# A Comparative Study of Delineated Watersheds through ASTER, SRTM and ALOS for evaluating morphological changes in Hathmati Basin, Gujarat, India

**Darshik Gajjar (1), Kishan Darji (1), Dhruvesh Patel (1), Cristina Prieto (2), and Dawei Han (3)**

(1) Department of Civil Engineering, School of Technology, PDPU, Gandhinagar, India (gajjardarshik@gmail.com),
(2) Environmental Hydraulics Institute "IH Cantabria",University of Cantabria, Santander, Spain (cristina.prieto@unican.es),
(3) Department of Civil Engineering, University of Bristol, Bristol, UK (d.han@bristol.ac.uk)

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## Abstract

Watershed morphological analysis is important for controlling floods and planning restoration actions, as well it is foremost useful to understand catchment hydrology. The morphometric parameters depend on the watershed characteristics; the characteristics vary as per their natural integrators of hydrological and geological processes, such that it requires an integrated approach to data analysis and modeling. In this study, Hathmati basin has been delineated by using a Digital Elevation Model (DEM). A crucial aspect of this task is the reliability of the DEM. If the DEM is not accurate, a catchment cannot be expected to be accurately delineated. Therefore, the present study focuses on the comparison of various morphological parameters like area, perimeter and Basin Length of a watershed which delineated through open source DEM i.e. 30-m ASTER, 30-m SRTM and 30-m ALOS (AW3D30). For a precise delineation of mini-watersheds, drainages were manually digitized from the Survey of India Topographic sheet and overly on DEMs to create Agree-DEM with the help of ArcGIS 10.2 and Arc Hydro Tool. As the result, delineated watersheds from ASTER, SRTM and ALOS were compared using the regression analysis. The area of the watershed delineated from SRTM DEM is 1988.41 km-2, while the ASTER-based and the ALOS-based watershed is 2008.55 km-2 and 1990.90 km-2. The regression analysis comparing the complete area of mini-watersheds yielded an R-2 of 0.9979 between the SRTM and ASTER-based, 0.9992 for the SRTM and ALOS-based and 0.9977 for ALOS and ASTER-based mini-watershed. The area of SRTM and ALOS-based watersheds are almost similar as per the R-2 value and which is same as for the derived basin length. The perimeter of watershed delineated from SRTM-based is 1464.35 km, while the perimeter of the ASTER-based watershed is 0.25% short and 0.6% long for the ALOS-based watershed. A yielded R-2 from the regression analysis compared with the perimeter of mini-watersheds between SRTM and ASTER-based reveals 0.9796, 0.9705 for the SRTM and ALOS-based, and 0.9879 for ALOS and ASTER-based watershed. Hence, SRTM can be more pertinent to derive the morphological parameters of Hathmati basin.

## Study Area

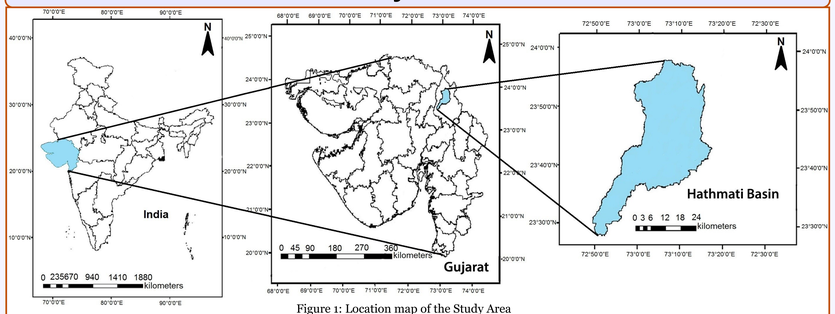


Figure 1: Location map of the Study Area

The Hathmati basin lying between 23°50'40" to 24°02'00" N and 72°44'51" to 73°15'04" E in Sabarkantha district, Gujarat, India (Figure 1). Covering a total area of 1085.66 km². According to 1:50,000 scale map of Survey of India (SOI), most of the study area falls into the topographical sheet numbers F43A13, F43A14, F43A15, F43B1 and F43B2. The present study has also been considered for the area besides the Hathmati basin, the foremost left tributaries of Sabarmati. Thus, further analyzing and prioritizing of the watershed can be carried out along the Hathmati basin.

## Objective

To find the reliability of DEM for a given catchment area based on the morphological variance.

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## Strategy

1. Manually extraction of drainges from toposheet for AgreeDEM process.
2. Delineation of watershed from AgreeDEM of ASTER, SRTM and ALOS.
3. Computation of Basic morphometric parameters of ASTER, SRTM and ALOS.

## Materials & Methods

**Table 1: Characteristics of Toposheet, ASTER, SRTM and ALOS**

| Characteristics | Toposheets | ASTER-DEM | SRTM-DEM | ALOS-DEM |
|---|---|---|---|---|
| Tile size | 8000 pixels x 4880 pixels | 3601 x 3601 cells (1° x 1°) | 1 arc-second (1° x 1°) | 1 arc-second (1° x 1°) |
| Spatial resolution | Scale: 1:50,000 | 1 arc-second (30m) | 1 arc-second (30m) | 1 arc-second (30m) |
| Geographic Coordinates | Latitude and Longitude | Latitude and Longitude | Latitude and Longitude | Latitude and Longitude |
| File format | JPEG, scanned 200dpi and bit depth 24, Projection: UTM and Geo-referenced to WGS 84 | Geo TIFF, signed integer 16bit and 1m/DN referenced to the WGS 84/EGM96 geoid | Geo TIFF, signed integer 16 bit and Referenced to the WGS 84/ EGM 96 geoid | Signed 16bit Geo TIFF and Referenced to WGS 84/EGM 96 geoid |
| No Data Values | -NA- | -9999 | -32768 | -9999 |
| Coverage | -NA- | North 83° – South 83° | North 60° – South 56° | North 60° – South 60° |

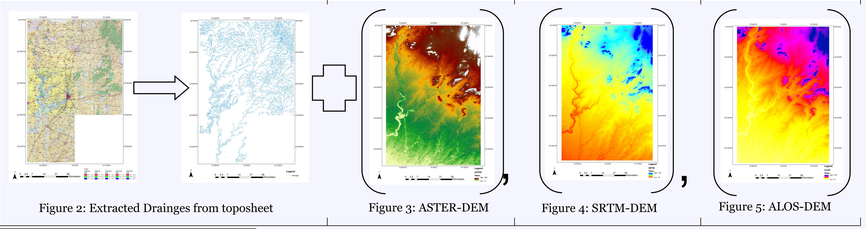

Figure 2: Extracted Drainges from toposheet

Figure 3: ASTER-DEM

Figure 4: SRTM-DEM

Figure 5: ALOS-DEM

Step 1: Extraction of drainges from Toposheet

Step 2: Acquiring DEMs and merging extracted Drainges with acquired DEMs with the help of AgreeDEM.

Step 3: Running below functions in ArcGIS 10.2 Environment to delineate the watersheds.

- 3.1 Fill Sink
- 3.2 Flow Direction
- 3.3 Flow Accumulation
- 3.4 Stream Definition
- 3.5 Snap Pour Points
- 3.6 Watershed

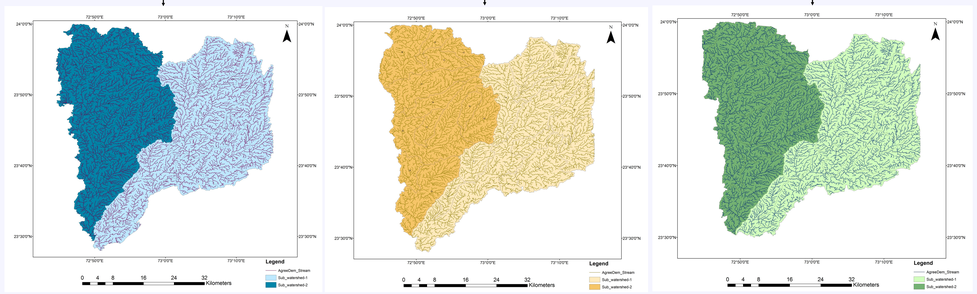

Figure 6: Delineated Watersheds from ASTER

Figure 7: Delineated Watersheds from SRTM

Figure 8: Delineated Watersheds from ALOS

## Results & Discussion

**Table 2: Empirical formulas for computation of morphometric parameters**

| Morphometric parameters | Formula | Reference |
|---|---|---|
| Area of the Basin | A=Area of the Basin in $km^2$ | Nookaratnam et al. (2005) |
| Perimeter of Basin | P=Perimeter in km. | Nookaratnam et al. (2005) |
| Basin Length ($L_b$) | $L_b = 1.312 \times A^{0.568}$ Where, $L_b$=Length of Basin (km) A=Area of Basin ($km^2$) | Nookaratnam et al. (2005) |

**Table 3: Computed morphometric parameters from ASTER, SRTM and ALOS**

| Sr. No. | ASTER | | | SRTM | | | ALOS | | |
|---|---|---|---|---|---|---|---|---|---|
| | Area | Perimeter | Basin Length | Area | Perimeter | Basin Length | Area | Perimeter | Basin Length |
| 1 | 694 | 503.46 | 129 | 695 | 510.86 | 113 | 687 | 474.33 | 116.53 |
| 2 | 83.9 | 51.49 | 16.2 | 59 | 40.31 | 13 | 57.4 | 37.88 | 13.09 |
| 3 | 164 | 102.41 | 23.8 | 173 | 123.23 | 33 | 166 | 146.6 | 37.25 |
| 4 | 129 | 62.81 | 20.8 | 133 | 101.35 | 28 | 134 | 68.75 | 23.71 |
| 5 | 112 | 101.28 | 25.7 | 115 | 114.07 | 31 | 114 | 103.51 | 30.35 |
| 6 | 96.5 | 55.09 | 17.6 | 83.3 | 57.9 | 16 | 89.6 | 73.65 | 22.59 |
| 7 | 178 | 127.78 | 33.5 | 180 | 119.32 | 32 | 182 | 115.9 | 32.54 |
| 8 | 551 | 456.44 | 105 | 550 | 397.31 | 97 | 562 | 452.56 | 108.79 |
| | 2009 | 1460.7 | 371 | 1988 | 1464.4 | 365 | 1991 | 1473.2 | 384.85 |

Comparison of delineated watershed between ASTER - SRTM - ALOS:

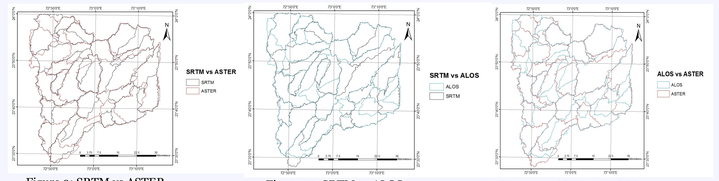


Figure 9: SRTM vs ASTER

Figure 10: SRTM vs ALOS

Figure 11: ALOS vs ASTER

## Main Findings

- The area of the watershed delineated from SRTM DEM is 1988.41 km-2, while the ASTER-based and the ALOS-based watershed is 2008.55 km-2 and 1990.90 km-2.
- The regression analysis comparing the complete area of mini-watersheds yielded an R-2 of 0.9979 between the SRTM and ASTER-based, 0.9992 for the SRTM and ALOS-based and 0.9977 for ALOS and ASTER-based mini-watershed.
- The perimeter of watershed delineated from SRTM-based is 1464.35 km, while the perimeter of the ASTER-based watershed is 0.25% short and 0.6% long for the ALOS-based watershed.
- The area of SRTM and ALOS-based watersheds are almost similar as per the R-2 value and which is same as for the derived basin length.
- A yielded R-2 from the regression analysis compared with the perimeter of mini-watersheds between SRTM and ASTER-based reveals 0.9796, 0.9705 for the SRTM and ALOS-based, and 0.9879 for ALOS and ASTER-based watershed.

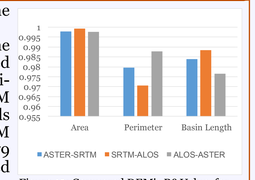


Figure 12: Compared DEM's $R^2$ Value for Area, Perimeter and Basin Length

## Conclusions

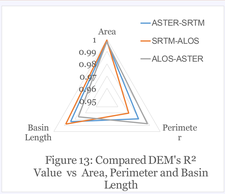


Figure 13: Compared DEM's $R^2$ Value vs Area, Perimeter and Basin Length

- As the accuracy of DEM varies, the boundary of watershed also varies over the given area.
- However, Comparing DEMs through regression analysis reveals that SRTM can be more pertinent than ALOS and ASTER to derive the morphological parameters of Hathmati basin.

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