

ABSTRACT

The Budameru River experienced a severe flood in 2024, causing major hydrological impacts in the urban areas of the NTR district, Andhra Pradesh. This study assesses flood runoff using Remote Sensing and GIS by integrating Survey of India toposheets, DEM from Bhoonidhi, Sentinel-2–derived LULC maps, and soil hydrological groups from NBSS & LUP to assign Curve Numbers under the NRCS method. Extreme rainfall, with over 150 mm recorded in Vijayawada on 1 September 2024, combined with heavy upstream inflows and historically high Krishna River levels, restricted flood discharge through the Budameru Diversion Channel. Urban encroachments, reduced floodplain width, incomplete canal modernization, and bund breaches further aggravated inundation. The analysis shows that intense rainfall, saturated soils, and urban land use significantly increased runoff and peak discharge, highlighting the effectiveness of geospatial-based NRCS-CN modelling for flood hazard assessment and basin management.

STUDY AREA

The Budameru rivulet is a minor tributary of the Krishna River, originating near Mylavaram in the NTR District of Andhra Pradesh and flowing southeast through Vijayawada before joining the Krishna near Kondapalli. It lies between 16°30′–16°57′ N latitude and 80°28′–82°48′ E longitude, draining a catchment of about 800 km² across both rural and urban areas. The basin is characterized by flat terrain and gentle slopes, which increases its vulnerability to flooding during intense rainfall events. Rapid urbanization and encroachments have reduced the natural drainage capacity of the rivulet, making the region highly prone to monsoon flooding and important for flood risk analysis and management.

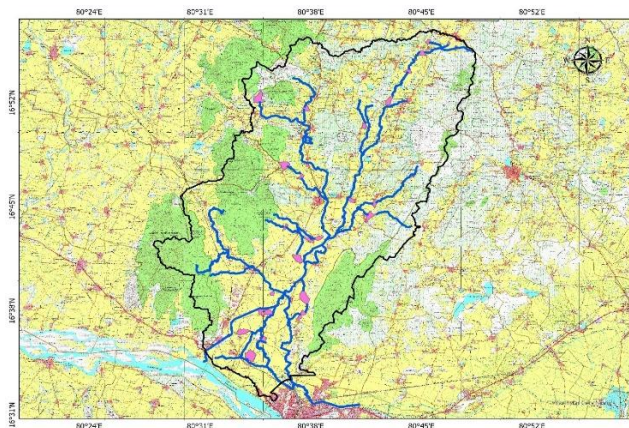
OBJECTIVES OF THE STUDY

- I. To delineate the Upper Budameru watershed and develop a detailed spatial database using DEM data.
- II. To analyze and map flood inundation in the Upper Budameru watershed using Sentinel-1 SAR data through remote sensing and GIS.
- III. To prepare a detailed LULC map from Sentinel-2 data and classify the basin into agricultural, built-up, barren, fallow, and water body categories.
- IV. To derive Hydrologic Soil Groups (HSG) from NBSS soil texture and drainage data and integrate them with LULC to determine Curve Numbers for the watershed.
- V. To estimate runoff depth, volume, and discharge using Thiessen polygon rainfall distribution, the NRCS-CN method, and Antecedent Moisture Condition (AMC) adjustments.

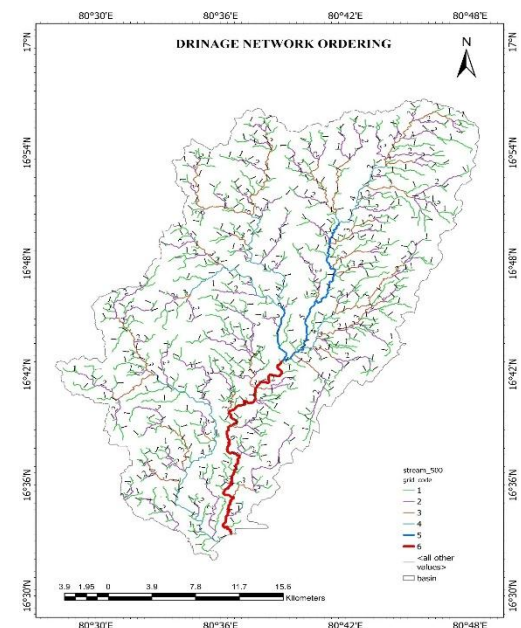
METHODOLOGY

Survey of India toposheets (65D/5, 65D/6, 65D/9, 65D/10, and 65D/13) were geo-referenced in ArcGIS Pro using the WGS 1984 coordinate system to ensure spatial accuracy. Key hydrological features such as rivers and streams were digitized to clearly represent the drainage pattern of the watershed. These digitized layers served as the base data for accurate watershed delineation.

The DEM of the study area was analysed to derive elevation, slope, flow direction, and flow accumulation, Stream order and Stream to Feature. These parameters helped identify drainage paths and zones where surface water naturally converges. Using this information, the catchment and sub-catchment boundaries were accurately delineated for hydrological analysis.

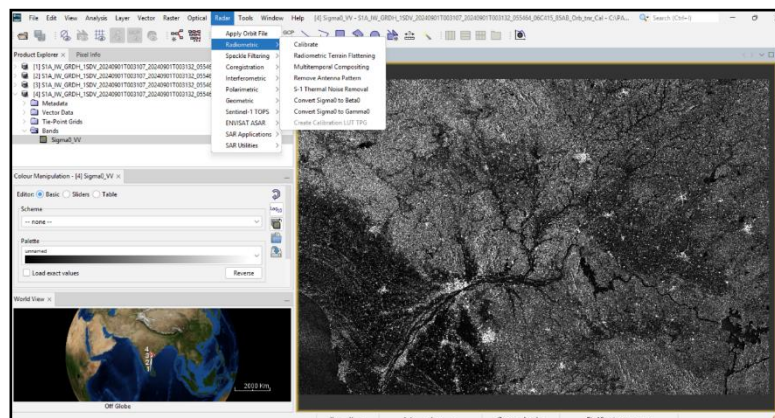


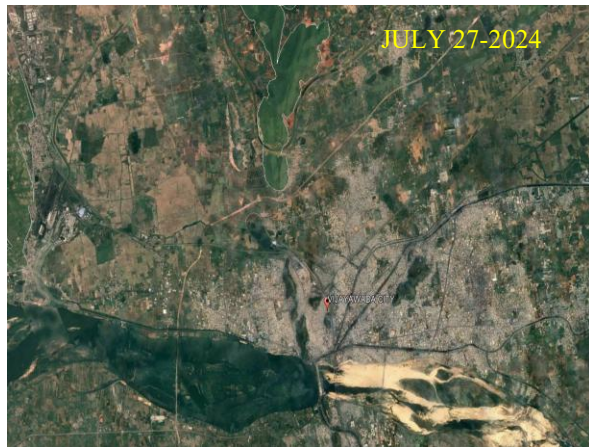
Digitized drainage map of Upper Budameru



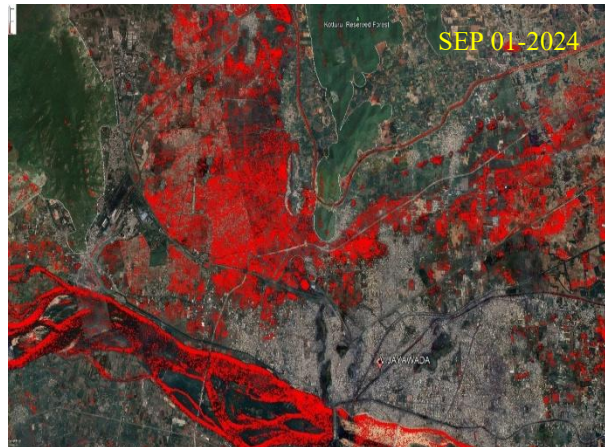
Stream order map of Upper budameru thre-500

Sentinel-1 SAR pre-flood and during-flood images were Pre-processed in SNAP using radiometric calibration and terrain correction to accurately detect water. Flood-affected areas were identified by comparing backscatter differences between the two datasets. The extracted inundation map was exported to Google Earth Pro for visualization, enabling precise delineation of the flood extent. Below image represents the Pre-processing options in SNAP software.



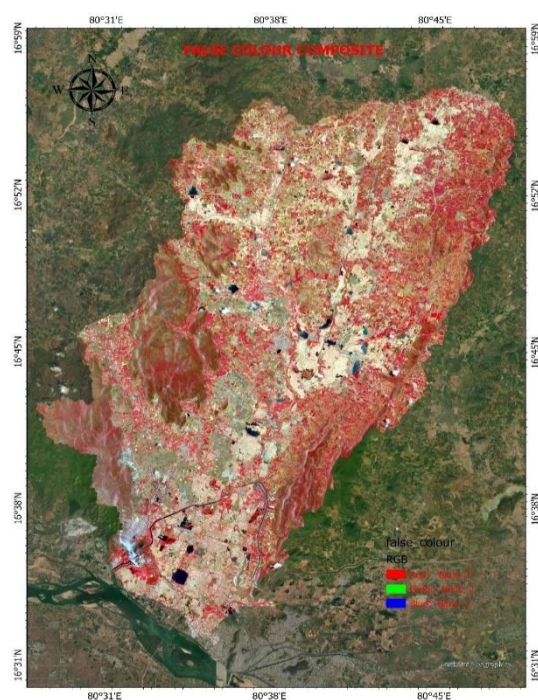


Pre-flood

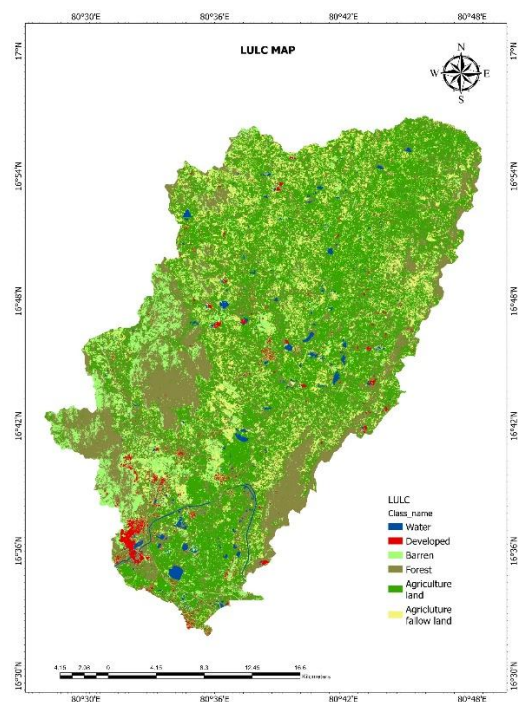


During flood

The LULC map was prepared from Sentinel-2 imagery and classified into agriculture, vegetation, water bodies, built-up, and barren land categories. Soil information from NBSS was incorporated, and both LULC and soil layers were intersected in ArcGIS Pro to identify Hydrological Soil Groups. This combined dataset served as the basis for assigning Curve Numbers (CN) according to land and soil characteristics. The derived CN values were then used to estimate potential surface runoff, supporting accurate hydrological and flood analysis.



False colour composite



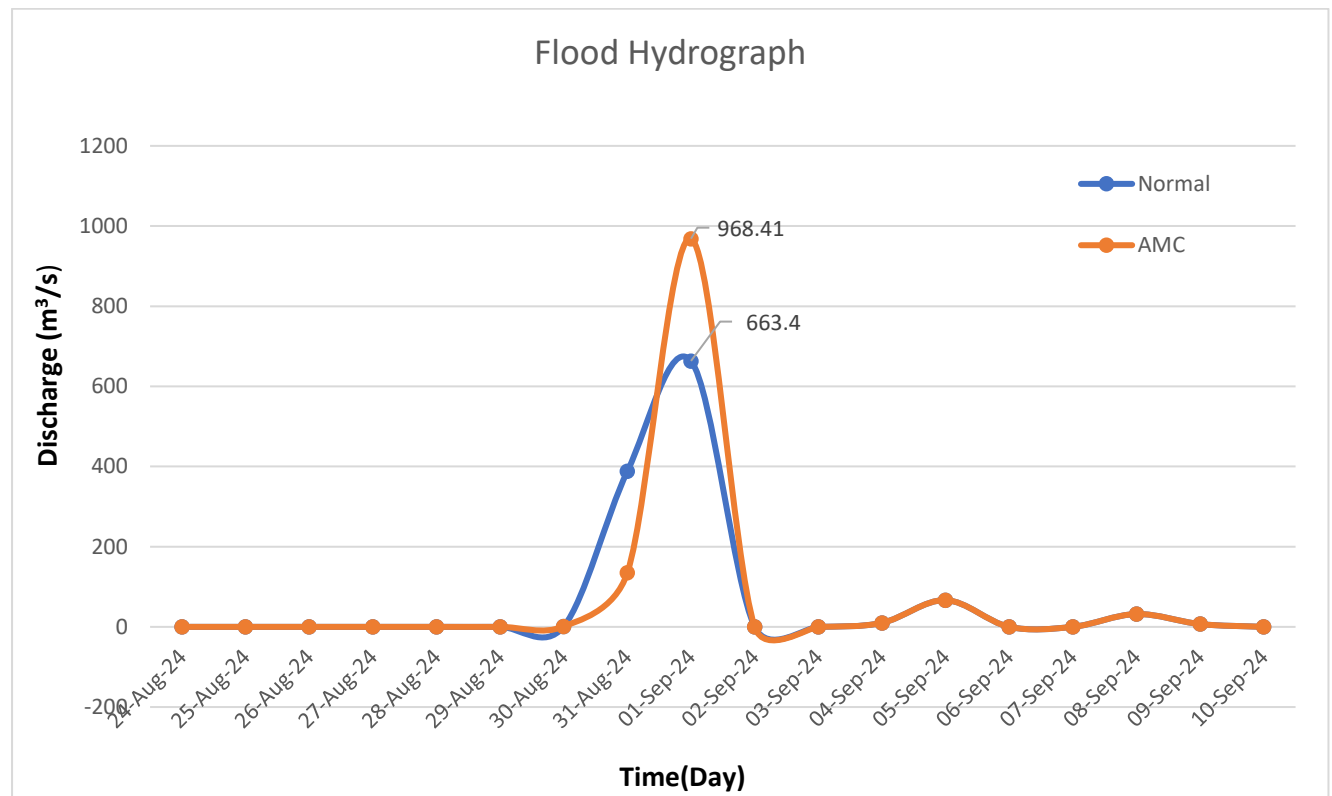
Land use Land cover of Upper Budameru

Thiessen polygons were developed for 10 rainfall stations in the NTR district to determine areal rainfall and were intersected with the watershed boundary to identify contributing zones. These polygons were further combined with the LULC–Soil CN map to compute weighted Curve Numbers that reflect local land and soil conditions. Antecedent Moisture Conditions (AMC) were evaluated using pre-event rainfall to adjust CN values for accurate runoff estimation. The updated CN was used in the SCS-CN formula to calculate

runoff depth, runoff volume, discharge and hydrograph generation. This process provided a clear understanding of the watershed's hydrological response and the intensity of the 2024 Budameru flood.

RESULT AND CONCLUSION

The flood hydrograph for the Upper Budameru watershed was generated by using the discharge values derived from the NRCS-CN runoff calculations. The computed peak discharges under different moisture conditions were plotted over time to show how the flood flow changes during the rainfall event. This hydrograph helps visualize the rising, peak, and recession phases of the flood.



Flood Hydrograph of Budameru 2024 (Normal & AMC Condition)

CONCLUSION

- The total runoff volume under Normal Condition is 100.93 mm³, and under AMC Condition is 105.42 mm³, indicating a significant increase in basin response due to reduced infiltration.
- The corresponding total discharge calculated from these volumes is 1168.20 m³/s for normal condition and 1220.18 m³/s for AMC condition.
- The peak discharge on 1 September 2024 is 663.40 m³/s under normal conditions and 968.41 m³/s under AMC-wet conditions, showing a strong increase due to wet antecedent soil moisture (Fig).
- AMC (Antecedent Moisture Condition) discharges are slightly higher than Normal discharges in almost all stations, showing that when soil is already wet, infiltration

reduces, and more rainfall becomes direct runoff, results in a 4.45% increase in total runoff volume, adding nearly 4.49 million cubic meters of additional floodwater in the basin.

- v. Mylavaram, Reddigudem and G. Konduru shows the highest discharge, indicating these areas receive intense rainfall and have low infiltration, contributing the most to flood.
- vi. The peak discharge rises sharply by about 306 m³/s (46%), indicating that saturated soils amplify the flood peak much more significantly than the total runoff volume.

Causes of inundation:

- i. Active encroachment along the banks of Budameru has narrowed the natural floodplain, reduced the channel's capacity and caused overflow during heavy rains.
- ii. Heavy rainfall in its history brought exceptional downpours that overwhelmed the catchment, quickly raising Budameru water levels and triggering widespread flooding.
- iii. The flood reached a maximum depth of 1349.23 mm, which greatly exceeded the normal water level and contributed to severe inundation in nearby residential and agricultural areas.
- iv. Tank breaches in Mylavaram released sudden large volumes of water into the Budameru, increasing downstream flood levels and worsening inundation.
- v. The Krishna River backwater effect prevents Budameru from draining into the river during high flows, causing water to reverse and flood upstream urban areas.

Mitigation measures of inundation:

- i. The existing Budameru stream should be thoroughly desilted to restore its original flow capacity and reduce the risk of overflow during heavy rains.
- ii. Encroached buildings along the Budameru banks should be demolished to restore the natural floodplain and improve water flow during floods.
- iii. Implement an early warning flood alert system in Velegaleru and Singh Nagar to provide real-time notifications and minimize damage to lives and property during high-risk flood events.
- iv. Provide regulated structures at Pavithra Sangamam to control and prevent the backwater effects from the Krishna River, protecting surrounding areas from flooding.