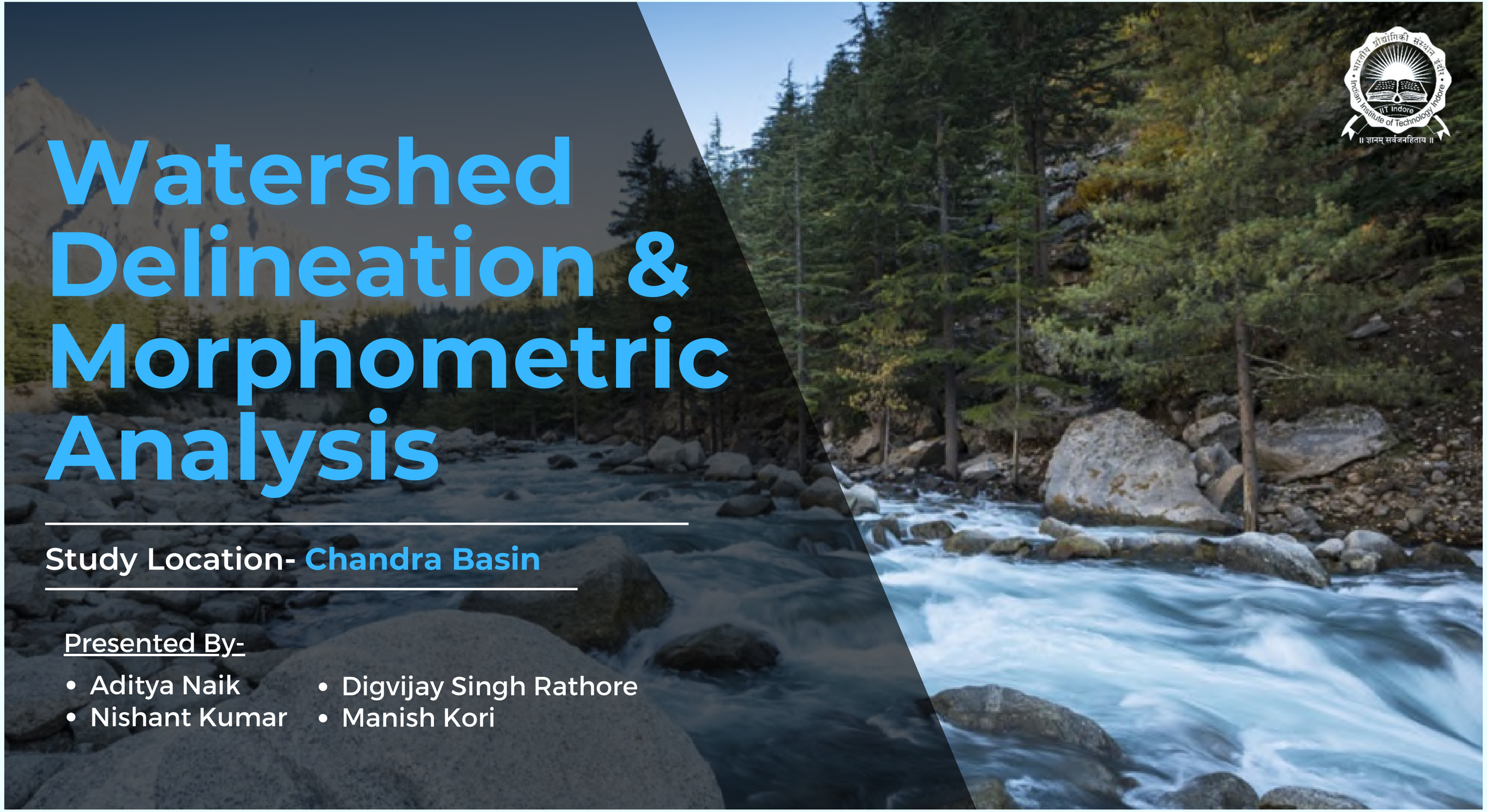
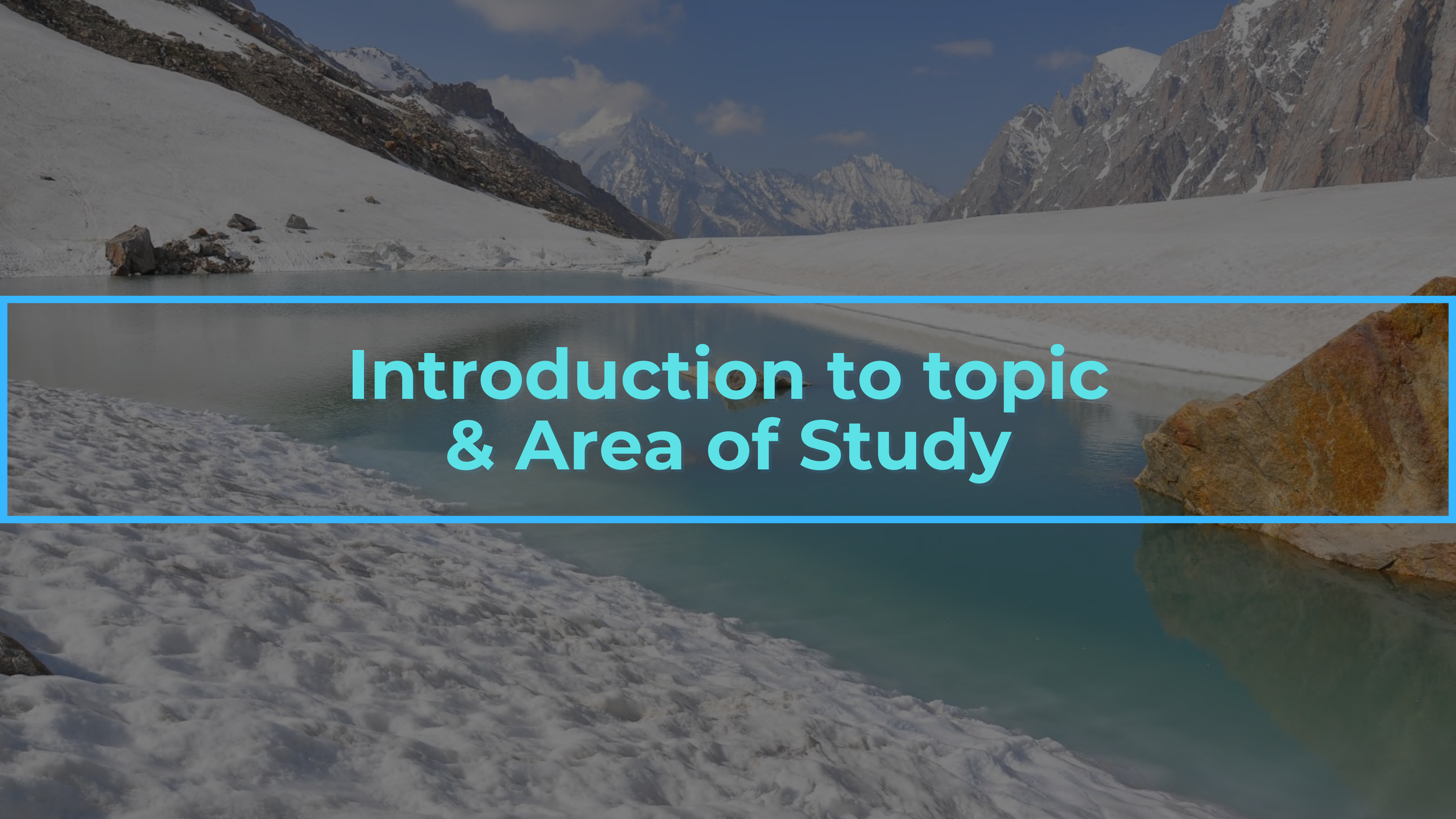


Watershed Delineation & Morphometric Analysis

Study Location- Chandra Basin

Presented By-

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

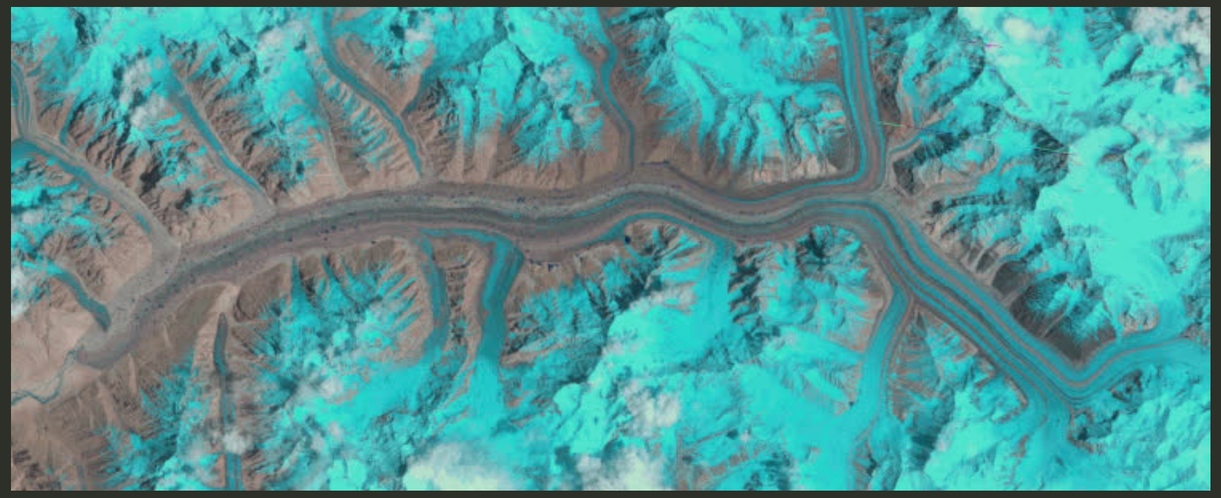


Introduction to topic & Area of Study

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.



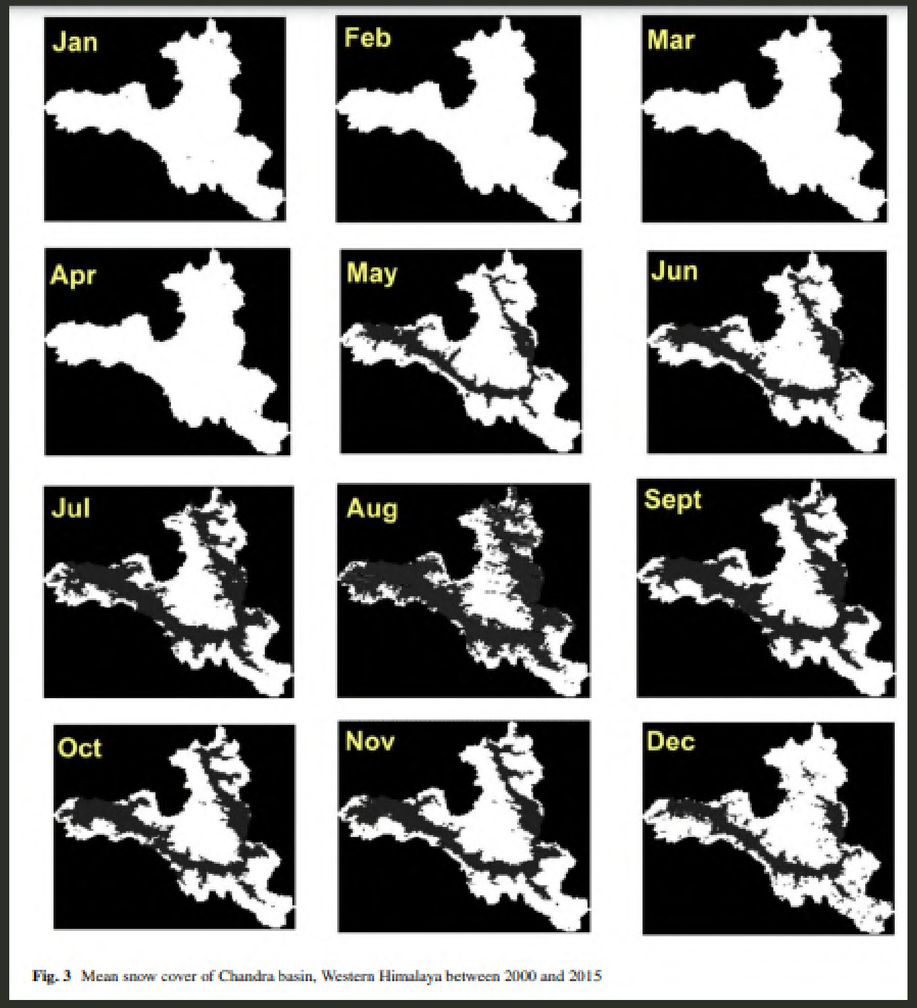
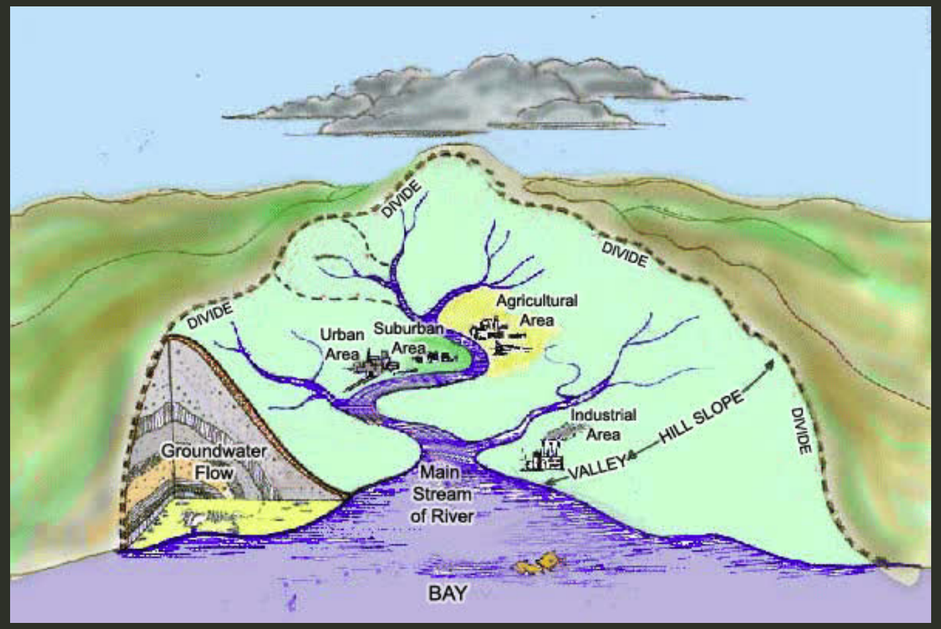


Fig. 3 Mean snow cover of Chandra basin, Western Himalaya between 2000 and 2015

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**
- **Schumn 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)	$C = 4\prod A/p^2$ Where, A= Basin area P= Basin Perimeter	V.C. Miller (1953)
	(4) Elongation ratio (R_e)	$R_e = (2\sqrt{A/\prod}) /L_b$ Where, A= Basin area, L_b= Basin length	S.A. Schumm (1956)
(C) Relief	(1) Relative Relief (R_R)	R_R =(Maximum altitude-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

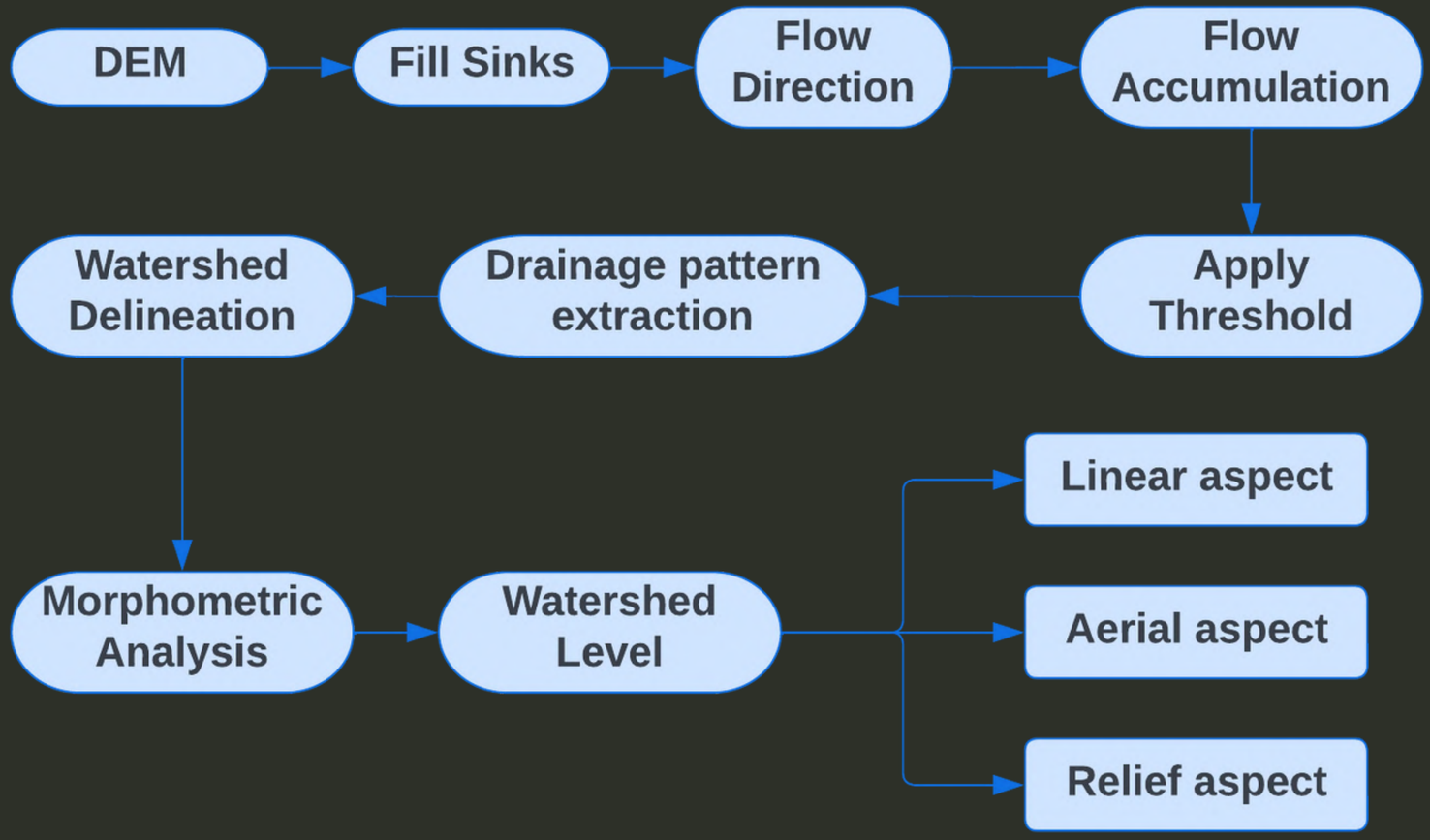
This project work focuses on Chandra river basin in Western Himalaya. The total area of Chandra basin lies between 77° 0' 0"E and 77° 50' 00" E and 32° 00' 0° N and 33° 10' 00" N, with the altitude varying from 2800 m to almost 6600 m.

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

Step1: Watershed Delineation

Methodology



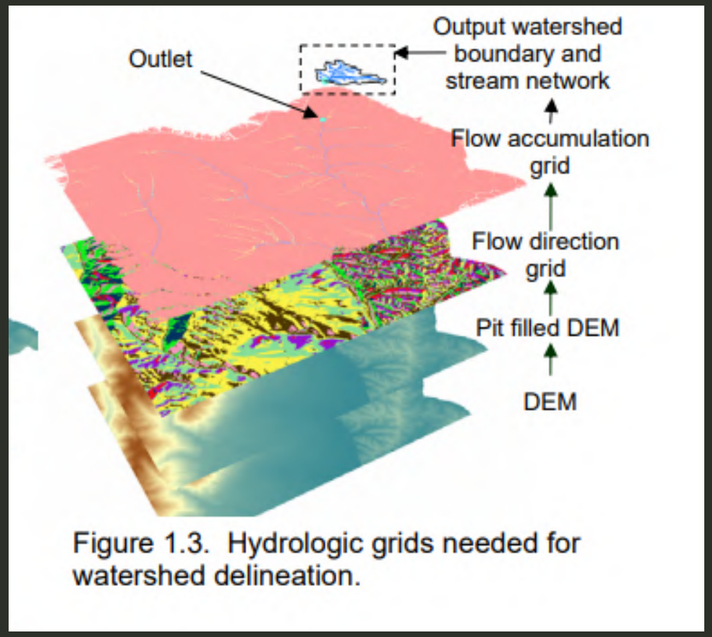
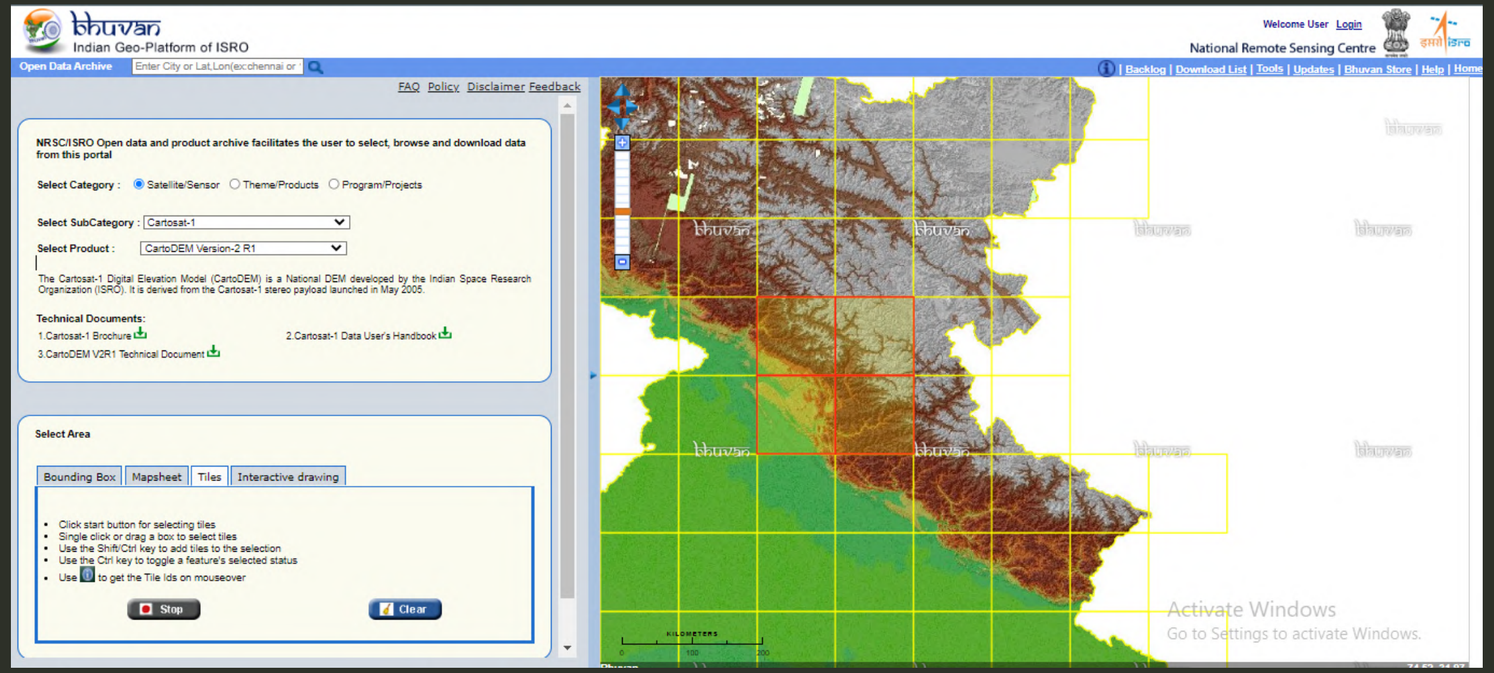


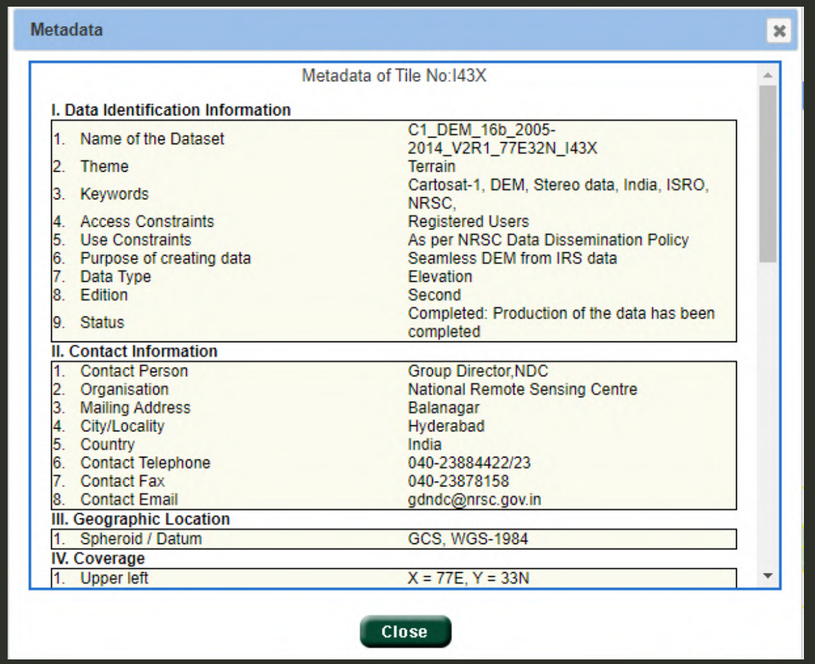
Figure 1.3. Hydrologic grids needed for watershed delineation.

DEM data procurement through Bhuvan

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

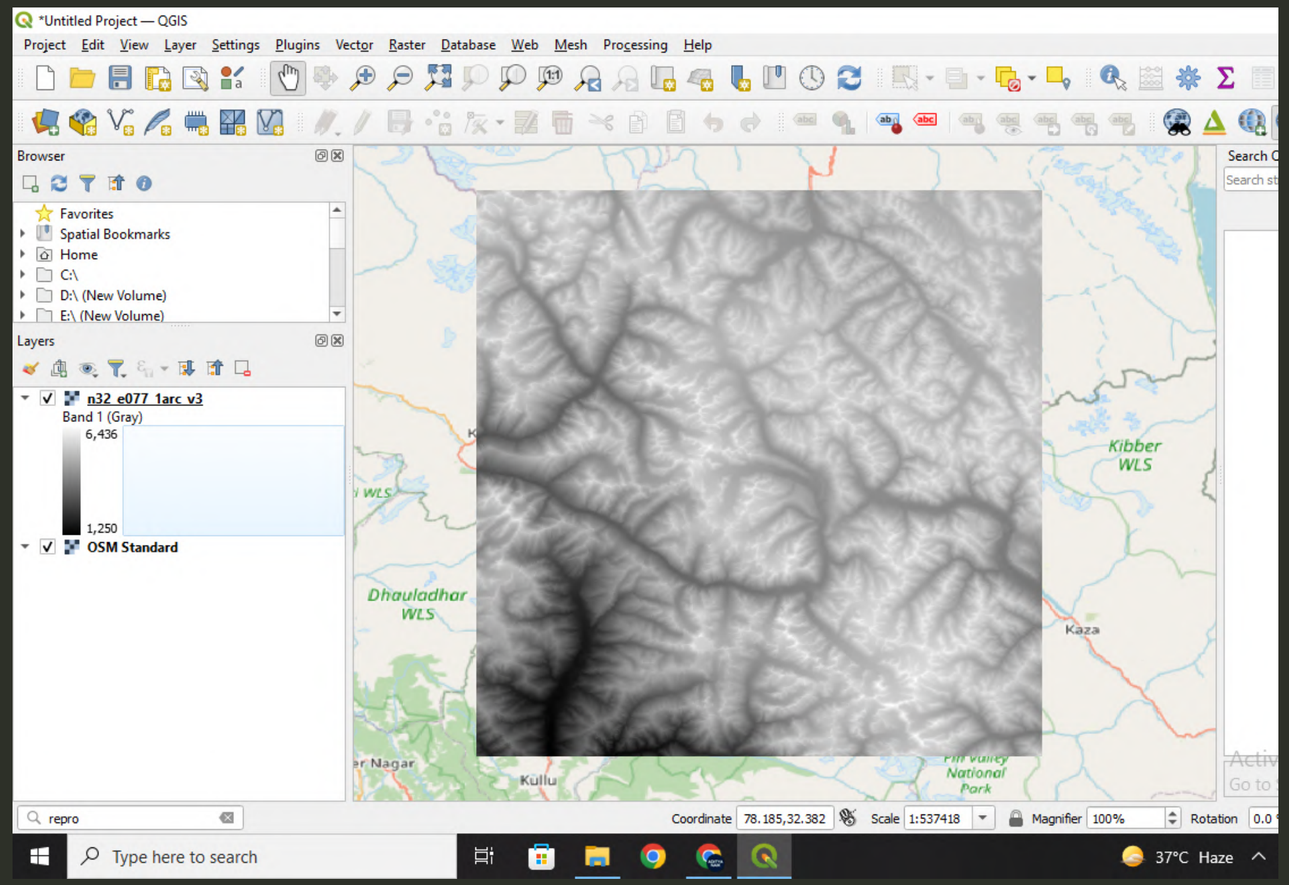
Steps:
Bhuvan>>Cratosat data>>select tile>>Download data
Dataset Name: C1_DEM_16b_2005-2014_V2R1_77E32N_I43X





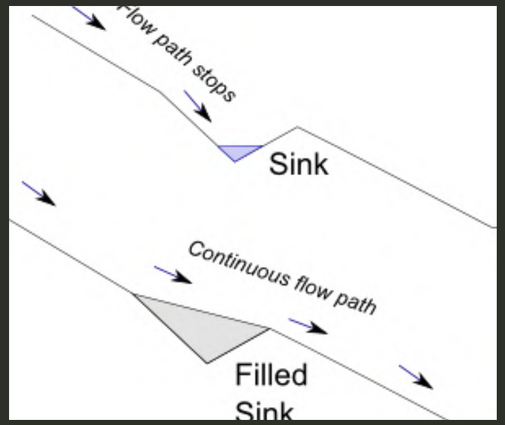
Opening and Reprojecting DEM file

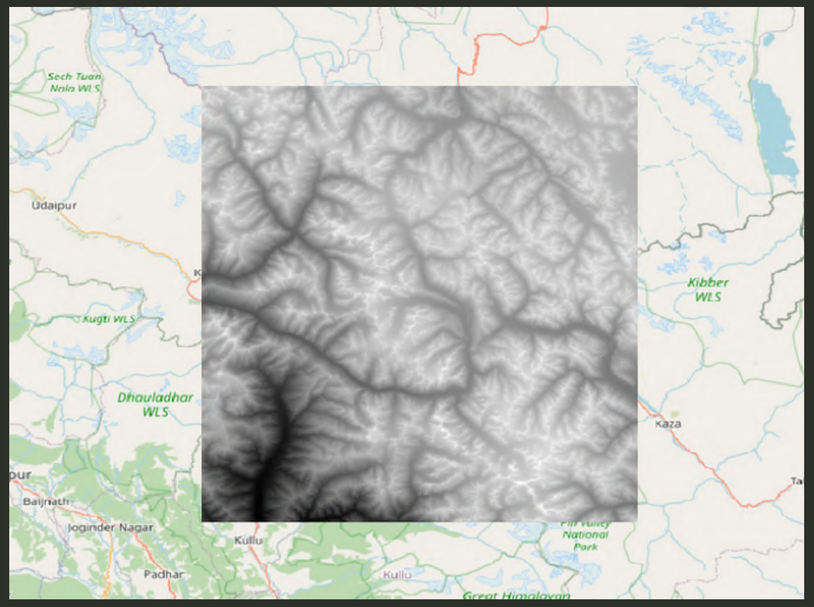
- Open DEM file in QGIS v3.22 (Directly drag and drop in layers panel)
- Reproject DEM
- We re-project our DEM to the appropriate projection, in our case we can use WGS 84/EPSG 4326. Raster>>Projections >> Warp (Reproject)>> WGS 84 for target CRS.
- We used QuickMapService plugin to add background map



Tool: Fill Sinks

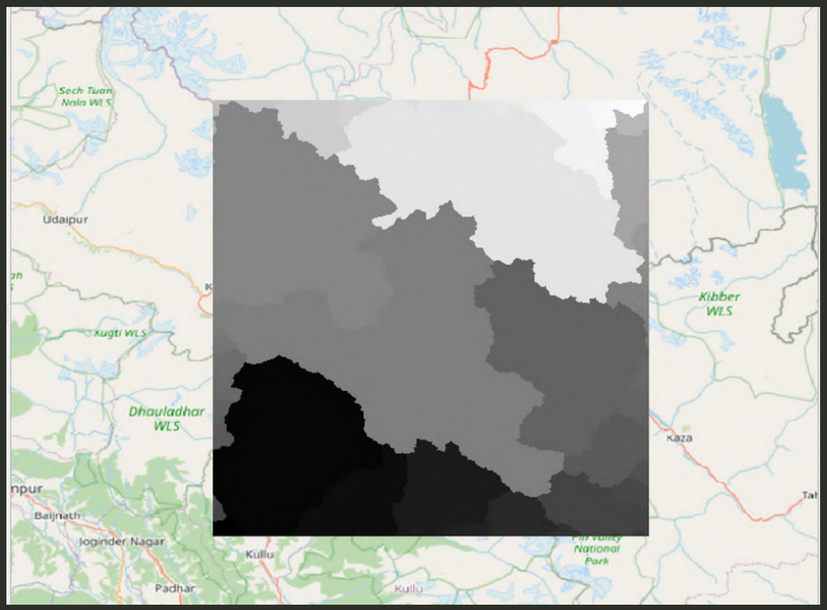
- The Fill Sinks tool by Wang & Liu produces a DEM free of depressions (AKA sinks) that would capture the flow of water, hence, conserving the waterflow in our data.
- Set minimum slope = 0.01
- This Algorithm (Wang & Liu) generates 3 outputs.





Filled DEM

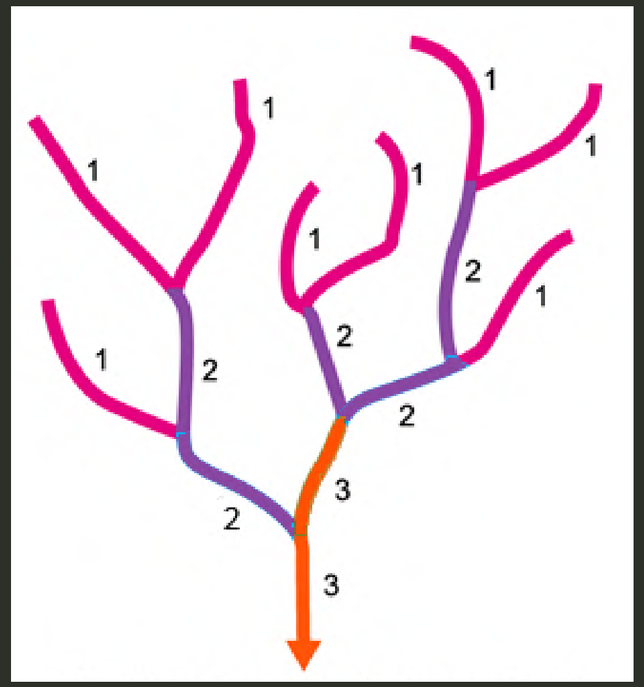
Flow Direction



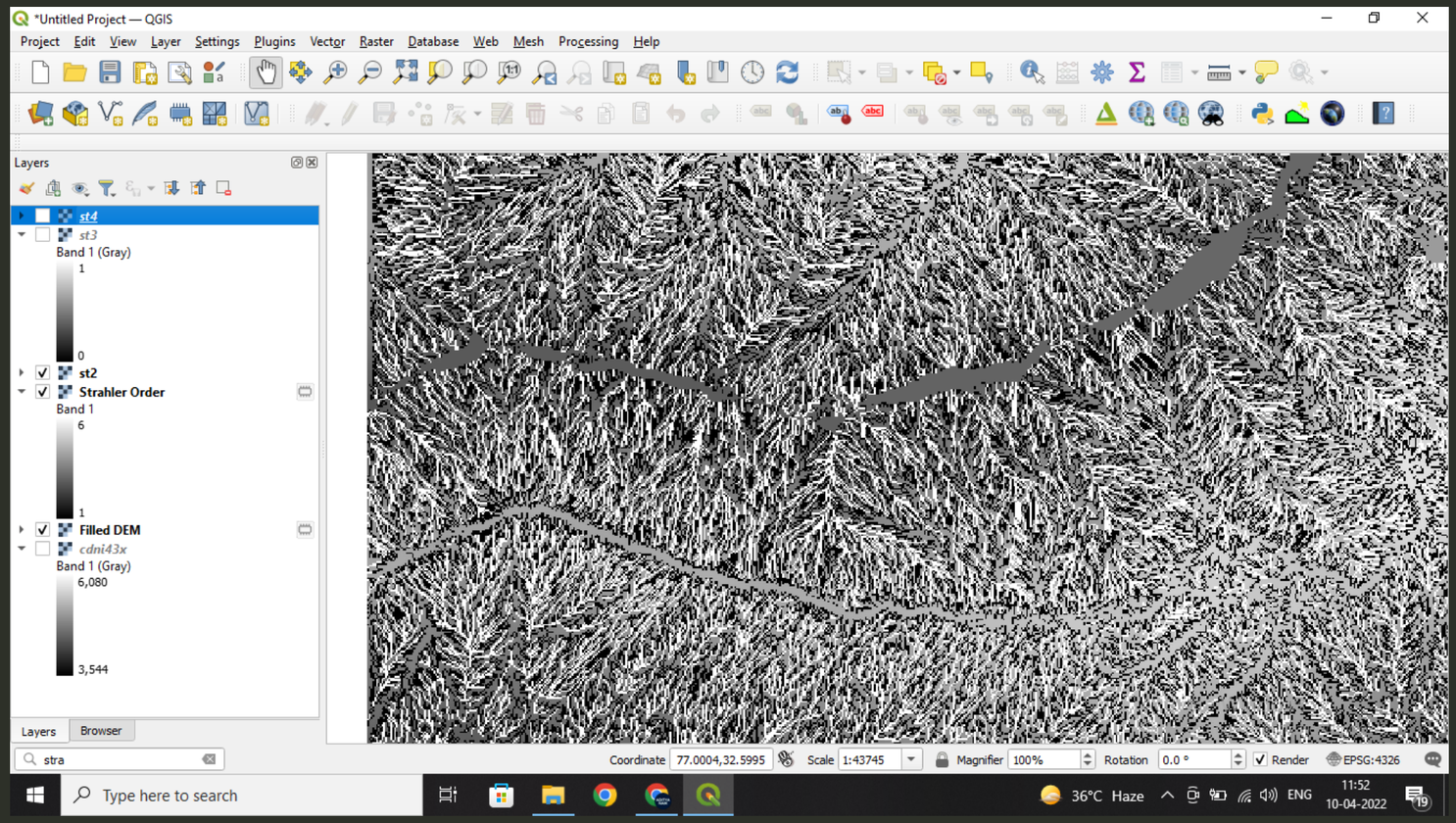
Basin Boundaries

Tool: Strahler Order

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



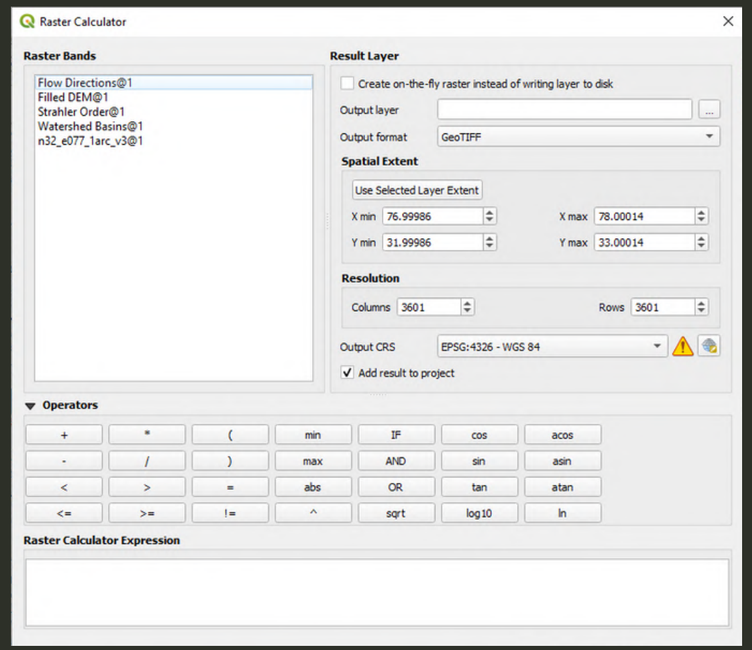
Strahler Order



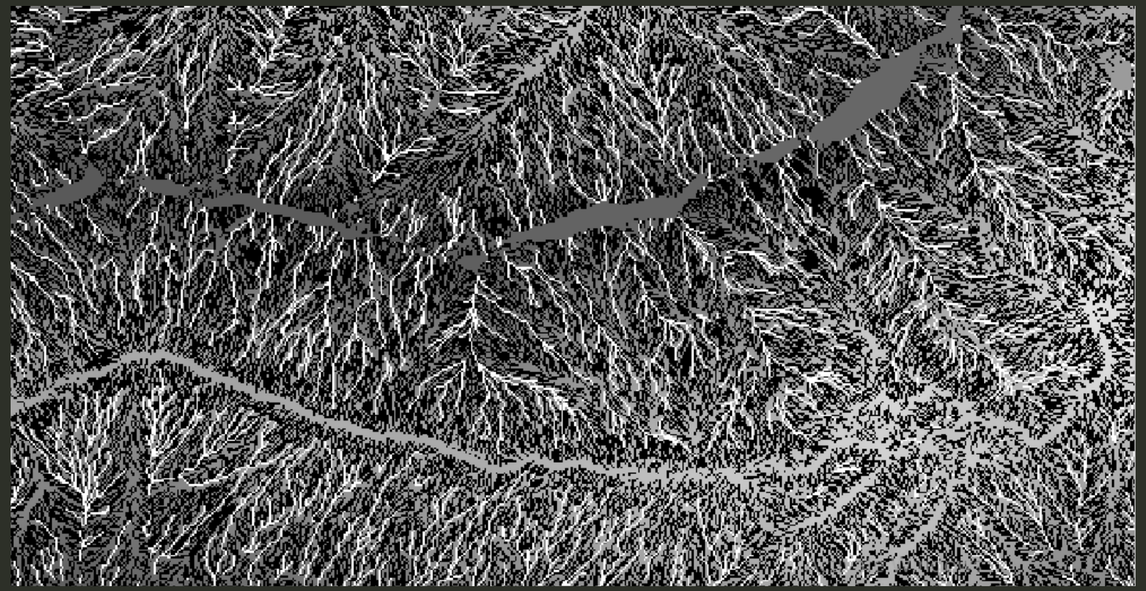
Maximum Strahler order=6

Tool: Strahler Order

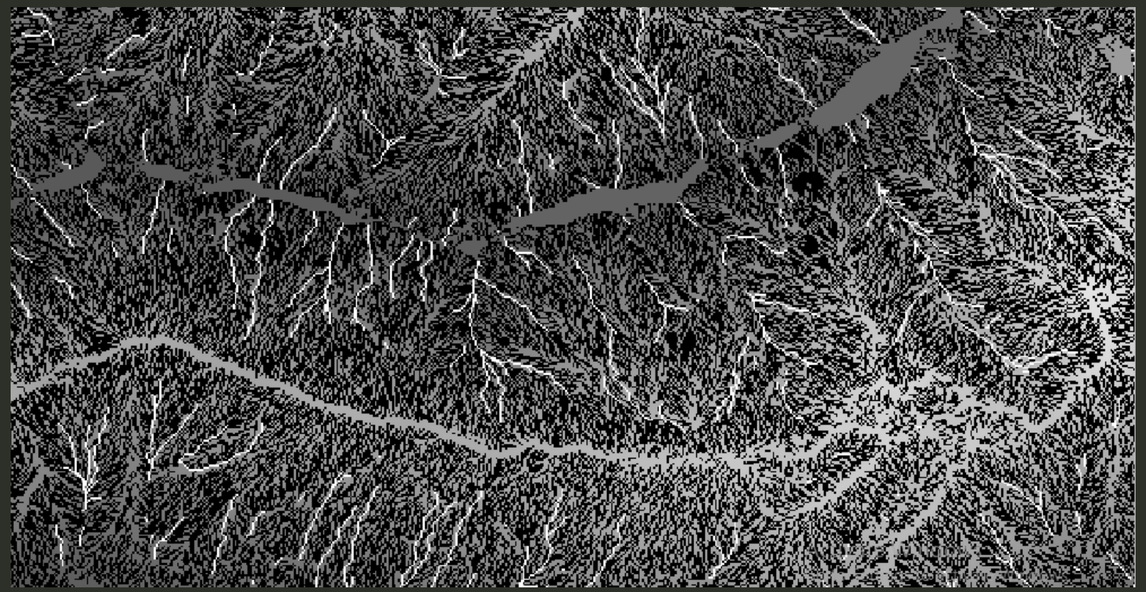
- Toolbox > SAGA > Terrain Analysis-Channels > Strahler Order
- Raster > Raster Calculator
- Set desired strahler order



Raster Calculator



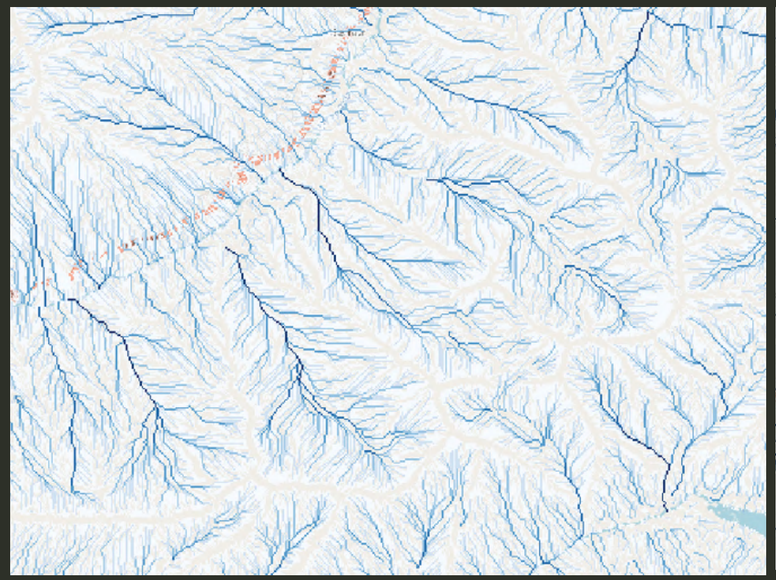
Streams with stralher order > 3

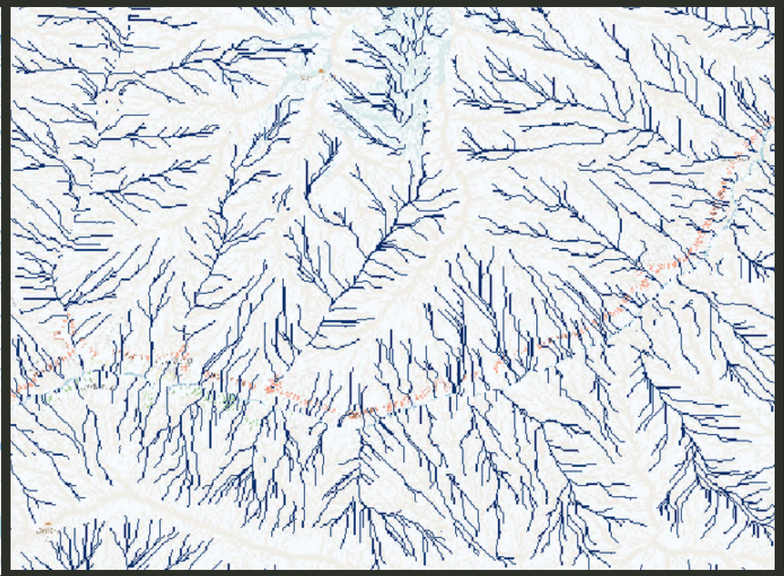


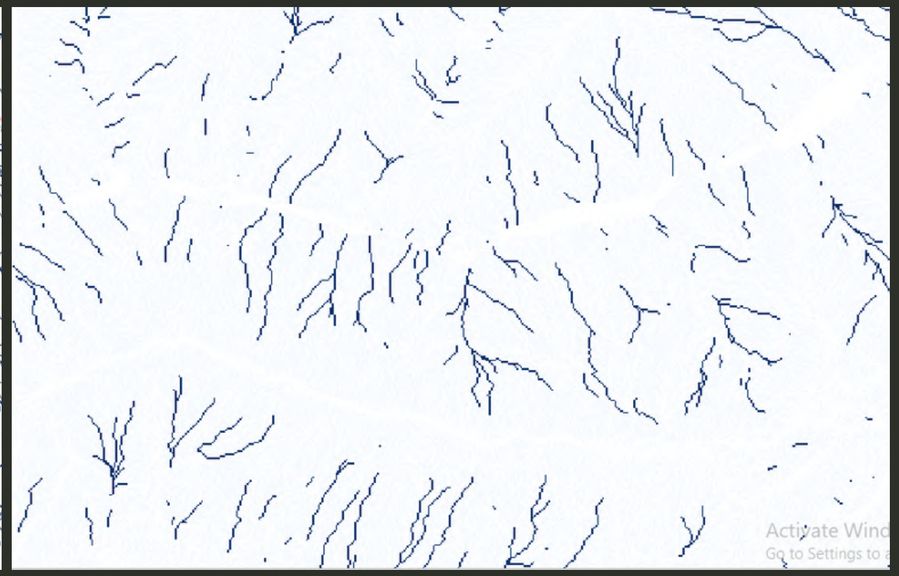
Streams with stralher order > 4

Let us Colourise the streams

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



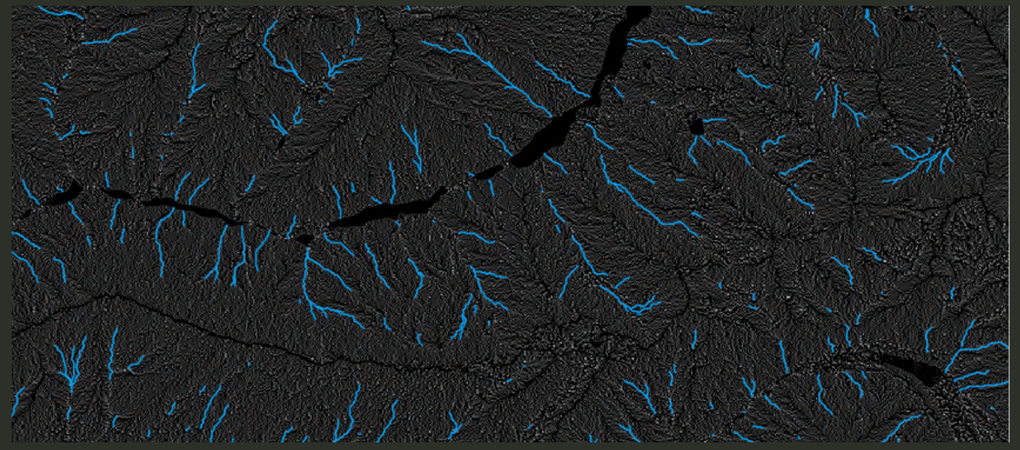


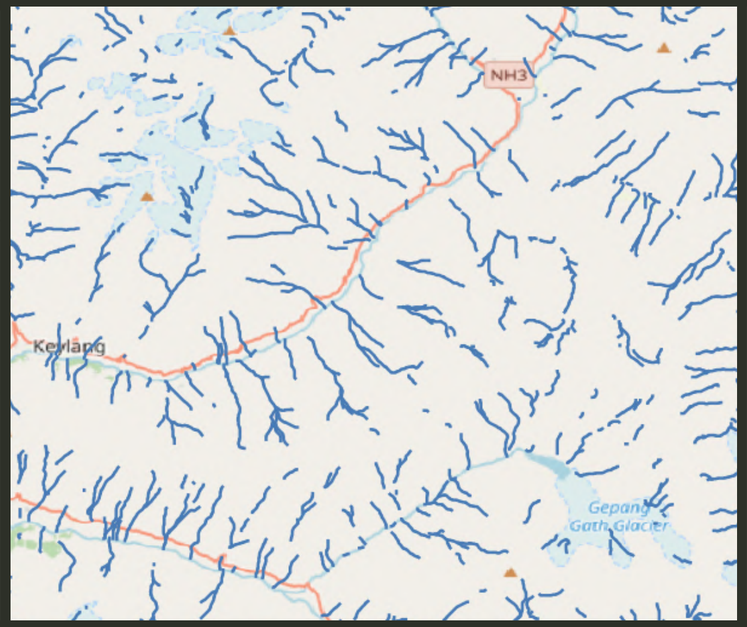


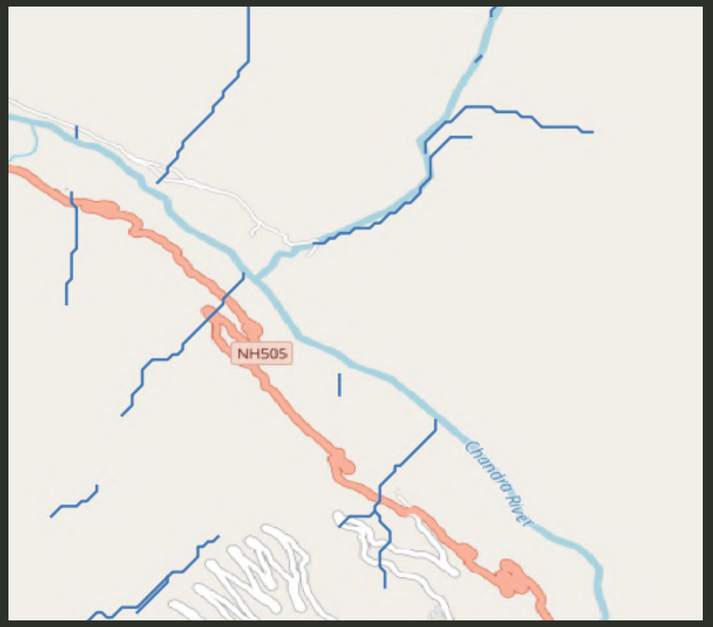
Increasing Strahler order

Vectorise the Streams

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

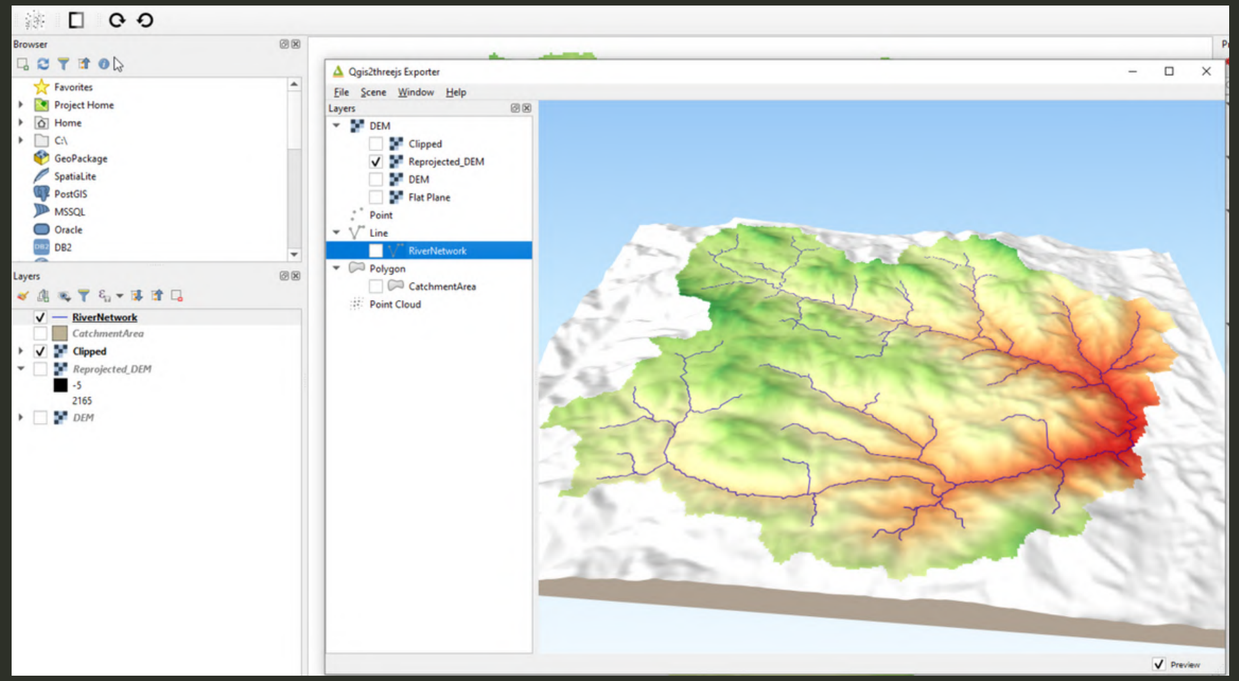




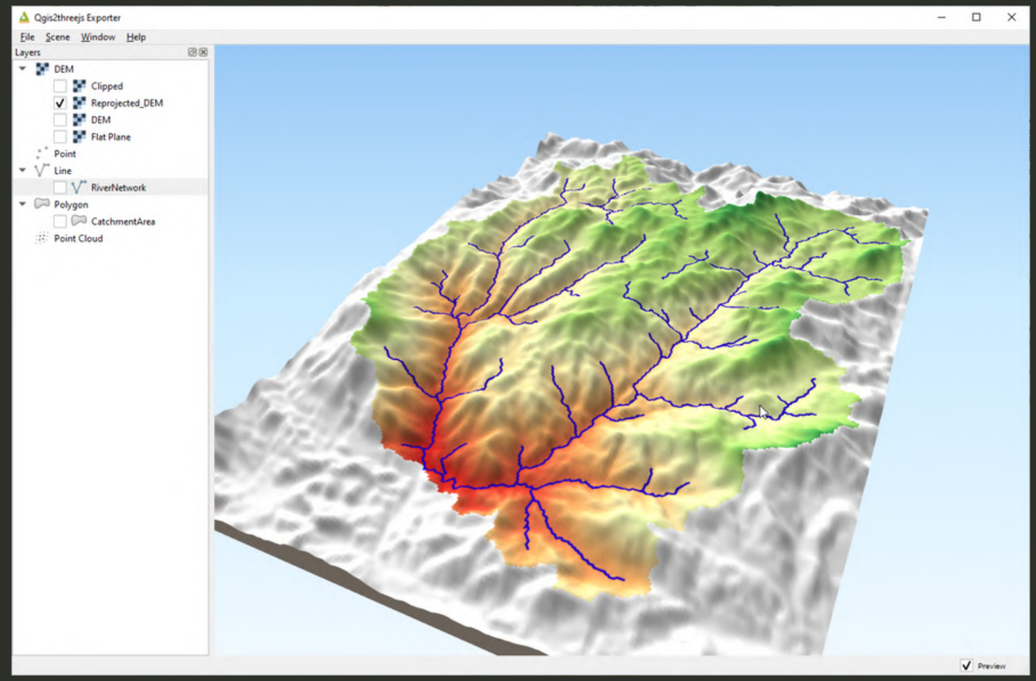


3D Modelling

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



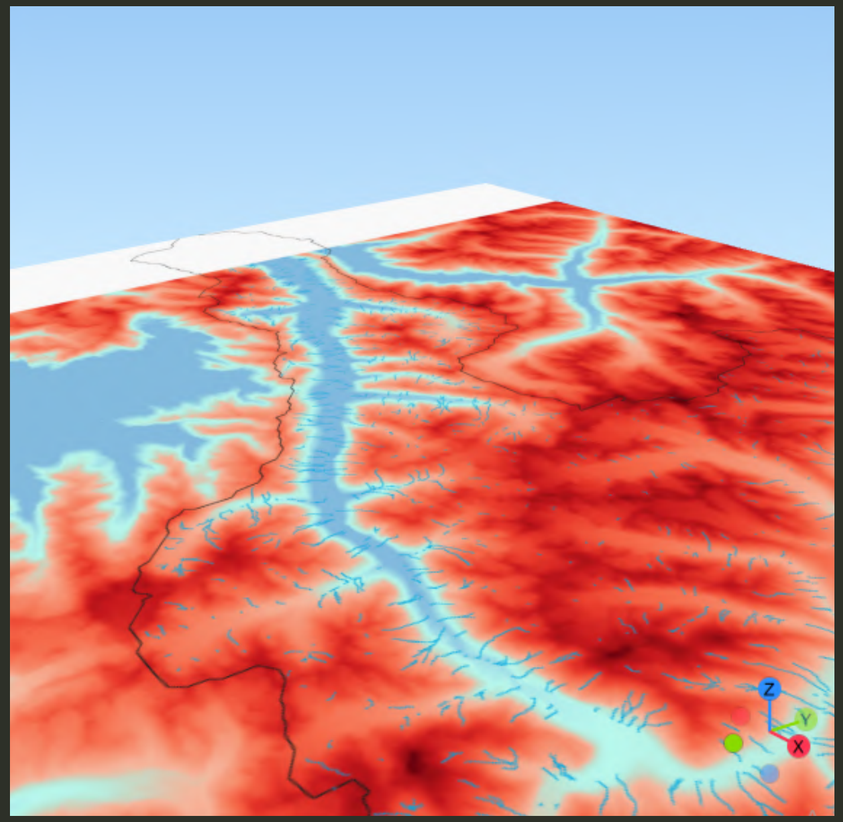
Colourise Clipped Area

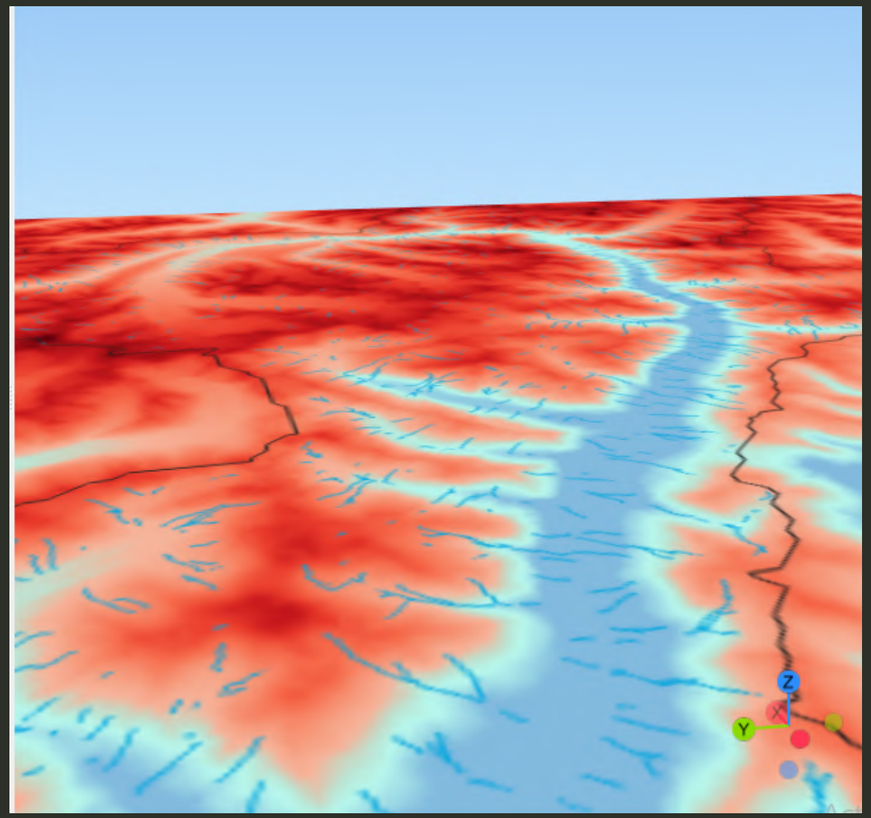


Model it using Qgis2threejs

3D Modelling

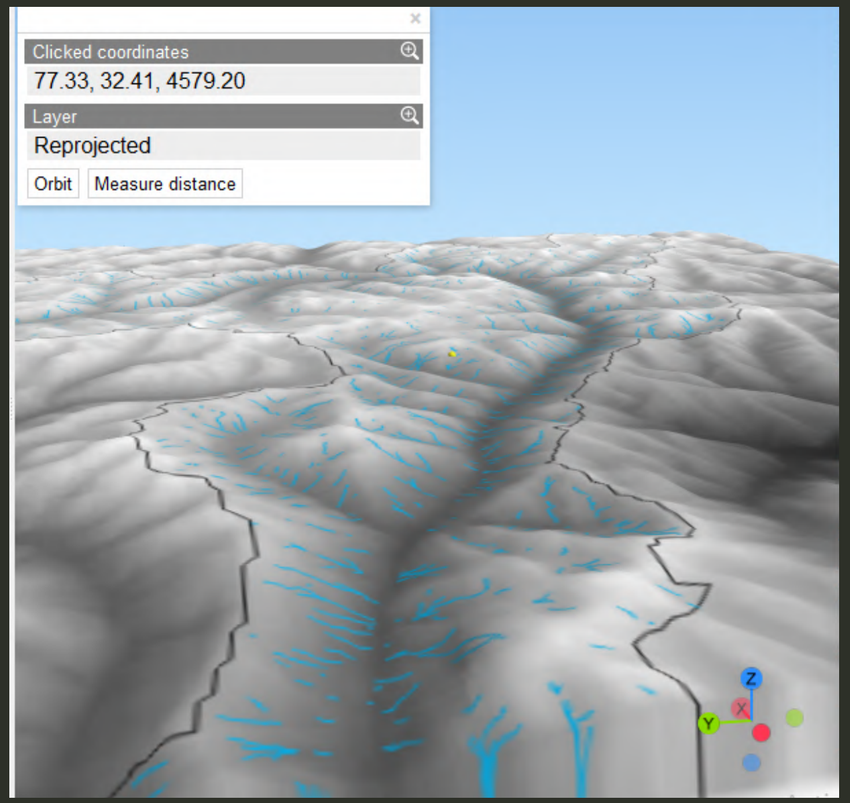
- Our Result

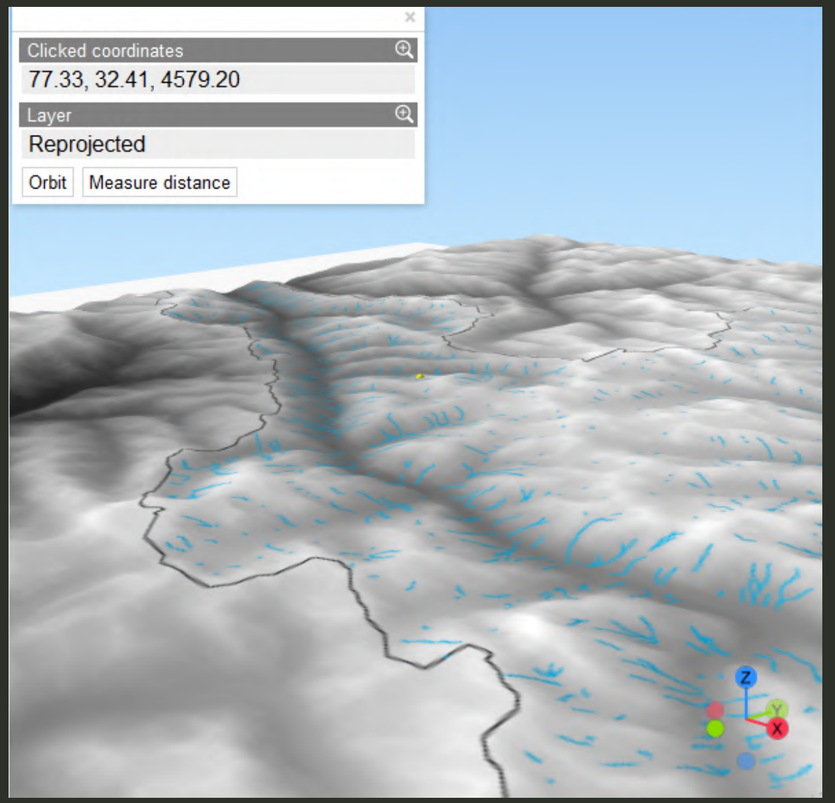


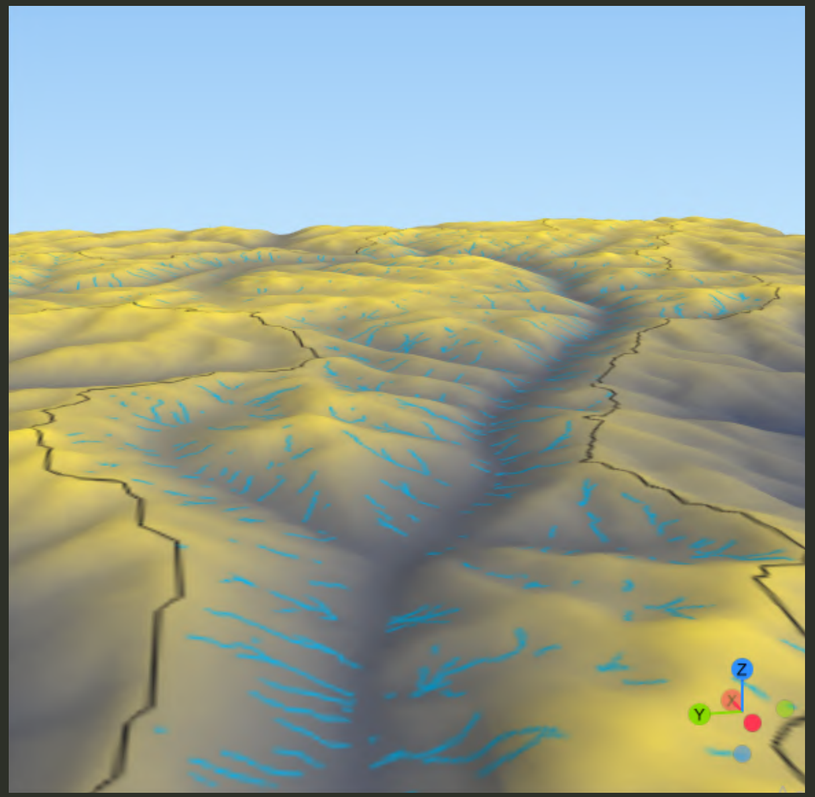


3D Modelling

- Our Result

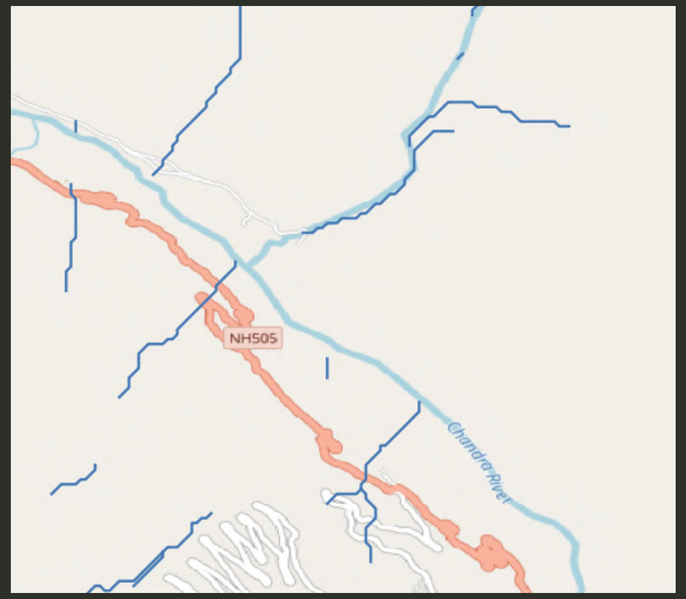


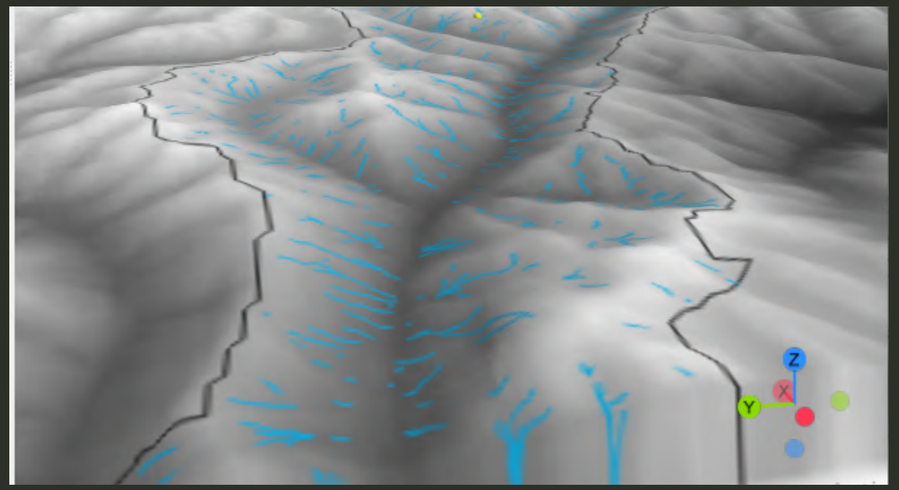


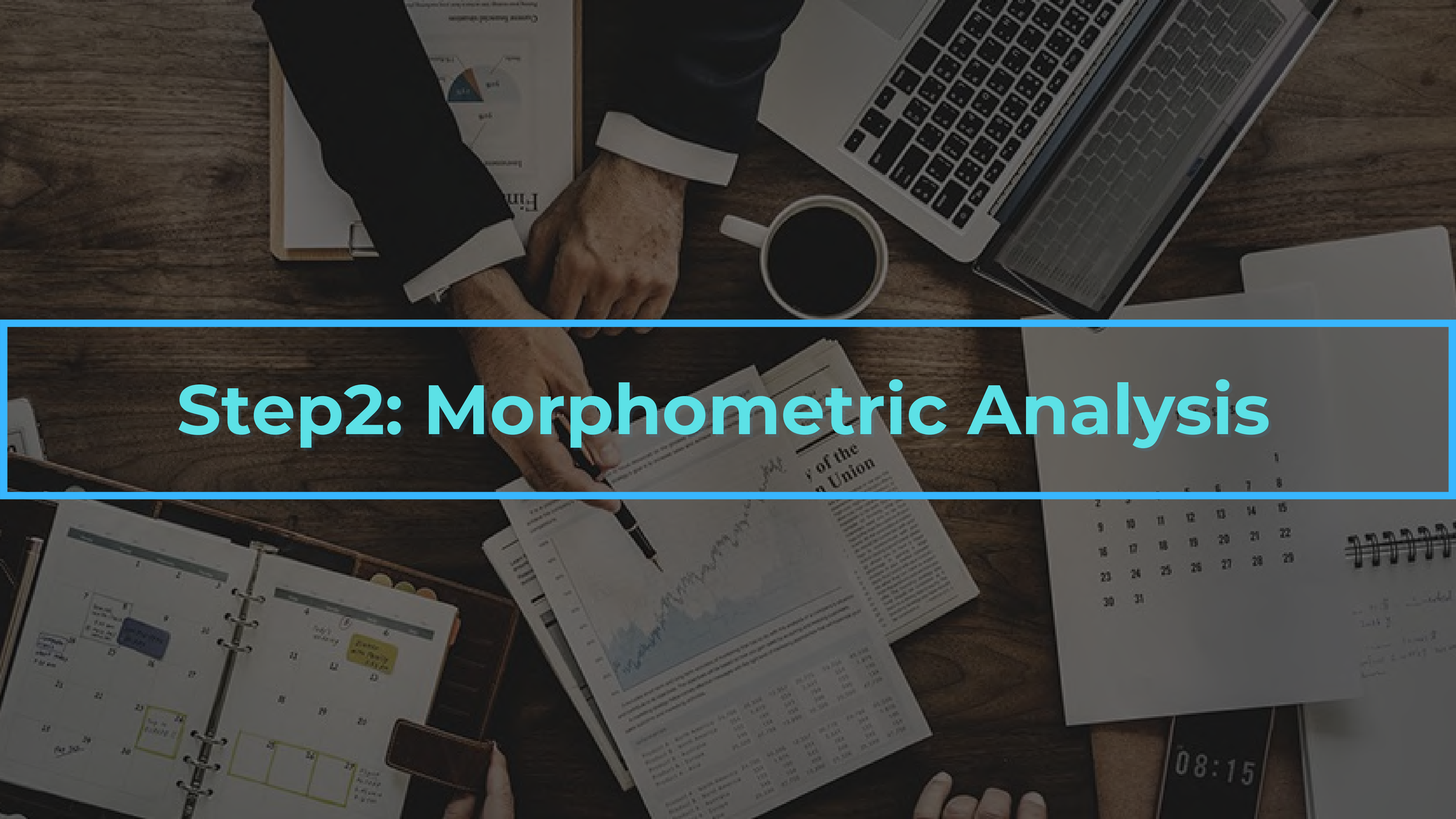


Reasons to shift to ArcGIS/ArcMap

- 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 ERSI's ArcGIS pro/ArcMap for the further in-depth analysis

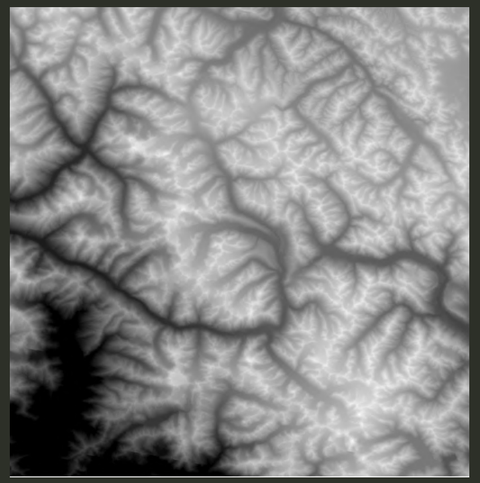
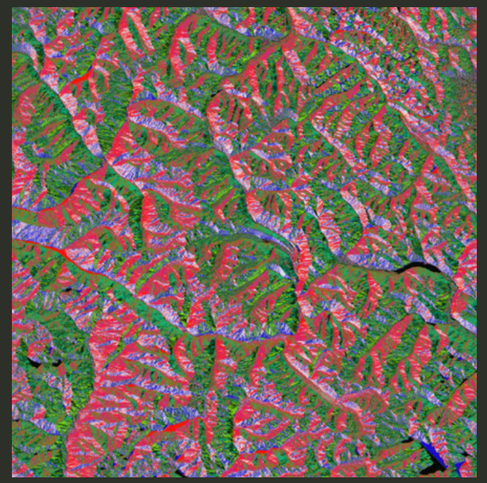
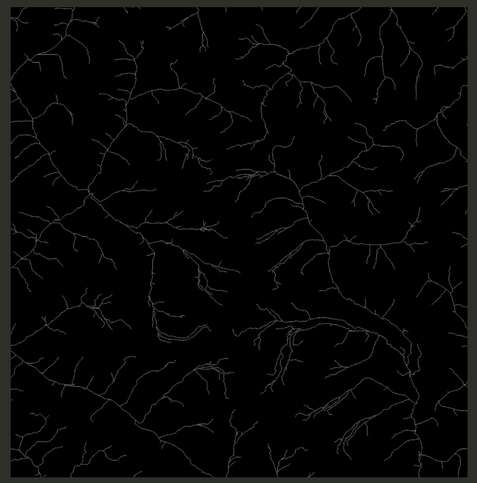
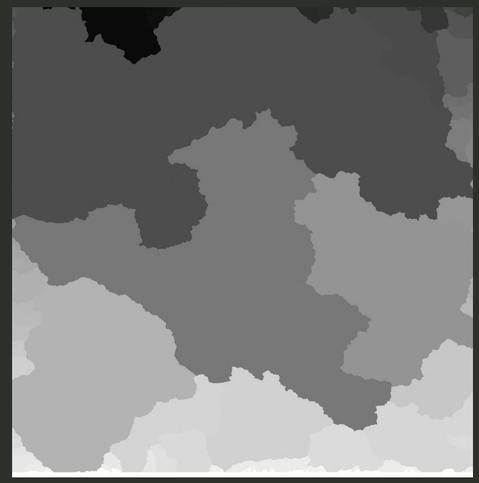
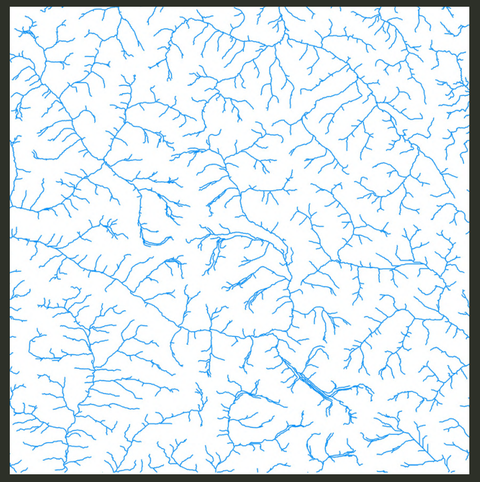
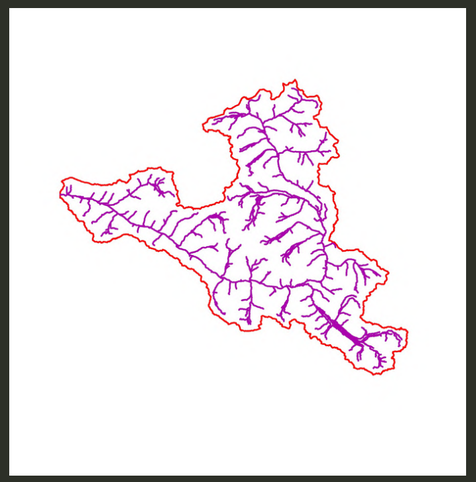
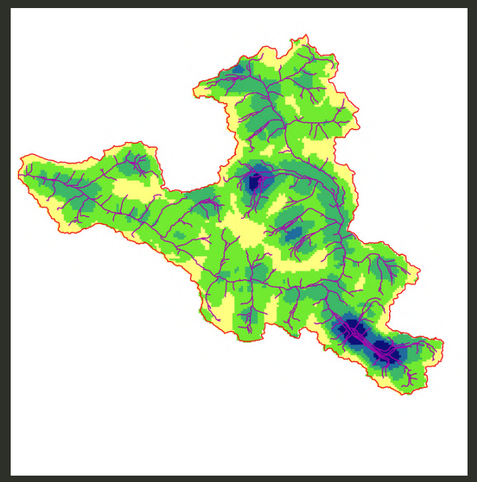






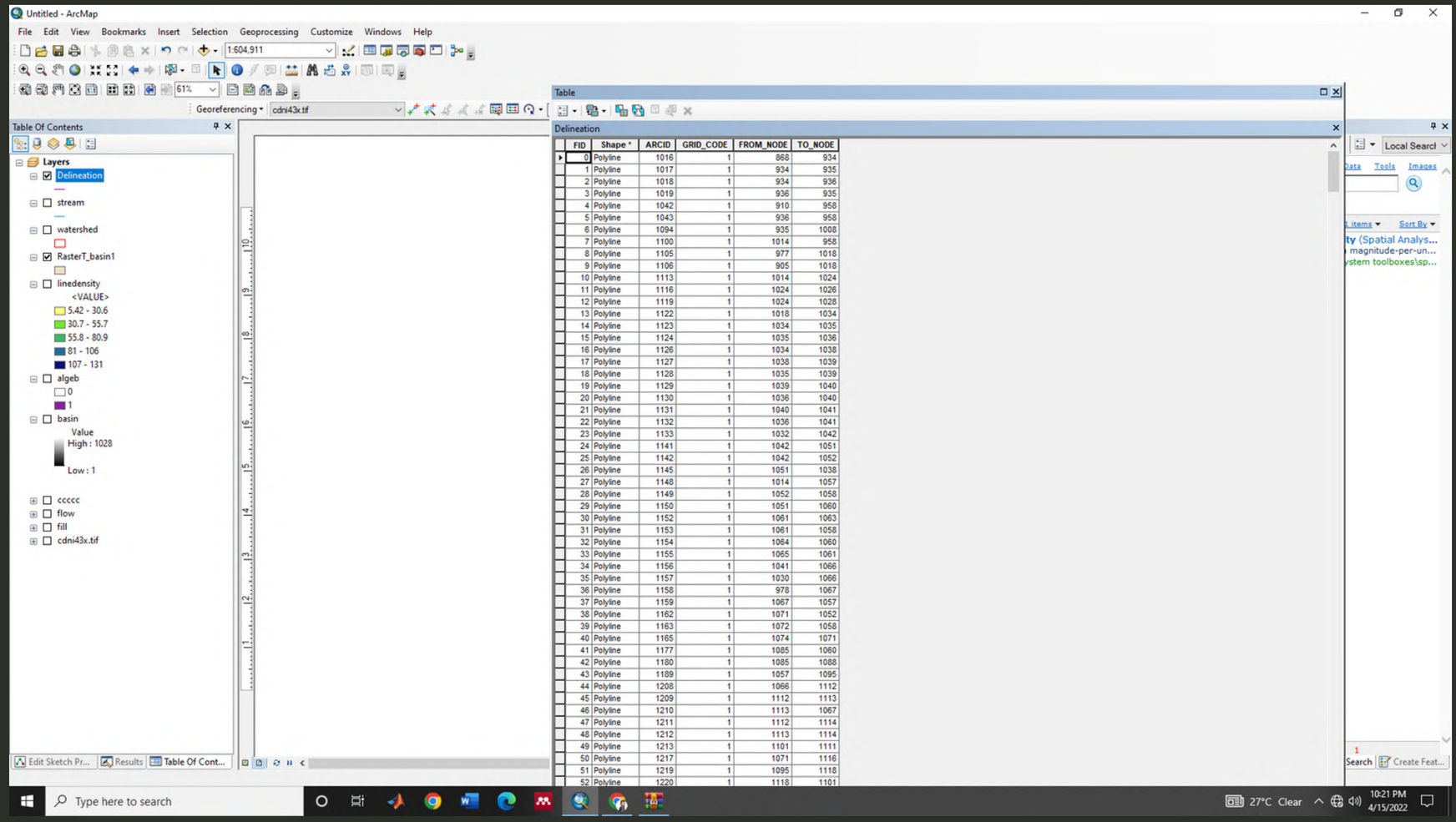
Step2: Morphometric Analysis

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-

Strean 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 poir	4860m
	Relief Ratio (Rh)	Rh = Bh / Lb Where, Bh=Basin relief, Lb=Basin lengt	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	0.307
	Stream frequency (Fs)	Fs=N/A Where, L=Total number of stream, A=Area of	0.317
	Texture ratio (T)	T=N1/P Where, N1=Total number of first order stream	2.004
	Circulatory ratio (Rc)	Rc=4πA/P2Where A= Area of basin,π=3.14, P= Perir	0.4843
	Elongation ratio (Re)	Re=√(Au/π)/ Lb Where, A=Area of basin, π=3.14, Lb=	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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Mr. Sachin Thakur

Teaching Assistant, Geodesy II

Thank You!!

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