Geomorphological Valuation of Sitla Rao Watershed Using ASTER- DEM, Dehradun, Uttrakhand, India.

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Abstract

In the present study geomorphological units of a part of Himalayan watershed has been delineated with the help of ASTER imagery. DEMs used in the present study are generated from toposheet contour interval, SRTM and ASTER. The morphological aspects of these features obtained from DEMs generated from different sources are compared. Geomorphological studies reveal different landform in the area of Sitla Rao watershed which lies in the foothill of Himalaya. Landforms identified in the study area are Doon Fan Gravel Terrace, Doon Fan Gravel Dissected Hill, Sub Recent Fan Terrace, Moderately Dissected Structural Hill, Piedmont Dissected Slope, River Terrace, Channel Bar and River channel. The spatial and statistical distributions of topographic attributes of these units were computed and compared using SAGA 2.3 software as a digital terrain analysis tool for studying topographic attributes extraction and analysis methods, based on grid DEMs. The study reveals that the DEM resolution has a great influence on terrain or topographic attributes and the statistical value become larger when DEM resolution changes from coarser to finer.

Keywords: Digital elevation model (DEM), SAGA 2.3, ASTER, Sitla Rao, Geomorphological units

1. Introduction

The Doon valley is a topographic depression of irregular parallelogram shape with longer axis running parallel to Lesser Himalayan range (Chandel and Singh, 2001). The location of the valley makes it interesting, with Lesser Himalaya in the north, Siwalik in the South and traversing Ganga and Yamuna in SE and NW direction. Geomorphologically landforms in the area are developed by the combine action of erosion, deposition and tectonic activity. Remote sensing method play an important role in the realization of the map, allowing the pattern that mark the landscape unit to be delineated. Digital elevation models (DEMs) are widely used and play an increasing important role in geomorphology, hydrology, soil erosion and many related geoanalysis field.
A good deal of work has been done to analyze effect on the application results of using DEMs with different resolution (Hutchinson and Dowling, 1991; Jenson, 1991; Zhang and Montgomery, 1994; Band and Moore, 1995; Braun et al., 1997; Walker and Willgoose, 1999; Wilson and Gallant, 2000; Wise, 2000; Tang et al., 2003; Saran et al., 2009; Suganthi and Srinivasan, 2010). Topographical attributes derived from DEMs analysis can be divided into primary and secondary attributes (Moore et al., 1991). In general, topographical information in DEMs can be represented and stored as three different forms: (i) a grid, (ii) a triangulated irregular network (TIN) or (iii) contour-line models (Weibel and Heller, 1991; Tarboton, 1997; Richard, 2004).

The present geomorphological studies carried out, mainly aimed to identify and delineate various geomorphic units using different photographic element (Table-1) in the area near Sitla Rao watershed highlighting the diverse topographic and material characteristic using high resolution ASTER image of the study area and to evaluate the dependence of terrain characteristic of DEM of the identified units depending upon the resolution of different DEM.

2. Study Area

The study area, Sitla Rao (Fig.1) is situated in the western part of the Dehradun district, Uttarakhand, in the Lesser Himalayas. The geographical dimension extends from 30°24'00" to 30°30'00" N latitude and 77°45'33" to 77°57'00" E longitude and is included in the SOI toposheet no.53 F/15. The district is bounded on the north-west by the district of Uttarkashi, in the east by the district of Tehri Garhwal and Pauri Garhwal, in the south by the district of Saharanpur (U.P) and at the southern tip touches the boundary of district Haridwar, its western boundary joins the Sirmur (Nahan) district of Himachal Pradesh.

3. Climate

The climate of the district is generally temperate and varies greatly from tropical to severe cold depending upon the altitude of the area and temperature variations due to difference in elevation is considerable. Three seasons experienced in the area include, cold winter season (Oct-Feb), hot or summer season (March-June) and wet monsoon season (July-
The area receives an average annual rainfall of 2073.3 mm. The relative humidity is high in monsoon season exceeding 70% on an average. Most of the annual rainfall in the district is received during the month from June to September, July and August being the most showery.

4. Geology and Geomorphology

Dehradun is situated in synclinal intermonatevalley within the Siwalik Formation and is separated from the Lesser Himalayan Formations in the north by Main Boundary Fault. Siwalik Group of rocks is thrusted over Indogangetic Plain sediments along the Himalayan Frontal Fault, forming Dehradun Valley as a piggyback basin (Ori abd Friend, 1984; Gupta, 1993). Geologically

<table>
<thead>
<tr>
<th>S.No</th>
<th>Geomorphic Unit</th>
<th>Geological Unit</th>
<th>Characteristics of Geomorphic Units</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Tone</td>
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<tr>
<td>1</td>
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<td>Doon Gravel</td>
<td>Light to medium</td>
</tr>
<tr>
<td>2</td>
<td>Doon Fan Gravel Dissected Hill</td>
<td>Doon Gravel</td>
<td>Light to medium</td>
</tr>
<tr>
<td>3</td>
<td>Sub Recent Fan Terrace</td>
<td>Doon Gravel</td>
<td>Light to medium</td>
</tr>
<tr>
<td>4</td>
<td>Moderately Dissected Structural Hill</td>
<td>Middle Siwalik</td>
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</tr>
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<td></td>
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<td>Upper Siwalik</td>
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<td></td>
<td></td>
<td>Lesser Himalaya</td>
<td>Dark</td>
</tr>
<tr>
<td>5</td>
<td>Piedmont Dissected Slope</td>
<td>Doon Gravel</td>
<td>Light to medium</td>
</tr>
<tr>
<td>6</td>
<td>River Terrace</td>
<td>Doon Gravel</td>
<td>Light to medium</td>
</tr>
<tr>
<td>7</td>
<td>Channel Bar</td>
<td>River Alluvium</td>
<td>Dark</td>
</tr>
</tbody>
</table>

Table-1: Characteristic of Geomorphic Units
Doon valley is bounded by two perennial rivers Yamuna and Ganga that drains the entire area with its tributaries, NW flowing Asan and SE flowing Suswa-Song respectively. It is the largest “Doon” in the Sub-Himalayan region and a longitudinal, synclinal basin with fluvialite sediments deposited in front of the abrupt rising of Lesser Himalaya (Mussoorie Range) in the north. The structural hills of Middle Siwalik rocks rise abruptly over the upper piedmont because of a Foothill Fault. These structural hills are controlled morphologically by lithology whereas the southern part consisting of alternating sandstone and shale overlain by massive sandstone, which grassy slope facing south and open mixed forest in northern aspects (Rao, 2002). The major part of the valley area is occupied by three fans i.e., Donga, Dehradun and Bhogpur fan (Singh, et al., 2001) deposited by the rivers, flowing from Lesser Himalaya

5. Material and Method

The detailed procedure of grid DEM generation was carried out is as follows: a) Topographic basemap on 1:50,000 scale and was scanned image registration was carried out using UTM projection plane (Zone 43N), with the help of Georeferencing Tool 1.0.0.0 and Geographic Translator 2.3., and vectorized using ArcGIS 3.2 to generate contour layer and spot elevation layer respectively to obtain spatial topological relation; b) The altitude values to the contour lines and spot elevation layer were assigned; c) contour polyline converted to TIN data; d) TIN data was modified using spot elevation data; e) By interpolation method resample from TIN data converted to Raster data to generate 20m×20m resolution DEM (the original DEM).

FCC of ASTER image was prepared using band 123 of VNIR in Multispec W32 software and landforms were identified after a complete literature review of the study area. Geomorphological map was prepared and digitized after georeferencing and subsequently the saved GeoTIFF file was imported to Arcview to create shape files for each unit which was then used to clip the required area for elevation, slope and aspect maps from the SRTM DEM, ASTER DEM and the Topographic DEM.

ASTER on board of Terra spacecraft is multispectral optical sensor, set in motion on December 1999, works in 14 spectral bands ranging from visible to thermal infrared band. These spectral bands have been divided into three radiometers namely VNIR (Visible Near Infrared Radiometer), SWIR (Short Wave Infrared Radiometer) and TIR (Thermal Infrared Radiometer) (Ersdac, 2003). Out of these three VNIR has a high performance, high resolution optical instrument with spatial resolution of 15 m. with two near infrared bands, having similar wavelengths namely 3n (nadir looking) and 3b (backward looking). The 3b band is used to achieve the backward looking and the setting angle between the
backward looking and the nadir looking has been designed to be 27.60° (Ersdac, 2002).
The successfully collected Synthetic Aperture Radar (SRTM) data over 80 percent of the landmass of the Earth between 60° N and 56° S latitudes during an 11-day Space Shuttle mission in February, 2000. The SRTM data was processed using SAR interferometry (IFSAR) to obtain a nearly global DEM (Rabus et al. 2003) and is freely available http://srtm.csi.cgiar.org for modeling and environmental applications.

6. Result and Discussion

Geomorphically Doon valley is divided into two slope regimes by axial drainage of NW flowing Asan and SE flowing Suswa-Song river joining the Yamuna and Ganga rivers respectively. In the northern slope of the Doon, the Siwalik Group occurs as uplifted and dissected hills and further south as pediments with a thick cover of gravel. Southern slope of the valley is covered by piedmont fan gravels derived from uplifted topography of the frontal Siwalik range in the south.
The geomorphological units namely Doon Fan Gravel Terrace, Doon Fan Gravel Dissected Hill, Sub Recent Fan Terrace, Moderately Dissected Structural Hill, Piedmont Dissected Slope, River Terrace, Channel Bar and River channel have been identified and delineated (Fig.2) are discussed below and is given in Table-1.

6.1 Doon Fan Gravel Terrace

Doon Fan Gravels forming terraces, consisting of gravels, pebbles, boulders, sand, clay and rock fragments. These terraces also known as fan cut terraces formed by the erosional work of the streams flowing down from the Lesser Himalaya and are extensively used for agricultural purposes. At places, these fans show differential upliftment and subsequent faulting in recent and sub-recent times.

6.2 Doon Fan Gravel Dissected Hill

Doon Fan Gravel Dissected Hill is represented in the study area as an elongated feature tapering towards south with variable slope and is found to be very gentle towards south. Quartzite, sandstone and clay constitute the composition of the fan material and cover a large area extending from apex of the fan in the north up to the Sub Recent alluvial deposits of Asan River. They are highly dissected by streams and gullies running down from the Lesser Himalaya and have thick vegetation.

6.3 Sub Recent Fan Terrace

Sub Recent Fan Terraces are conspicuous on either side of the Asan River. They maintain a bit higher elevation from valley floor of recent alluvium. This unit is sub-recent in age and comprises boulders, gravels, pebbles, sand and clay, deposited on the lower part of the piedmont dissected slope as well as on the lower part of Doon Fan Gravel Terrace.
<table>
<thead>
<tr>
<th>Geomorphological Units</th>
<th>Minimum elevation in meter</th>
<th>Maximum elevation in meter</th>
<th>Mean elevation in meter</th>
<th>Relief in meter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASTER-DEM</td>
<td>SRTM-DEM</td>
<td>Topographic-DEM</td>
<td>ASTER-DEM</td>
</tr>
<tr>
<td>Dun Fan Gravel Dissected Hill</td>
<td>457.99</td>
<td>512.15</td>
<td>479.75</td>
<td>973.23</td>
</tr>
<tr>
<td>Dun Fan Gravel Terrace</td>
<td>427.18</td>
<td>488.24</td>
<td>477.16</td>
<td>1220.16</td>
</tr>
<tr>
<td>Moderately Dissected Structural Hill</td>
<td>719.07</td>
<td>838.57</td>
<td>676.92</td>
<td>2481.86</td>
</tr>
<tr>
<td>Piedmont Dissected Slope</td>
<td>408.07</td>
<td>438.23</td>
<td>425.59</td>
<td>431.35</td>
</tr>
<tr>
<td>River Terrace</td>
<td>403.45</td>
<td>460.70</td>
<td>439.91</td>
<td>650.69</td>
</tr>
<tr>
<td>Subrecent Fan Terrace</td>
<td>414.25</td>
<td>458.69</td>
<td>446.34</td>
<td>522.40</td>
</tr>
</tbody>
</table>

Table: 2: Minimum maximum, mean elevation (meter) and relief (meter) statistics of various geomorphological units obtained from ASTER-DEM, SRTM-DEM and Topographic-DEM
6.4 Moderately Dissected Structural Hill

Modestly Dissected Structural Hills are confined to the Middle Siwalik in the study area. These hills are characterized by fold and fault with gentle to steep dip towards NW having moderate to high relief and posse’s distinct water divide. Presence of compact, massive, medium to coarse grained friable sandstone favors moderate dissection in this zone. This unit is characterized by high drainage density with sub-dendritic to dendritic and at places trellis pattern.

6.5 Piedmont Dissected Slope

The Piedmont zone extends from the Siwalik water divide in the south to synclinal axis of the Doon valley in north. It consists of assemblages of boulder, gravel, clay and pebbles, derived from the Upper Siwalik Formations. In the southern part it shows a steeper gradient and parallel to sub parallel drainage pattern.

6.6 River Terrace

River Terraces are the relicts of former flood plain levels that have undergone cyclic uplift and subsequent erosion under the influence of different physical and climatic conditions. The river terraces are formed by down cutting of fan material (Piedmont) and shifting of river courses constitute older alluvial formation consisting of river borne detritus deposits of varying dimensions. The sediment matrix of terrace consists of clay, silt, sand, gravel, pebbles and boulders.

6.7 Channel Bar

Channel bar, the youngest and the lowest geomorphic units identified in the floor of the river bed. These low relief geomorphic features are mostly observed in Sitla Rao river. Channel bars develop in the river flowing through unconsolidated materials like boulder, pebble, sand, silt and clay and develop channel bars. Channel bars are found in the Asan, Sitla Rao, Mauti Nadi, Gauna Nadi, Koti Nadi and Chor Khala.

6.8 River

In the study area Asan river bifurcates into many tributaries and streams, narrow/less wide in the upper reaches of the valley and show valley widening as they enter into the upper level of the gravel terrace. This unit represents the lowermost relief and consists of soft saturated sediments. The bed consists of reworked Doon fan gravel, older Doon gravel mixed with boulders and pebbles, derived from the Lesser Himalayan rocks.

7. DEM Analysis

The elevations (minimum, maximum and mean) relief, mean slope and mean aspect statistics of various geomorphological units have been generated from ASTER-DEM, SRTM-DEM and Topographic-DEM (Fig.3) and given in Table-2, and shown in Fig.2.a, b, c and d. The ASTER-DEM has been shown as
DEM-1, SRTM-DEM as DEM-2 and Topographic DEM as DEM-3 respectively.

7.1 Comparison of minimum, maximum and mean elevation and relief in meter of the geomorphological units

The elevation statistics (Table 2) generated from DEM-1, DEM-2 and DEM-3 depict that the minimum elevations (Fig. 2.a) encountered in the Doon Fan Gravel Dissected Hill are 457.99, 512.15 and 479.75 meter respectively. Further analysis shows that for Doon Fan Gravel Terrace the minimum elevations obtained from DEM-1, DEM-2 and DEM-3 are 427.18, 488.24 and 477.16 meter respectively. The minimum elevations obtained from DEM-1, DEM-2 and DEM-3 for Moderately Dissected Structural Hill are 719.07, 838.57 and 676.92 meter respectively and for Piedmont Dissected Slope the minimum elevations are 408.07, 438.23 and 425.59 meter as obtained from DEM-1, DEM-2 and DEM-3 respectively. The DEM-1, DEM-2 and DEM-3 based minimum elevations for River Terrace is 403.45, 460.70 and 439.91 meter respectively. The Sub Recent Fan Terrace showing minimum elevations are 414.25, 458.69 and 446.34 meter as obtained from DEM-1, DEM-2 and DEM-3 respectively.

Table-2, Fig.2.b shows that the maximum elevations of the Doon Fan Gravel Dissected Hill obtained from DEM-1, DEM-2 and DEM-3 are 973.23, 941.68 and 923.06 meter respectively. The maximum elevations incurred from DEM-1, DEM-2 and DEM-3 for Dun Fan Gravel Terrace are 1220.16, 1040.85 and 1045.58 meter respectively, while the maximum elevations from DEM-1, DEM-2 and DEM-3 for Moderately Dissected Structural Hill are 2481.86, 2108.66 and 2095.77 meter respectively. For Piedmont Dissected Slope the maximum elevations from DEM-1, DEM-2 and DEM-3 are 431.35, 448.00 and 441.66 meter respectively. The maximum elevations from DEM-1, DEM-2 and DEM-3 for the River Terrace are 650.69, 612.40 and 708.26 meter respectively. Similarly for the Sub Recent Fan Terrace...
Terrace the maximum elevations obtained respectively from DEM-1, DEM-2 and DEM-3 are 522.40, 517.89 and 502.49 meter.

The mean elevations of the Dun Fan Gravel Dissected Hill encountered from DEM-1, DEM-2 and DEM-3 are 611.18, 636.90 and 599.3 meter respectively (Table-2, Fig.2.c). The mean elevations obtained from DEM-1, DEM-2 and DEM-3 for Dun Fan Gravel Terrace is 658.37, 666.95 and 634.14 meter respectively. For Moderately Dissected Structural Hill the mean elevations obtained from DEM-1, DEM-2 and DEM-3 are 1468.88, 1477.70 and 1234.39 meter respectively. For Piedmont Dissected Slope the mean elevations obtained from DEM-1, DEM-2 and DEM-3 are 418.20, 444.00 and 432.95 meter respectively. For the River Terrace the mean elevations obtained from DEM-1, DEM-2 and DEM-3 are 247.24, 151.70 and 268.34 meter respectively. Similarly for the Sub Recent Fan Terrace the relief obtained from DEM-1, DEM-2 and DEM-3 are 108.15, 59.20 and 56.15 meter respectively.

The relief (Table-2, Fig.2.d) of the Doon Fan Gravel Dissected Hill obtained from DEM-1, DEM-2 and DEM-3 are 515.23, 515.23 and 443.3 meter respectively. The relief obtained from DEM-1, DEM-2 and DEM-3 for Doon Fan Gravel Terrace are 792.98, 552.60 and 568.42 meter respectively while Moderately Dissected Structural Hill shows the relief, obtained from DEM-1, DEM-2 and DEM-3 are 1762.00, 1270.08 and 1418.85 meter respectively. Relief obtained for Piedmont Dissected Slope from DEM-1, DEM-2 and DEM-3 is 23.28, 9.77 and 16.07 meter respectively. For the River Terrace the relief obtained from DEM-1, DEM-2 and DEM-3 are 247.24, 151.70 and 268.34 meter respectively. Similarly for the Sub Recent Fan Terrace the relief obtained from DEM-1, DEM-2 and DEM-3 are 108.15, 59.20 and 56.15 meter respectively.
Fig. 3: Elevation maps of various geomorphological units generated from ASTER-DEM, SRTM DEM and Topographic-DEM.
7.2 Comparison of mean slope in degree of different geomorphological units:
The analysis of the slope statistics (Table-3, Fig.4 and 5) generated from ASTER-DEM (DEM-1), SRTM-DEM (DEM-2) and Topographic-DEM (DEM-3) reveal that the mean slope of the Doon Fan Gravel Dissected Hill are 13, 2 and 3 degree respectively. Further analysis shows that for Doon Fan Gravel Terrace the mean slope obtained from DEM-1, DEM-2 and DEM-3 are 15, 3 and 5 degree respectively and for Moderately Dissected Structural Hill the mean slope obtained from DEM-1, DEM-2 and DEM-3 are 36, 16 and 24 degree respectively.

<table>
<thead>
<tr>
<th>Geomorphological unit</th>
<th>Mean slope in degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dun Fan Gravel Dissected Hill</td>
<td>13 2 3</td>
</tr>
<tr>
<td>Dun Fan Gravel Terrace</td>
<td>15 3 5</td>
</tr>
<tr>
<td>Moderately Dissected Structural Hill</td>
<td>36 16 24</td>
</tr>
<tr>
<td>Piedmont Dissected Slope</td>
<td>8 1 1</td>
</tr>
<tr>
<td>River Terrace</td>
<td>9 0 1</td>
</tr>
<tr>
<td>Subrecent Fan Terrace</td>
<td>8 1 1</td>
</tr>
</tbody>
</table>

Table-3: ASTER-DEM, SRTM-DEM and Topographic DEM based comparison of mean slope statistics of different geomorphological units.

For Piedmont Dissected Slope the mean slope obtained from DEM-1, DEM-2 and DEM-3 are 8, 1 and 1 degree respectively. For the River Terrace the mean slope obtained from DEM-1, DEM-2 and DEM-3 are 9, 0 and 1 degree respectively. Similarly for the Sub RecentFan Terrace the mean slope incurred from DEM-1, DEM-2 and DEM-3 are 8, 1 and 1 degree respectively.

7.3 Comparison of mean aspect in degree of different geomorphological units:
The analysis of the aspect statistics (Table-4, Fig.6 and 7) generated from ASTER-DEM (DEM-1), SRTM-DEM (DEM-2) and Topographic-DEM (DEM-3) reveal that the mean aspect of the Dun Fan Gravel Dissected Hill obtained from DEM-1, DEM-2 and DEM-3 are 198, 240 and 245 degree respectively. Further analysis shows that the mean aspect obtained for Doon Fan Gravel Terrace from DEM-1, DEM-2 and DEM-3 are 187, 235 degree respectively and for Moderately Dissected Structural Hill the mean aspect obtained from DEM-1, DEM-2 and DEM-3 are 200, 252 and 244 degree respectively. Similarly for the Sub RecentFan Terrace the mean aspect obtained from DEM-1, DEM-2 and DEM-3 are 198, 240 and 245 degree respectively.

Fig. 4: ASTER-DEM, SRTM-DEM and Topographic-DEM based comparison of mean slope (degree) statistics of different geomorphological units.

Fig-5: Mean slope maps of various geomorphological units generated from ASTER-DEM, SRTM DEM and Topographic –DEM

8. Conclusion

The digital elevation model (DEM), an important source of information, is usually used to express a topographic surface in three dimensions and to imitate essential natural geography. The present study analyzed digital elevation data sources and their structure, the comparison of the statistics of numerous terrain attributes extracted from the different DEMs. The results show that DEM is a very effective tool for terrain analysis: many terrain attributes (such as elevation slope, aspect, relief etc) can be derived and can be displayed with both image and attribute databases with the help of GIS.

The elevation statistics (minimum, maximum and mean), relief statistics, slope statistics and aspect statistics of various geomorphological units have been generated from ASTER-DEM (DEM-1), SRTM-DEM (DEM-2), and Topographic DEM (DEM-3) and the analysis of the minimum elevation of different geomorphological units in the study area shows that the DEM-1 has comparatively lesser elevation as compared to the DEM-2 and DEM-3 in all of the geomorphological units. However the difference in the relief and mean elevation among the various DEMs is more pronounced in the highland areas, such as moderately dissected hill which is in the Lesser Himalayan region, as compared to the lowland areas of Doon Valley. An analysis of the minimum elevation of all the geomorphological units DEM-1 shows comparatively lesser elevation as compared to the DEM-2 and DEM-3. This is due to higher accuracy obtained in mapping 15m area by ASTER. Moreover, the relief difference among the studied DEMs is more obvious in all the geomorphological units since the study falls in the hilly terrain of Himalayan foothill. The analysis of the slope statistics reveal that the mean slope of the DEM-1 is showing the high value of the mean slope in all geomorphological units as compared to the

Table 4: ASTER-DEM, SRTM-DEM and Topographic DEM based comparison of mean aspect statistics of different geomorphological units.

<table>
<thead>
<tr>
<th>Geomorphological unit</th>
<th>Mean aspect in degree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASTER-DEM</td>
</tr>
<tr>
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<td>198</td>
</tr>
<tr>
<td>Dun Fan Gravel Terrace</td>
<td>200</td>
</tr>
<tr>
<td>Moderately Dissected Structural Hill</td>
<td>210</td>
</tr>
<tr>
<td>Piedmont Dissected Slope</td>
<td>174</td>
</tr>
<tr>
<td>River Terrace</td>
<td>187</td>
</tr>
<tr>
<td>Subrecent Fan Terrace</td>
<td>189</td>
</tr>
</tbody>
</table>

Fig. 6: ASTER-DEM, SRTM-DEM and Topographic DEM based comparison of mean aspect (degree) statistics of different geomorphological units and 236 degree respectively. Similarly for the Sub Recent Fan Terrace the mean aspect obtained from DEM-1, DEM-2 and DEM-3 are 189,266 and 262 degree respectively.
Fig-7: Mean aspect maps of various geomorphological units generated from ASTER-DEM, SRTM DEM and Topographic –DEM
DEM-2 and DEM-3. The analysis of the aspect statistics reveal that the mean aspect show lower value in DEM-1 in all the geomorphological units in comparison to the DEM-2 AND DEM-3. Furthermore, the DEM-2- and DEM-3 show lesser difference in the aspect direction. These terrain parameter variations depend on ability of GIS to process the values provided in DEM mapped on different scale and the accuracy of mapping. The study clearly demonstrate that the DEM resolution has a great influence on terrain attributes and the statistical values become larger when DEM resolution changes from coarse to fine.

REFERENCES


