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Research Article

Geospatial Analysis Of Denudational Processes In Auranga River Basin

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ABSTRACT

Denudation is a geomorphic process involving the breakdown, erosion, transportation, and eventual deposition of rock and soil materials from higher to lower elevations. The present study investigates the spatial patterns and intensity of denudational processes in the Auranga River Basin, located across parts of Gujarat and Maharashtra, using topographic maps and satellite-based Digital Elevation Models (DEMs) from 1966–67 and 2018. The analysis was conducted through GIS-based spatial modeling, particularly the cut-and-fill tool, to quantify surface changes over time. The Auranga basin, covering approximately 800 km², reveals significant erosion (1596.64 km²) and deposition (711.95 km²), with only 0.0016 km² remaining unchanged. Sub-basin level assessment indicates the highest erosion in the Tan and Man river sub-basins (319.52 km² and 313.06 km² respectively), followed by varying degrees of material removal and deposition in Nirpan, Lower Tan, Vanki Nadi, and Lower Auranga sub-basins. These changes correspond with physiographic features such as dissected hills, slopes, and riverbanks. The results emphasize the dynamic geomorphological transformation of the basin, driven by natural agents including weathering, mass wasting, erosion, and fluvial transportation. This spatial evaluation aids in understanding landscape evolution, watershed management, and planning for sustainable land use in the Auranga river basin.

Key Words: Denudation, Weathering, Erosion, Transportation, Mass Wasting

I. Introduction:

Denudation is the process of wearing away and removing rocks from the Earth's surface through various natural forces like weathering, erosion, water, ice, and waves. It leads to the degradation and leveling of land masses, shaping the Earth's landscape over time. (Merritts, D., 2000). Basin relief plays a crucial role in determining denudational characteristics, as it influences the rate and pattern of erosion, sediment transport, and deposition within the basin. The relief affects the flow of water, sediment load, and overall geomorphic processes, shaping the landscape over time. That's a concise way to put it: Denudation = Weathering + Erosion + Transportation. These three processes combined lead to the wearing away and removal of rocks and sediments from the Earth's surface. Physiographycally leafy shape of drainage basin appering hills like Gavala dongar, Ambun dongar, and Kalam dongar in the east, Tanacchiya, south slope of Ganava hill, north slope of Ghontval dungar in middle part of the basin, East slope of Gorkhada hill, slope of Avadha hill, north slope of Sidumbar and Rajpuri talat village are in the west. The dissection pattern of hills, including highly dissected, moderately dissected, and low dissected hills, provides valuable insights into the denudation chronology of an area. By analyzing these patterns, researchers can reconstruct the geological history and understand the stages of landscape evolution over time (N. Durg Prasad, 2019). In high-relief areas, landsliding often dominates hillslope denudation. Landslides typically occur when the strength threshold of soil or rock is exceeded, often due to factors like heavy rainfall, earthquakes, or human activities. This process plays a significant role in shaping the landscape and influencing geological hazards (Tucker G., Bras R. 1998).

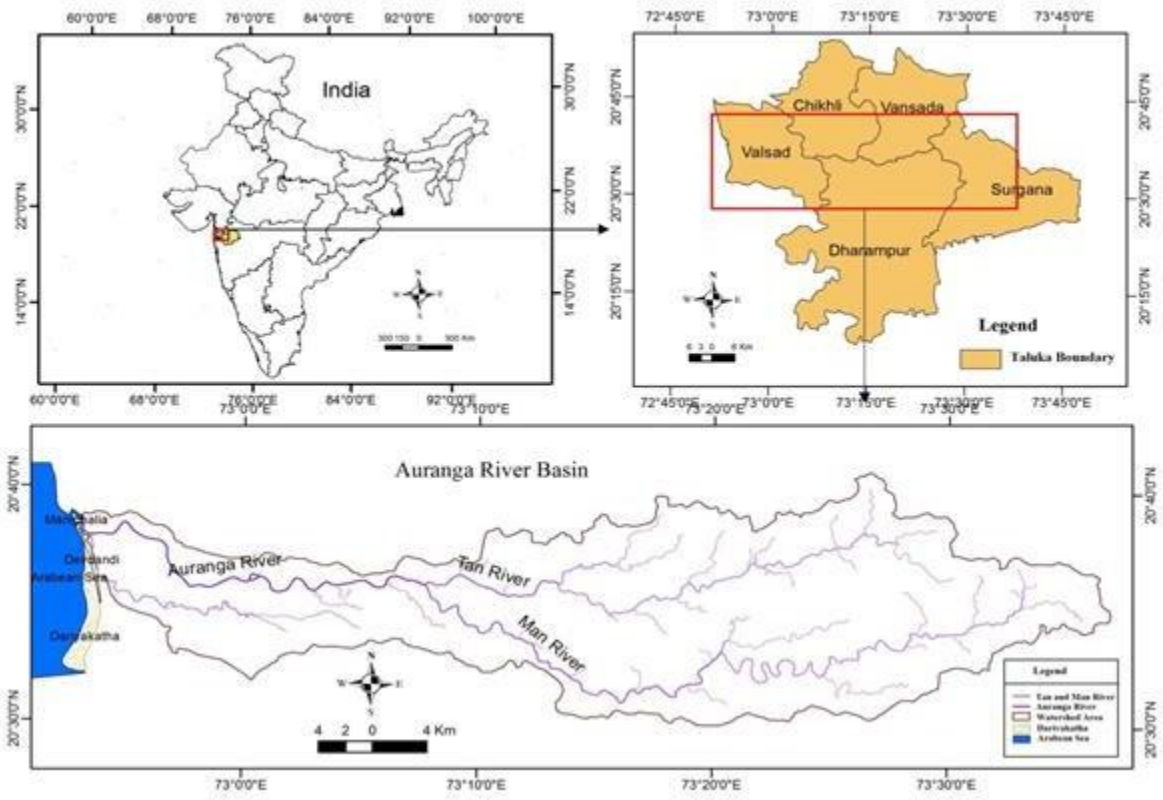
Denudation encompasses the loss of mass from a landscape through both solid particles (sediments) and solutes (dissolved substances), incorporating all forms of erosion, weathering, and transportation processes that shape and reshape the Earth's surface (Jens M. Turowski and Kristen L. Cook, 2016). The erosion process can be broadly categorized into weathering, transportation, and corrosion, encompassing physical, chemical,

and biological mechanisms that break down and remove rock and soil materials (Gilbert, 1877). Denudation measurements are typically conducted at the catchment scale, quantifying the total volume of material removed from the area over a specified time period. This helps assess landscape evolution, erosion rates, and sediment transport dynamics (Jens M. Turowski and Kristen L. Cook, 2016). The study attempted landscape erosion and material removal (denudation) differs across a geographic area in the Auranga river basin.

II. Study Area:

Auranga river basin lies between north latitudes 200 30' 17"N to 200 40' 52"N and east longitudes 720 52' 59"E to 730 36' 55"E with effective drainage area of 800 km2. Study area includes the maximum portion of Valsad district of Gujarat and Nashik district of Maharashtra. Auranga river also drained into smaller areas of Bansda and Chikhali tehsil of Navsari district; it flows within five teshils that includes in the study region. The Auranga river basin form in part of the Western Ghats in Gujarat and Maharashtra (Map 1.1).

Study Area



III. Methodology:

The following data sources and methodology has been adopted for the present study.

a) Data Source:

i) Primary and Secondary Data: The study utilizes a combination of primary and secondary data sources. Primary data would involve original, firsthand information collected specifically for this research, while secondary data would come from existing sources, such as literature, databases, or previous studies. Primary data is obtained by field visit. To observe, identify and measured the various fluvial features, field visit was conducted during month of May and December 2019.

ii) Topographical Data:

The Survey of India (SOI) Toposheet no. 46D/14, 46H/2, 46H/3, 46 H/6, 46H/7 and 46H/10 on 1:50,000 Scale has been used.

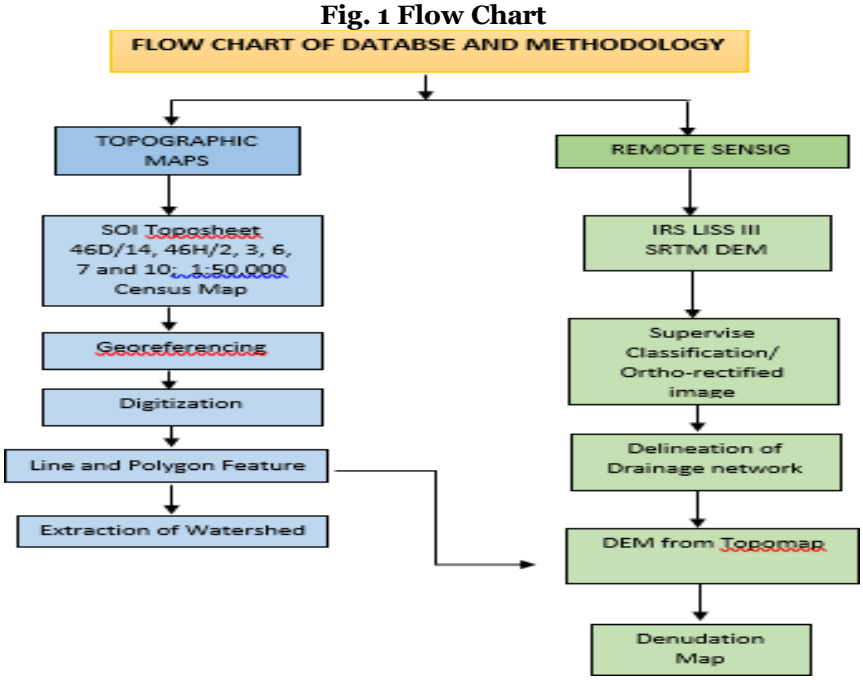
iii) Remote Sensing Data:

For land resource mapping IRS-Resourcesat-2, LISS III, data have been used and processed in ArcGIS 10.2.2 software.

iv) Digital Elevation Model (DEM):

A Digital Elevation Model (DEM) is created by converting contour maps into raster format through digitization and surface analysis, resulting in a digital representation of elevation data. SRTM DEM, spatial resolution 30 meters data have been used for the study. For the study of Denudational processes various stapes were adopted as per described in flow chart as follows (Fig. 1).

Fig. 1 Flow Chart



IV. Procedure obtained:

The denudation processes was obtained by topographic map and digital elevation data (DEM) from 1966-67 and 1970-71 to December 7, 2018 respectively. This later provided information of spatial of denudation processes. The cartographic representation is performed on scale 1:50,000. Result obtained from digitized topo map DEM and SRTM DEM. After a while cut-and-fill operation has been perform spatial analysis environment in ArcGIS, land surface modification involves altering the elevation of a landform through removal or addition of material. This process, often analyzed using the Cut Fill tool, calculates the areas and volumes of change, helping to assess the impact of earthwork operations in two different time period. It delineates areas of surface material removal, addition, and regions where the surface remains unchanged, providing a clear picture of the modifications. From the output raster it considered that positive volumes to be material were cut (removed) and negative volume material was filled (added) (Table 1).

Table: 1 Denudation Matrix (1966-67 to 2018)

Sr. No.	River Basin	Deposition (-) Area (sq.km)	Erosion (+) Area (sq.km)	No Change (Area sq.km)	Net Gain (Volume km³)	Net Loss (Volume km³)
1	Lower Tan	41.82	216.83	0.0002	-0.26	2.56
2	Lower Auranga	74.63	269.96	0.0003	-0.39	2.9
3	Vanki Nadi	77.39	264.60	0.0003	-0.4	2.88
4	Man	253.53	313.06	0.0003	-2.96	4.17
5	Nirpan	113.72	212.68	0.0002	-1.29	2.56
6	Tan	150.86	319.52	0.0003	-1.73	4.5
	Total	711.95	1596.64	0.0016	-7.03	19.57

V. Discussion:

Denudation is the process of stripping away the Earth's surface through leaching, erosion, and other forces, resulting in the transfer of material from higher elevations to lower areas like rivers, lakes, and valleys, ultimately reshaping the landscape.

1. Agents contribute to the processes of Denudation:

a. Weathering: Weathering is the process of breaking down rocks into smaller particles through physical,

biological, or chemical means, ultimately changing the Earth's surface.

b. Mass Movement or wasting: Mass movement, also known as mass wasting, refers to the downslope movement of rock fragments and soil due to gravity, wind, water, or other forces, often resulting from weathering processes. This movement can reshape the landscape and occur in various forms, such as landslides, rockfalls, or soil creep.

c. Erosion: This describes erosion and weathering, which involve the displacement, disintegration, and wearing away of rocks and soil by natural agents like water, wind, ice, and gravity, leading to changes in the landscape.

d. Transportation: Eroded particles are transported by natural agents like wind, water, and sea waves, moving them from one location to another and reshaping the landscape.

e. Deposition: This refers to deposition, which is the process of settling and accumulation of eroded, weathered, or transported materials, such as sediment, in a new location.

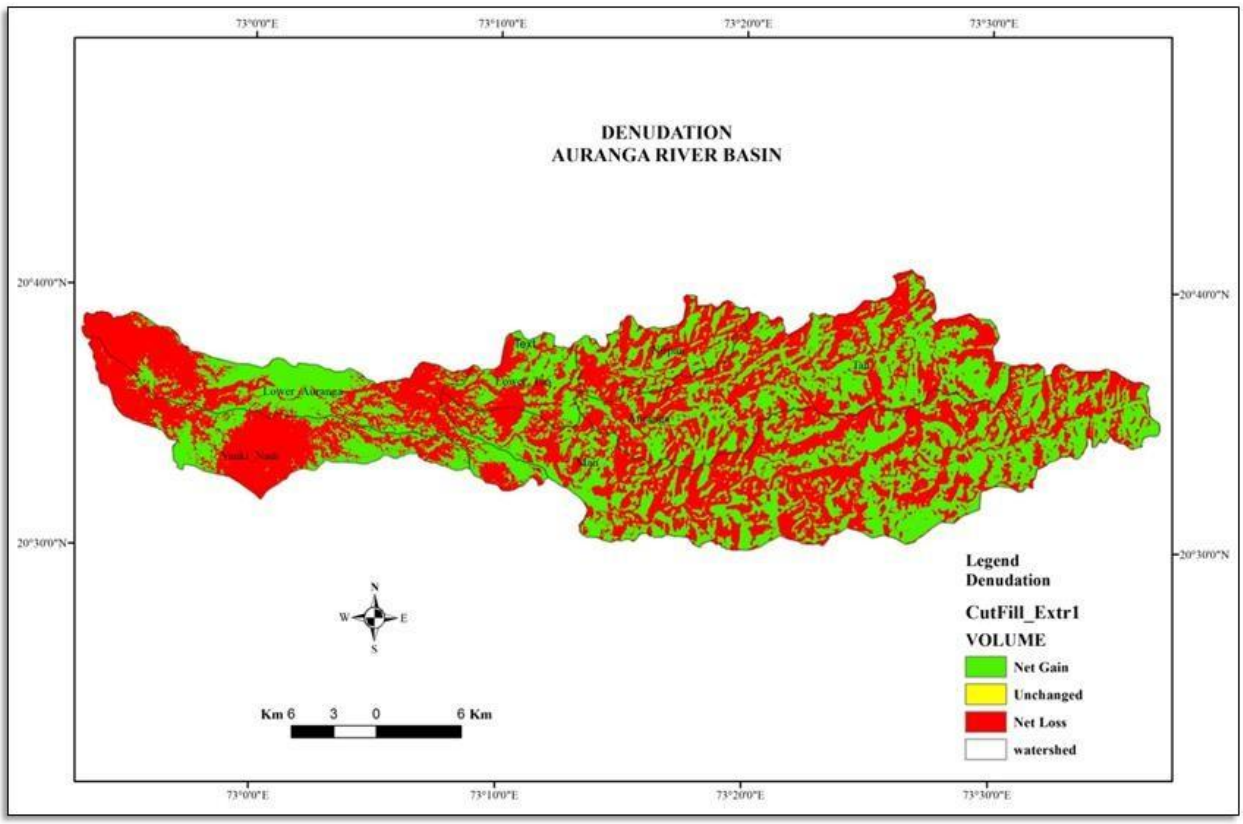
Table 1 and map 1 reveals description of denudation of Auranga river basin. It expressed in sq.km.and cub.km. It shows that the 1596.64 sq.km area were gets eroded since 19667 to 2018. While the denudational process, removal material was deposited at the foothill as well as along the river channel. Total 711.95 sq.km. area were gets deposited, whereas only 0.0016 sq.km area has observed unchanged in the study area.

2. Sub-Basin wise Spatial Denudational Processes:

There are total six sub-basin of Auranga river basins i.e. Tan river basin, Man river basin, Nirpan river basin, Lower Tan river basin, Vanki nadi basin and Lower Auranga river basin.

i) Denudation in Tan River Basin:

Tan and Man river basin is separated by inter mediate hills viz. Dhukty dongar in the east, Rasha dongar in the mid and Nikordha dongar in the south. Tan river basin covers 187 sq. km. It extended east to west in nothern part of the Auranga basin. In this basin erosional and depositionl process of denudation is observed. Near about 319.52 sq. km. area gets eroded in this sub basin. The erosional processes were observed in the tops and western slope and spur of Dhuktya Dongar, south slope of Songir, Karanjul (K), Chikarpad Dongar, Pilya Dungar and Dasarpada hill tops. The depositional processes has identified in the areas between Nirva Dongar and dhuktya dongar. The areas fill villages of Songir, Jambhulpada, Guhi in the east of the basin. Ragatvihir, Chikarpada, and mankuniya villages are observed deposition.



Map. 1.

ii. Denudation in Man River Basin:

Man river basin covers 324 sq.km. It extended east to west in south part of the Auranga basin. In this basin erosional and depositionl process of denudation is observed. The erosion and deposition has taken place about 313.06 sq. km and 253.53 sq. km. area respectively in this basin. The surface erosional was observed in areas of hill top of Gavala dongar, Ambun dongar, and Kalam dongar in the east, Tanacchiya, south slope of Ganava hill, North Slope of Ghontval dungar in middle part of the basin, East slope of Gorkhada hill, slope of Avadha hill, North Slope of Sidumbar and Rajpuri talat village are in the west. Whereas deposition take place in areas of west slope of Chuli dongar, east slope of Kalam dongar, east slope of Payar dongar in the east, south slope of Sondar dongar, western slope of Tanacchiya hill to Manayachond village, along river Man near village Gadi in the mid of the basin and village areas of Sidumbar, Kngvi, areas between Nani and Mothi Dholdungari in the south.

iii. Denudation in Nirpan River Basin:

In the Nirpan river basin 212.68 sq.km areas has found erosion, whereas 113.72 sq.km areas has deposition. Erosional places are hill top of Khadakpayar, watershed divide area of Ravaniya hill, middle hilly part and southern part of the basin. Foothill of Khadakpayar hill in the east, village areas of Badmal, Anklachh and Bartad has found deposition.

iv. Denudation in Lower Tan River Basin:

Lower Tan river basin erosion and deposition has found 216.83 and 41.82 sq.km respectively in the region. Erosion is found in the village areas of Toranvera east, west and south of village Gouri etc. whereas an area between Toranvera and Jamanpada, Khatana-east, and Wadpada has found deposition sight.

v. Denudation in Vanki Nadi Basin:

The erosional and depositional area has found 264.60 sq.km and 77.39 sq.km. respectively in the Vanki nadi basin. The erosion has found in the area along first, second order streams in upper catchment of Vanki nadi, village areas of Anjlav, and Rabda in the mid and lower Vanki nadi area. Upper Vanki nadi area, village areas between Dulsad and Bustar, Parnera and Chanwai has found deposition field.

vi. Denudation in Lower Auranga River Basin:

Lowe Auranga river basin extended from confluence of river Tan and Man to mouth or river Auranga. It has found the areas of erosion and deposition 269.96 sq. km and 74.63 sq. km respectively. It has also found trace amount of no change area i.e. 0.003 sq.km. Erosional area of this region are found in confluence area of river Tan and Man, village areas of Bahej, Marla, Kaparia in upper part of the basin and village Dhamdachi to mouth of river Auranga. Left and right bank side of river Auranga near Marala, Open scrub areas between Bhundwada and Ghadoi, villages Kanjan hari, Pardi areas has observed deposition.

VI. Conclusion:

The Auranga river basin experiences significant denudation, a process of mass loss from the landscape through physical, chemical, and biological mechanisms that measured at the catchment or basin scale, representing the volume of material removed over time. The Auranga river basin exhibits significant denudational processes, varying across sub-basins. The Tan river basin experienced notable erosion (319.52 sq. km) and deposition in village areas and hilltops. Similarly, the Man river basin saw significant erosion (313.06 sq. km) and deposition (253.53 sq. km) on hilltops, slopes, and streams. Other sub-basins, including Nirpan, Lower Tan, Vanki Nadi, and Lower Auranga, also showed substantial erosion and deposition, primarily in village areas, hilltops, and along streams. These processes highlight the dynamic nature of the basin's geomorphology.

The Auranga river basin has undergone extensive denudational changes between 1967 and 2018. During this period, approximately 1596.64 sq. km of area experienced erosion, while around
711.95 sq. km was affected by deposition, mainly at the foothills and along the river channels. Only a negligible portion of 0.0016 sq. km remained unchanged, highlighting the dynamic nature of geomorphic processes in the basin.

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