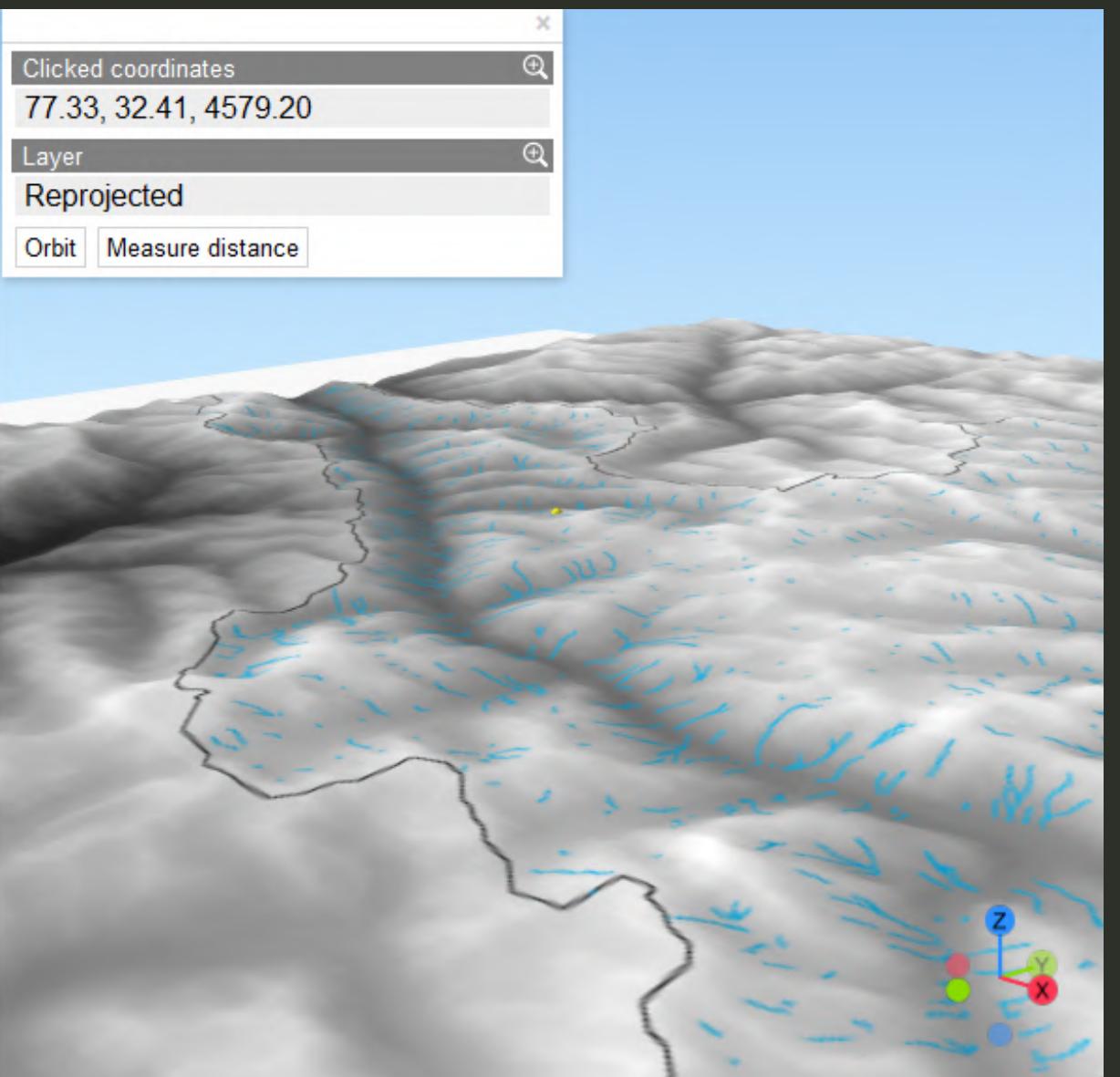
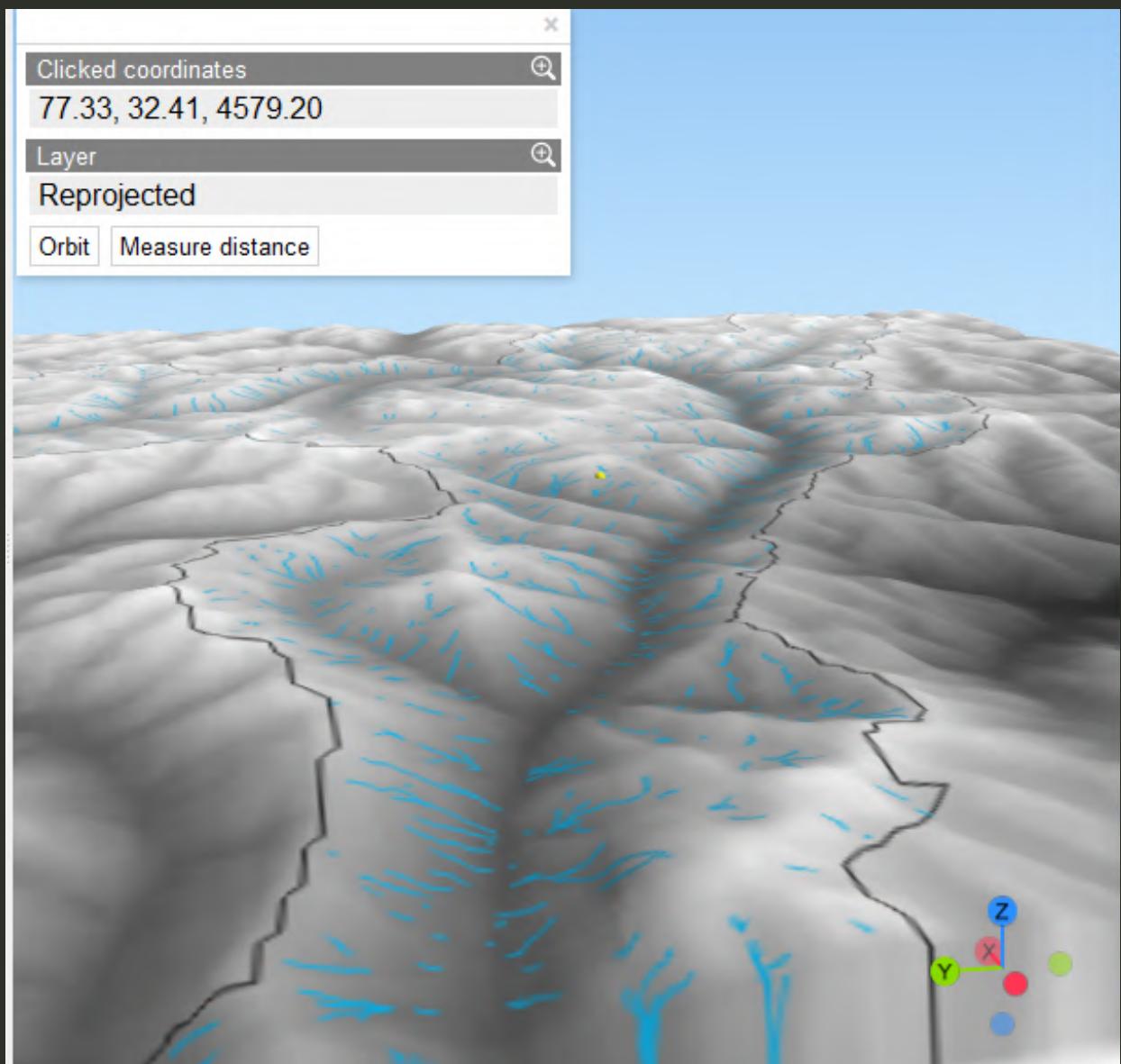


- Our Result



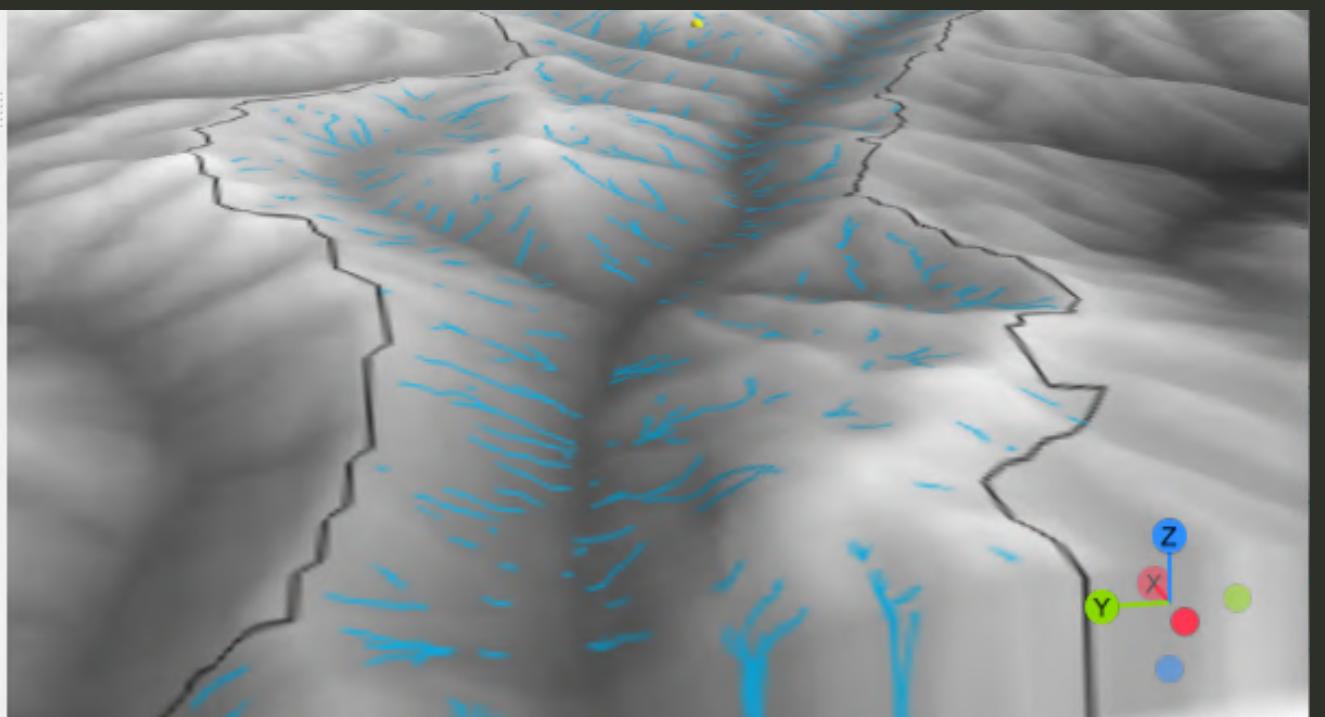
3D Modelling

- Our Result



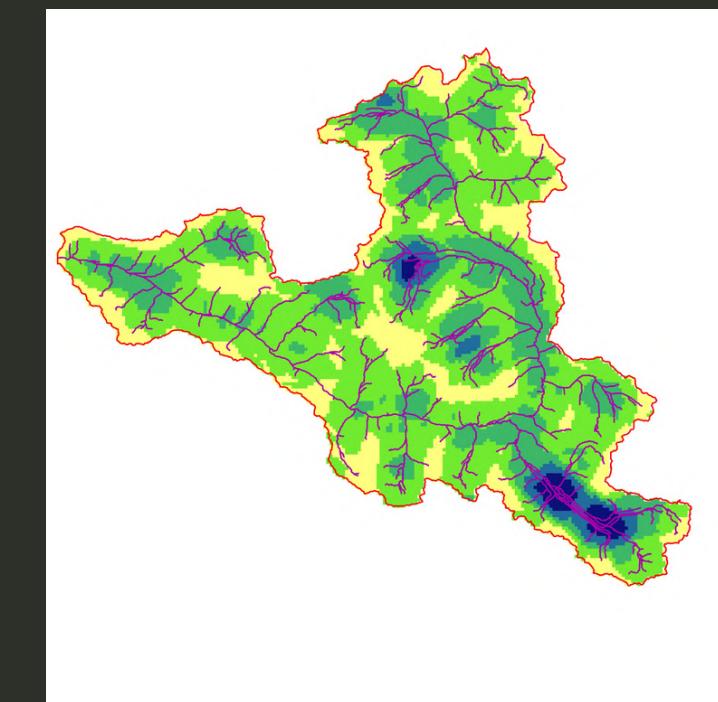
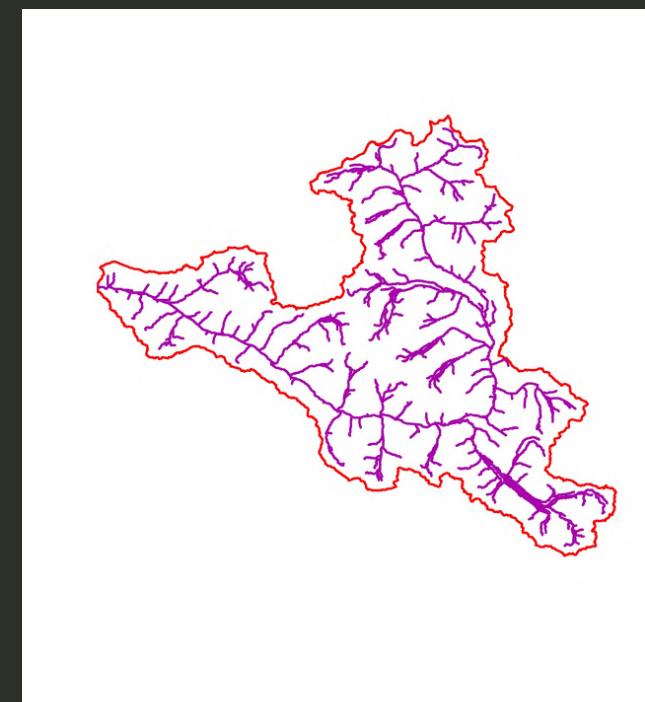
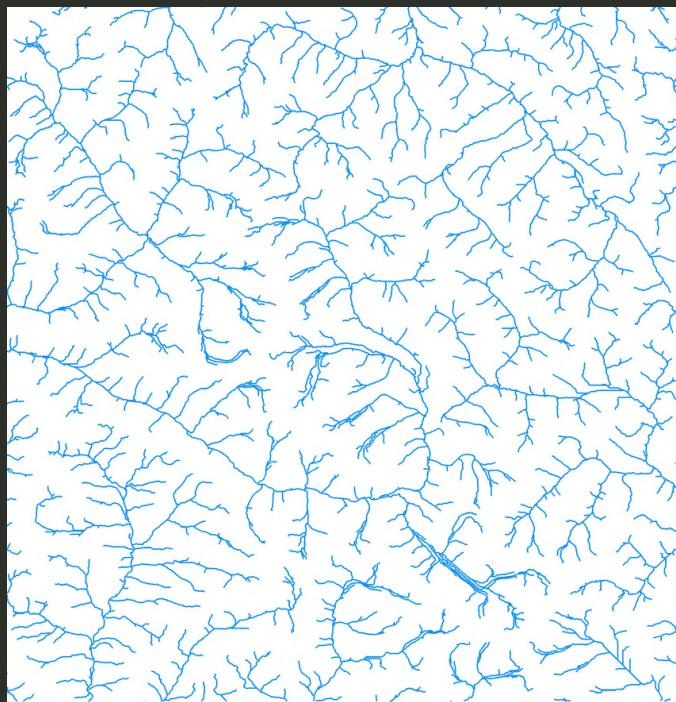
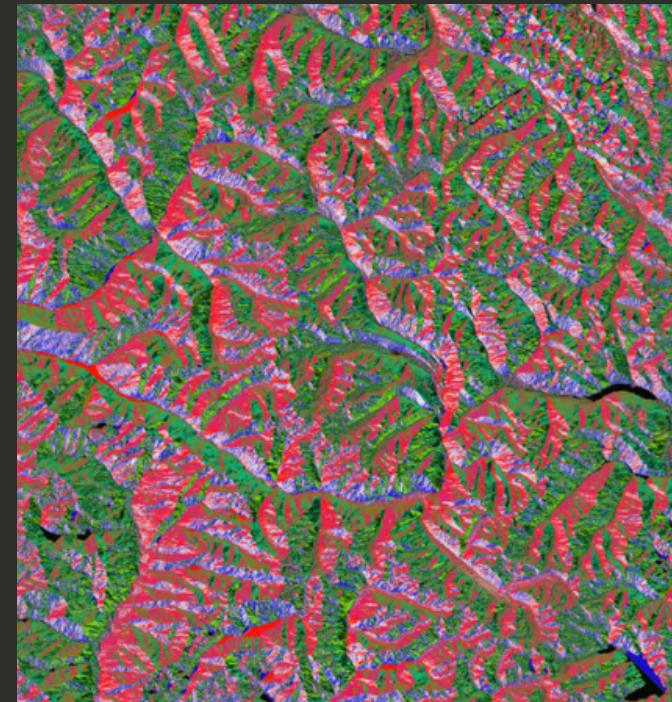
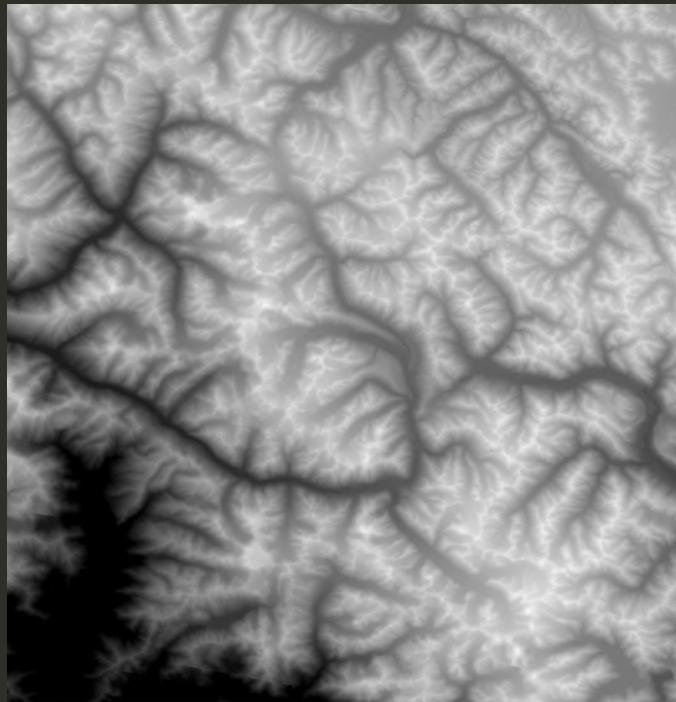
Reasons to shift to ArcGIS/ArcMap

- Unable to trace original river as QGIS need an another extension files
- Analysis tools that are available on QGIS are unable to process required data
- Quantifiable data is very hard to track on QGIS
- Hence we are using ERSL's ArcGIS pro/ArcMap for the further in-depth analysis



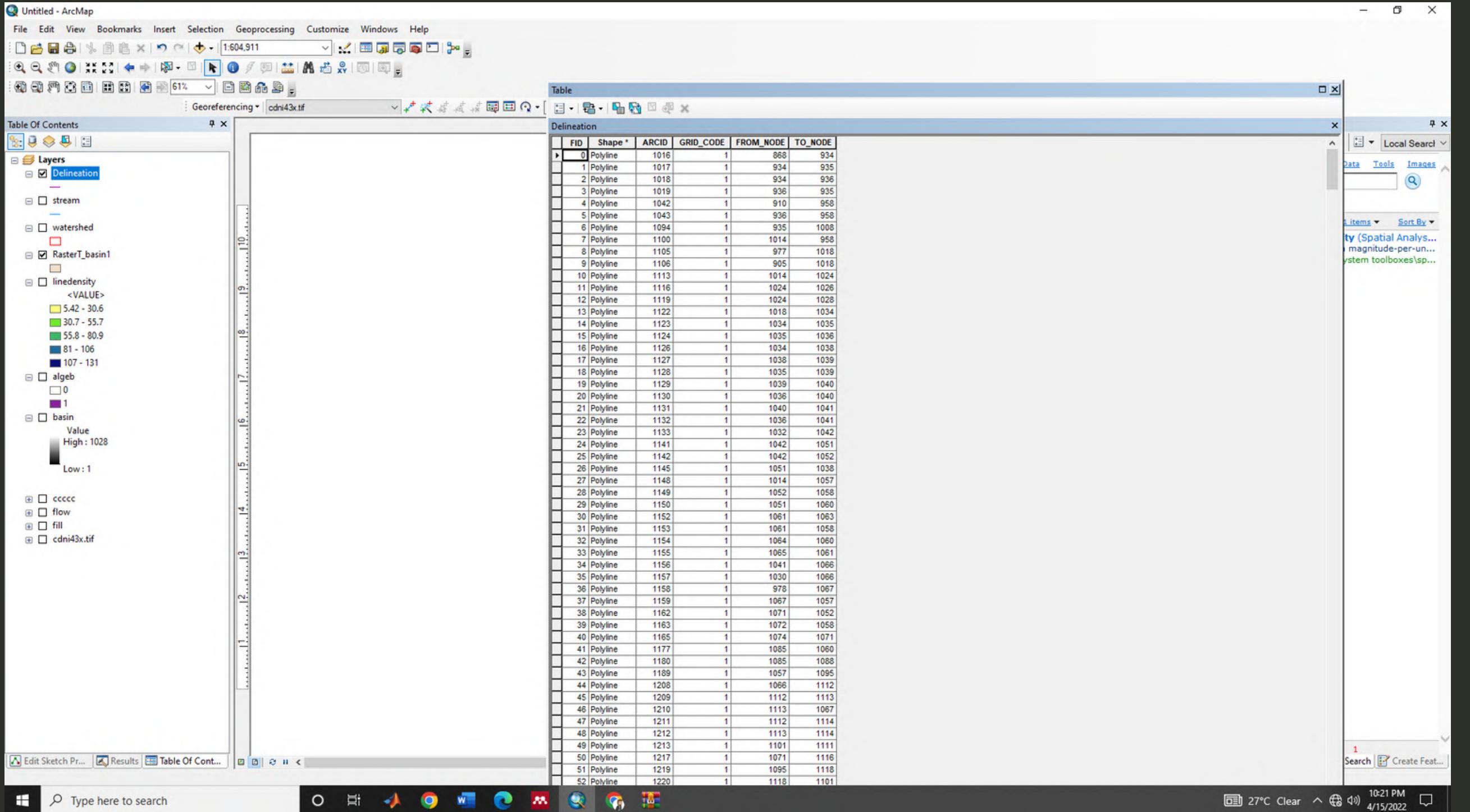
Step2: Morphometric Analysis

Delineation via ArcMap



Since the processing method is same, so are the steps that we follow.

Delineation via ArcMap



We use spatial data analysis tool to get stream length and stream density for further morphometric analysis

Results-



Stream Order	No. of Streams	Bifurcation Ratio	Mean Bifurcation Ratio	Mean Length
I	501		3.05	0.96605
II	206	2.43		
III	42	4.9		
IV	11	3.82		
V	3	3.67		
VI	2	1.5		
VII	1	2		

Linear Aspect

Area of Basin= 2410 sqkm.
 Perimeter of Basin= 251 km
 Length of Chandra river= 105 km
 Summation of length of streams= 740 km

Relief Aspects	Basin relief (Bh)	Vertical distance between the lowest and highest point	4860m
	Relief Ratio (Rh)	Rh = Bh / Lb Where, Bh=Basin relief, Lb=Basin length	0.08349
	Ruggedness Number (Rn)	Rn=Bh×DdWhere,Bh= Basin relief, Dd=Drainage den	0.25439
Aerial Aspects	Drainage density (Dd)	Dd=L/A Where, L=Total length of stream, A= Area of basin	0.307
	Stream frequency (Fs)	Fs=N/A Where, L=Total number of stream, A=Area of basin	0.317
	Texture ratio (T)	T=N1/P Where, N1=Total number of first order stream	2.004
	Circulatory ratio (Rc)	Rc=4πA/P ² Where A= Area of basin,π=3.14, P= Perimeter of basin	0.4843
	Elongation ratio (Re)	Re=√(Au/π)/ Lb Where, A=Area of basin, π=3.14, Lb=Length of basin	2908.92
	Length of overland flow (Lg)	Lg=1/2Dd Where, Drainage density	1.628
	Constant channel maintenance(C)	Lof=1/Dd Where, Dd= Drainage density	3.257

Relief Aspect

Aerial Aspect



Concluding Remarks-

- We successfully delineated the watershed of Chandra basin using QGIS
- Though we faced many issues in QGIS, we tried to eliminate those using ArcGIS
- Morphometric analysis was simply executed on ArcMap.
- QGIS requires many additional resource files to execute our task.
- The quality and resolution of data set plays an important role in processing and analyzing the information available .
- There has been no research on the watershed of the Chandra river and almost no literature is available on the internet to compare the accuracy of our results. (i.e. no standard result available for comparision)



Acknowledgements



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Presented By-

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- Nishant Kumar
- Digvijay Singh Rathore
- Manish Kori