CE613A: Computer Methods in Hydraulics & Hydrology
**Assignment – 11**

# Watershed Delineation, Land Use Impact, and Dam Capacity Estimation near Panki, Kanpur


Report submitted by:-

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**Introduction:**

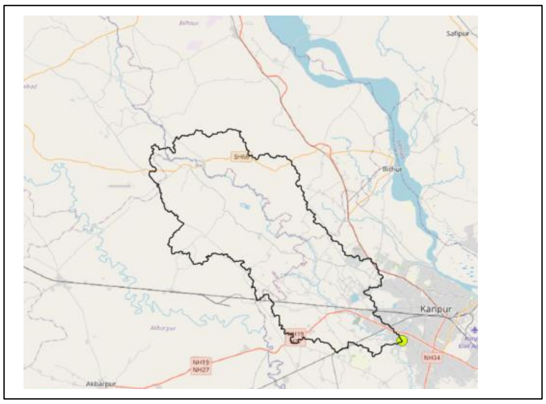
In this study, the primary objectives are:

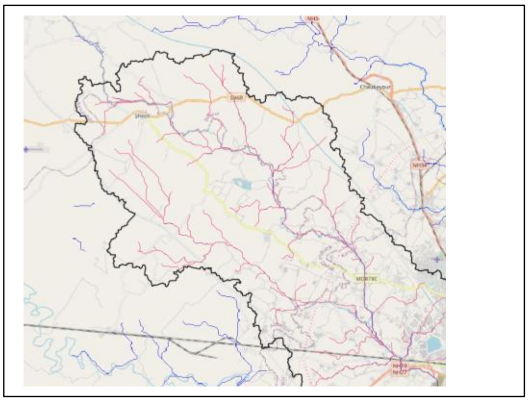
1. To analyse the land use distribution and evaluate its impact on runoff generation and infiltration potential.
2. The geospatial analysis carried out for the Kanpur area and the Panki watershed, Pandu. The tasks were performed using Google Earth Engine and GIS tools, including watershed delineation, LULC classification, stream network extraction, and dam impact assessment.
3. To simulate a dam near Panki with an assumed High Flood Level (HFL) of 130 meters above MSL, and calculate the inundated area and volume of water retained.
4. Area of Interest:
   - Latitude: 26° to 27° N
   - Longitude: 80° to 81° E

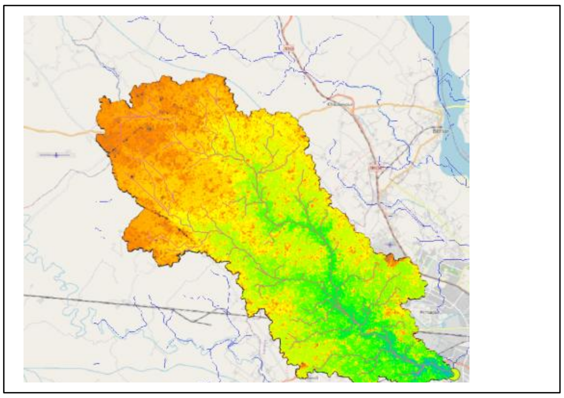
This analysis combines GIS techniques using QGIS, hydrological modelling, and basic volume computation based on raster elevation data.

## Step 1: Watershed Delineation and DEM Processing

- A Digital Elevation Model (DEM) of the region was obtained and loaded in QGIS.
- The watershed was delineated using hydrological tools (like fill sinks, flow direction, and flow accumulation).
- The outlet point was manually set near the Panki region to define the pour point for the catchment.
- Once the watershed boundary was generated, it was vectorized and saved as a shapefile.
- This delineated watershed served as the base for subsequent analysis like land use extraction, volume estimation, and simulation.





In this study, we selected the Pandu River at Panki, Kanpur as our area of interest. The process began with a Digital Elevation Model (DEM) which we clipped to focus on the local watershed. The clipped raster was then polygonized (converted to vector) to facilitate further spatial operations in QGIS.

We then performed watershed delineation using the following essential layers:

- DEM subset
- Outlet point (marked near Panki manually)
- Flow Direction
- Flow Accumulation
- Stream Direction
- Drainage Basin

These inputs were used to derive the upslope contributing area, which we named upslope_watershed1, representing the catchment contributing to the Pandu River at the chosen outlet.

### *Tools Used:*

- QGIS with GRASS or SAGA toolboxes
- DEM raster (downloaded via Google Earth Engine)

### *Steps Followed in QGIS:*

1. Loaded the DEM raster into QGIS.
2. Used SAGA → Terrain Analysis - Hydrology tools from the Processing Toolbox.
3. Applied "Fill sinks (Wang & Liu)" to process the DEM.
4. Used "Catchment area (Parallel)" to compute flow accumulation.
5. Selected the outlet point (near Panki ) manually or via shapefile.
6. Ran "Watershed basins" to delineate the entire drainage area.
7. Extracted stream network and sub-basins using "Channel network and drainage basins".

## Step 2: Land Use Land Cover (LULC) Analysis

The LULC.tiff file used in this analysis was downloaded from Google Earth Engine (GEE). A custom Python script was written to process and upload the file to our local drive. The raster was then imported into QGIS for further spatial analysis.

### *Key Processing Steps:*

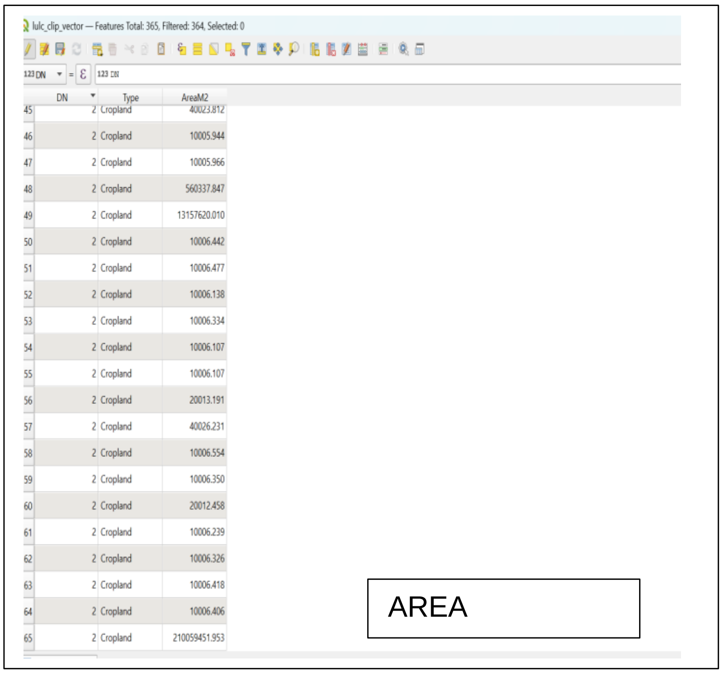
1. Vectorized the LULC raster layer to convert it into polygon features.
2. Assigned appropriate land use classes (e.g., Cropland, Bushland, Waterbody, etc.) using a color-coded scheme.
3. Labelled each polygon with the correct land use type using a layer named layer_dem_.
4. Calculated the area for each polygon and derived the total area and percentage covered by each land class.

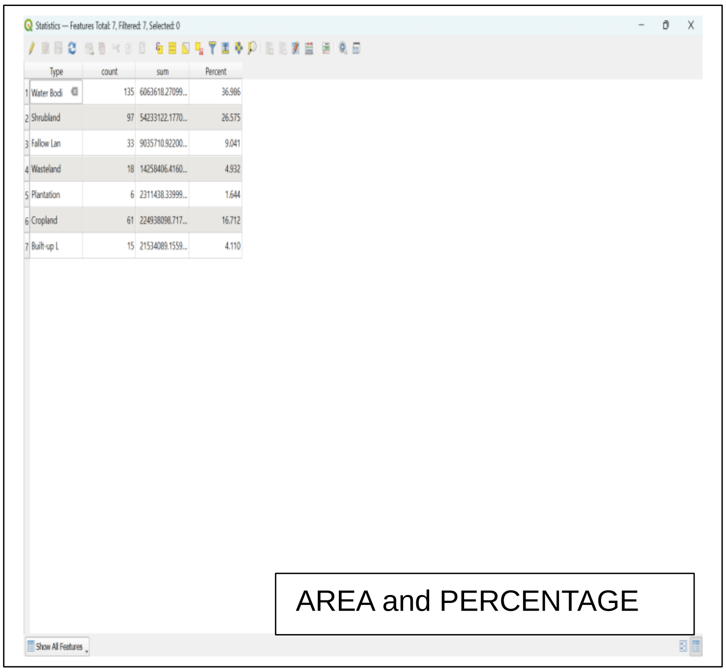
From the analysis, it was found that Cropland dominates the watershed in terms of area coverage, indicating its potential influence on hydrological responses like infiltration and runoff.

*Steps in QGIS:*

1. Load both the LULC raster and delineated watershed shapefile.
2. Use “Clip Raster by Mask Layer” to trim the LULC raster to fit the watershed boundary.
3. Apply “Raster layer zonal statistics” to extract area per LULC class.
4. Export the attribute table to Excel or CSV, and calculate:

Percentage = (Class Area / Total Watershed Area) × 100.




Visual Outputs and Statistics

Here are the visual and tabular outputs obtained from the analysis:

- Map showing the study area in India (Pandu River, Kanpur)
- Land use category-wise statistics:
- Detailed Area Table from QGIS:

The statistics table shows that Cropland occupies the maximum area, followed by Waterbodies and Shrubland. This helps in understanding the land use dynamics of the watershed and provides insights for further hydrological and environmental assessments.

Impact on Runoff Generation and Infiltration

The Land Use Land Cover (LULC) classification plays a crucial role in determining the hydrological behaviour of a watershed, especially in terms of runoff generation and infiltration capacity.

- Cropland, which is the dominant land use class in the Pandu River watershed (as evident from the area statistics), generally has moderate infiltration depending on crop type and soil management practices.

- The presence of vegetation and soil in croplands helps increase infiltration compared to impervious surfaces like built-up areas, which promote surface runoff.
- Shrub land and bushland also contribute positively to infiltration due to their vegetative cover.
- On the other hand, built-up lands and wastelands reduce infiltration and significantly increase surface runoff due to lack of permeability and vegetation.

## Step 3: Estimation of dam capacity and Inundation Area

To evaluate the feasibility of constructing a dam near Panki, we assumed a High Flood Level (HFL) of 130 meters above Mean Sea Level (MSL). Using QGIS hydrological tools and the available DEM, we simulated the inundation zone and calculated both the inundated area and potential storage volume.

### *Key Processing Steps:*

- The area submerged under the 130 m contour was delineated and then vectorized for spatial analysis.
- Zonal statistics and QGIS tools were used to calculate:
    - Inundated Area (up to HFL 130 m)
    - Reservoir Volume (total volume beneath the water surface)

From the QGIS attribute table (trial_stats), the calculated volume was found to be approximately:

Volume≈228,053,583 m^3 (≈228 million cubic meters)

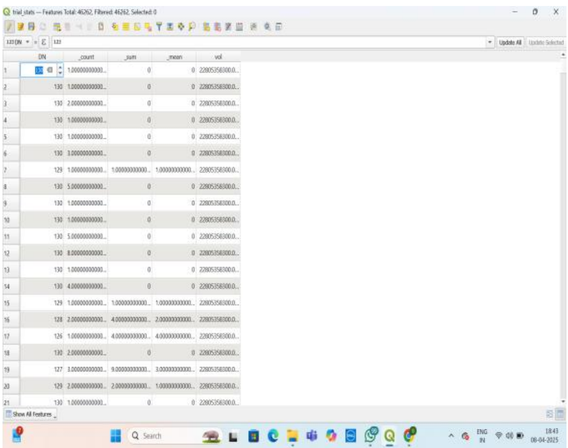
This value represents the total storage capacity of the proposed dam when filled to HFL = 130 m.

### *Steps in QGIS:*

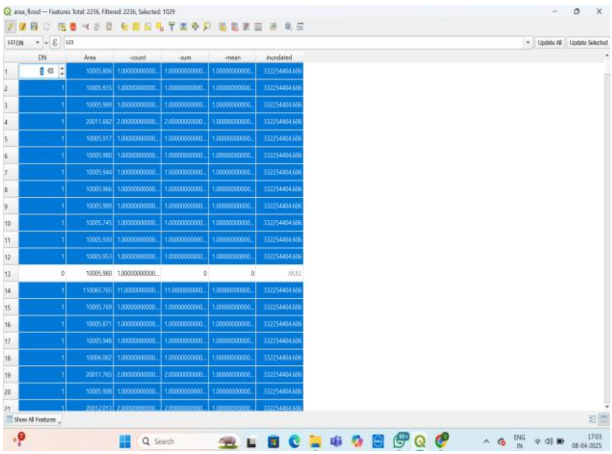
1. Load the DEM and generate elevation contours.
2. Select the 130 m contour to define the inundation boundary.
3. Use Raster Calculator with the expression

   "DEM" < 130

4. Apply Raster layer statistics to compute:
    - Pixel count
    - Total area = Pixel count × pixel resolution
5. Use the “Volume Calculation” plugin or GRASS → Raster Surface Volume to estimate storage volume.



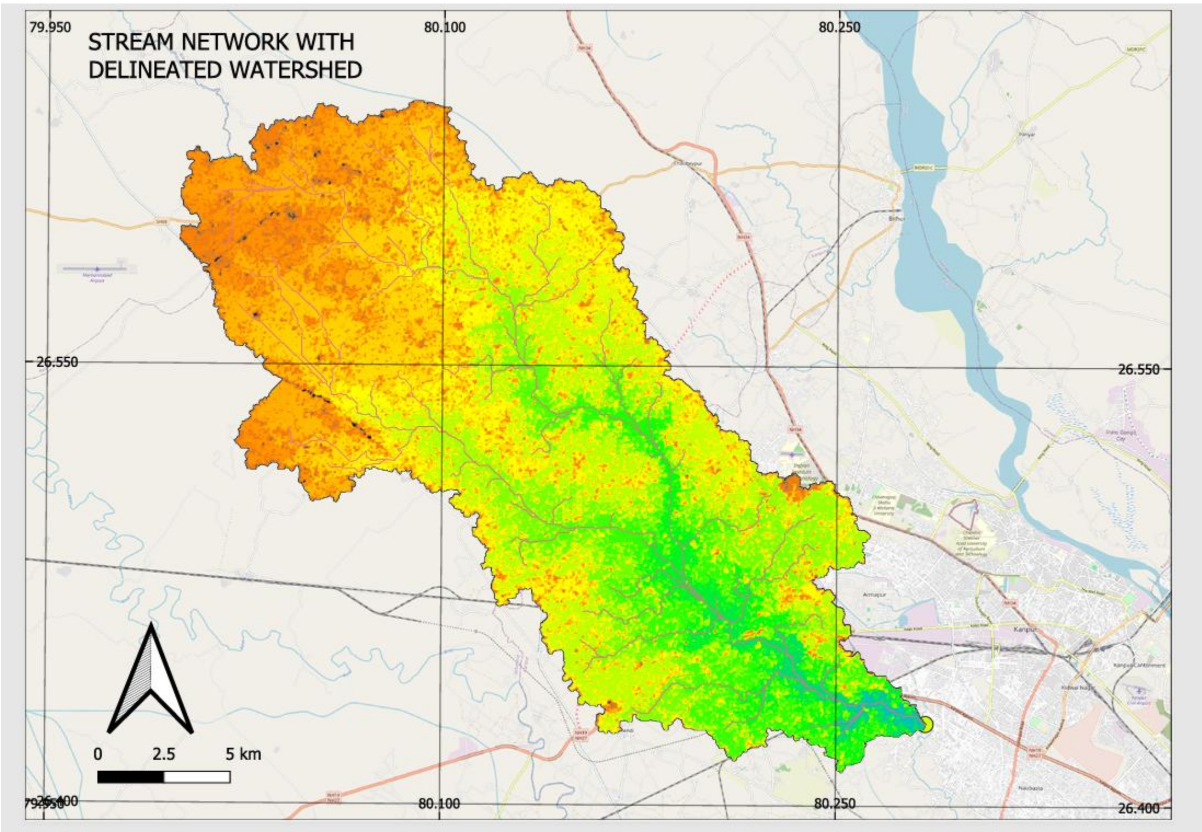
VOLUME



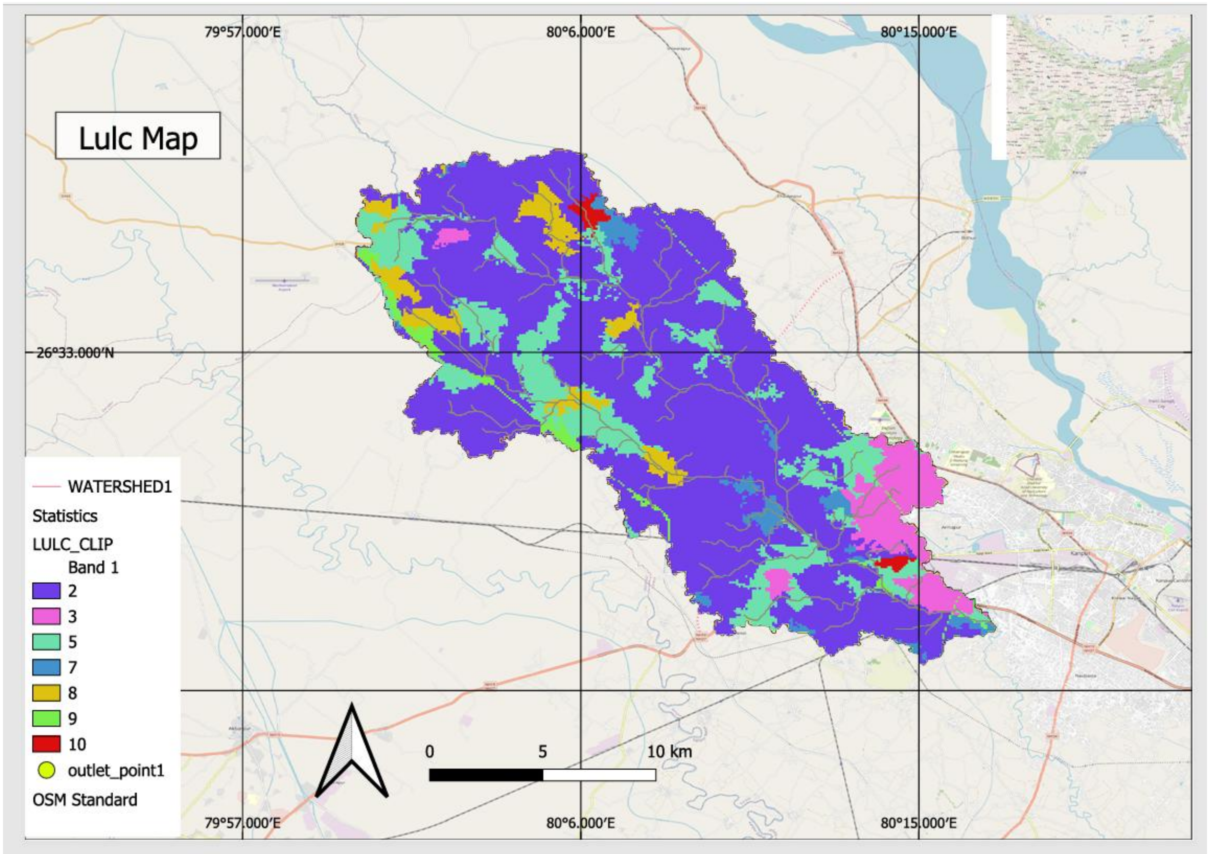
INUNDATION AREA

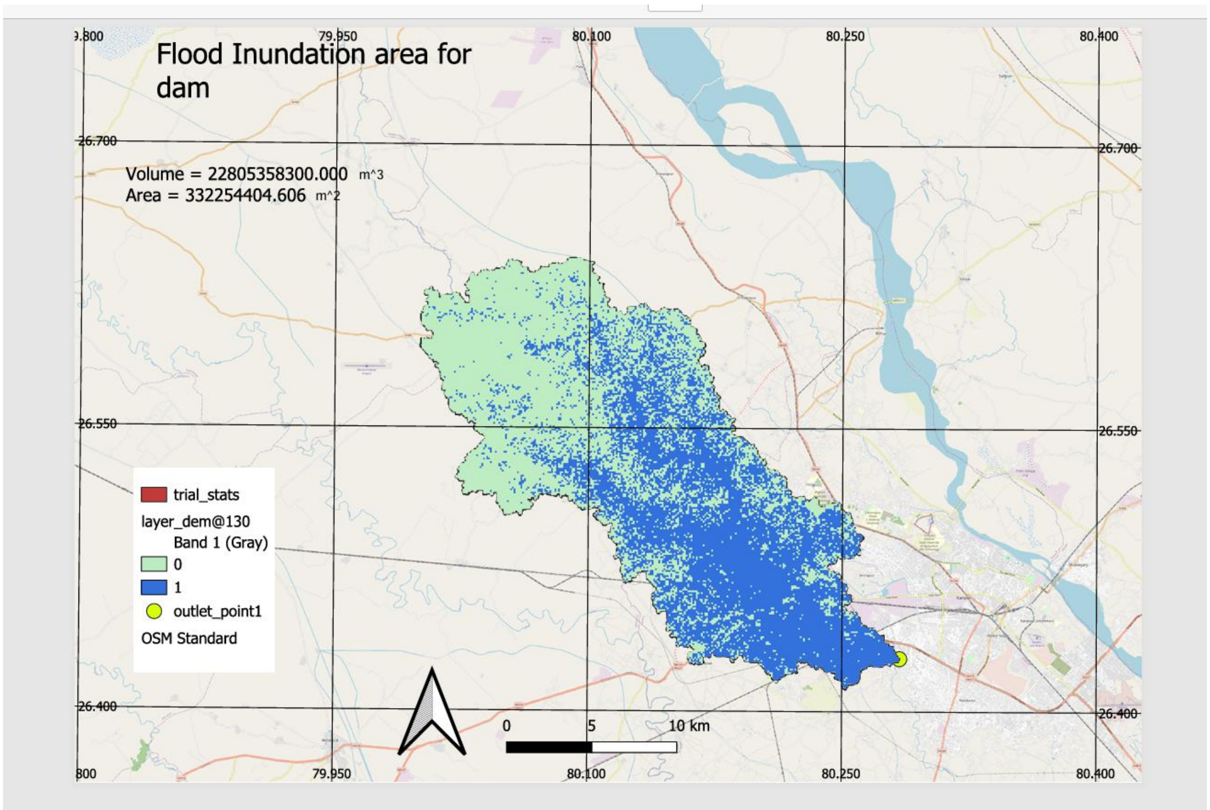
## MAPS:-

New Delhi
Lucknow
Gorakhpur
Varanasi
Dhanbad
Kolkata
Bhopal
Nagpur
Cuttack

STREAM NETWORK WITH
DELINEATED WATERSHED
79.950
80.100
80.250
26.550
26.550
0
2.5
5 km
26.400
80.100
80.250
26.400


Lulc Map
79°57.000′E
80°6.000′E
80°15.000′E
26°33.000′N
WATERSHED1
Statistics
LULC_CLIP
Band 1
2
3
5
7
8
9
10
outlet_point1
OSM Standard
0
5
10 km


Flood Inundation area for dam
Volume = 22805358300.000 m^3
Area = 332254404.606 m^2
79.950
80.100
80.250
80.400
26.700
26.550
26.400
trial_stats
layer_dem@130
Band 1 (Gray)
0
1
outlet_point1
OSM Standard
0
5
10 km

## Conclusion

In this project, we explored the Pandu River watershed near Panki, Kanpur using QGIS and remote sensing tools. We started by working with the **DEM**, clipped it to our area, and performed watershed delineation to define how water flows and drains into the river.

Next, we used **a** LULC file from Google Earth Engine, vectorized it in QGIS, and categorized the land into types like Cropland, Bushland, Waterbody, etc. After calculating the area and percentage for each type, we found that Cropland covers the largest portion of the watershed. This means the region likely supports both good infiltration and runoff, which are important for water flow and storage planning.

Lastly, we imagined a dam near Panki with a High Flood Level of 130 meters. We simulated the area that would get submerged and calculated the inundated area and storage volume**.** The reservoir would hold around 228 million cubic meters of water, giving us a good estimate of the dam's potential.

Overall, this process helped us understand the terrain, land use, and water storage possibilities in a real-world context using geospatial tools.