6.1 Previous Studies

The slope loss or gain in altitude per unit horizontal distance in direction or the inclination of any segmental element of the earth surface with the datum, expressed in degrees is a function of multiple complex forces, such as climatic, biotic, lithologic, tectonic i.e. which control and or guide to processes involved in its development and as such it is of prime concern to geomorphologists. Slope is an important element of the landscape which discovers close observation. It is a measure of the rate of ascend or descend per unit horizontal distance (Gradient) expressed in degrees. There are two school of thought regarding the sequential evolution of slope namely the 'uniformitarian' or 'paralleled retreat' led by Lester King (1967) and 'climatic control' followed by Davis W.M. (1909) Like absolute and relative relief, information regarding from the contour map; it can also slope determined by field measurements. The technique for calculation of slope was put for as early as 1890 by Finesterwalder, who inteneded the following formula.

This method appears to result in over-weighting certain parts of topography, because it has always been a tendency to emphasize valleys in reference to peaks.

6.2 Methodology for the Present Study –

Wentworth (1930) devised a method by covering the entire area with a grid of equally spaced E-W and N-S lines, counting the number of crossing of contour lines on four sides of a square of grid and then calculating the slope the help of following formula

\[
\tan \theta = \text{Average Slope} = \frac{\text{Average Length Contour} \times \text{Contour interval}}{\text{Total area}}
\]

This method gives only a general an average picture to
Average Slope

slopes with the result that very high and very low values of slope are somewhat smoothened. Smith (1935) therefore examined the problem on the basis of the altitudes of relief i.e. relative relief. Which by implication gives a picture of average slope. It hides the actual values, Pushing it upward or downward, with the result that, at times, smaller escarpment get completely lost in area of gentle slopes. Later Miller, A.A. (1949) suggested that the differences in minimum and maximum elevations obtained for various squares of the grid, should be divided by their respective horizontal distance. Another modification was put forward earlier by Raisze and Henry (1937). They divided the large scale topographical map ratio into small standard spacing i.e. the some number of contour lines per mile of horizontal equivalent and represent slope in feet/mile. The chosen categories were seven and in numbers representing-slopes of under 50/miles 50-100/mile and 50 on. A horizontal scale of standard contour spacing was drawn 50 that number of contours per million, the map scale could be checked with divides and the slope categories as certained by careful inspection. Later Robinson (1948) divided still another, rather difficult and laborious method to produce a quantitatively accurate relief map from areal slope data. He covered his map with a network squares was estimated and one dot for each degree of average
slope was placed within it/ the dots were not placed systematically within each square, but their positions were determined by reference to contours on the topographical map and to dots in adjacent squares so that continuity may be maintained. Although the dot density gives a very good visual impression, yet it fails to give a precise quantitative information regarding slopes.

Miller, O.M (1960) has been concerned with a method preferable to hypsometric tinting an oblique hill shading for presenting the pattern of relief at high attributes and high speeds. He first suggested this slope-zone method in 1951 and developed it later in 1960. His aim was to emphasize slope rather than elevating by dividing the surface into a series of zones with successive degrees of slopes and indicating them by clear, through subdued tinting.

6.3 Average slope Categories –

The average slope of Mor basin has been obtained by Wentworth method. This method has been used quite frequently for presenting slope morphology. In the present analysis the contour map of the study area has been covered with network of squares having and unit of 10.24Km$^2$ and then the number of contour cutting have been counted along each side of unit
Average Slope

square. Sub-sequencey the number of contour cutting per meter has been calculated by dividing the total number of contour cutting of squareunit. In this way, some 435 by 4mile (sum of the four sides of square have been analysed the slope values, thus obtained can be divided into the following categories as suggested by Singh, R.L. (1967), Fig. 6.2 Table VI.1 gives the distribution of average slope in the study area. Statistical analysis shows that the mean median and modal values of an average slope in the area are 3.89, 3.20 and 3.99 respectively.

Table VI.1
Slope-Area Relationship in Mor Basin

<table>
<thead>
<tr>
<th>Sloping Degree</th>
<th>Symbol</th>
<th>Frequency</th>
<th>Area (Km²)</th>
<th>%</th>
<th>Cum %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2</td>
<td>Sl</td>
<td>186</td>
<td>1904.64</td>
<td>42.76</td>
<td>42.76</td>
</tr>
<tr>
<td>2 – 5</td>
<td>Sg</td>
<td>146</td>
<td>1495.04</td>
<td>33.56</td>
<td>76.32</td>
</tr>
<tr>
<td>5 – 10</td>
<td>Sm</td>
<td>52</td>
<td>532.48</td>
<td>11.95</td>
<td>88.27</td>
</tr>
<tr>
<td>10 – 15</td>
<td>Sms</td>
<td>31</td>
<td>317.44</td>
<td>7.14</td>
<td>95.41</td>
</tr>
<tr>
<td>15 &gt;</td>
<td>Ss</td>
<td>20</td>
<td>204.80</td>
<td>4.59</td>
<td>100.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>435</td>
<td>4454.40</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

Mean : 3.89, Median : 3.20, Mode : 3.59
All these values fall under the category of level slopes. The mean is a bit matter to origins than median. It is noted that the mean value of average slope is higher as compared to its modal and median values. The mean, median and modal value of 3.89, 3.20 and 3.99 in fact indicates that the present topography is in old stage landform development. Thus the area is at present, experiencing some what accelerated erosion after its unliftment in the late Tertiary times.

6.3.1 Areal Distribution of Average slope categories and their correlation with Absolute relief –

Table VI.2 show that relationship between absolute relief and average slopes. The statistical correlation of these variables is somewhat difficult as the data for slopes have not been extracted from each one minute squares like that of absolute relief. Instead these are based on parallelism and spacing of contour lines. However a comparison of the slope map (Fig 4.1) with altitudinal map (2.1) through some light on the diversity of slope distribution in the area. There is low positive coefficient of correlation is (+0.286). it is noted that a large part of basin surface except the highland margins in the old age of landform development.
It is also noted that the average slope categories (Fig. 5.2) more or less coincide with the various altitudinal zones. This clear from the following description of the five broad categories of average slopes suggested slope in the area is as follow (Fig. 6.1, 6.2 Table VI.2)

**6.3.1.1 Level Slope (Sl : Less than 2°) –**

Level slope category covers an area of about 1904.64Km² or 42.76% of the study area. It is largest category in terms of areal coverage. It is mostly confined to the lower peneplain and gently sloping alluvium flood plains of the major streams. Patches of the level slope also occur associated with the flat-topped upper basin surface. Table V.2 which give the distribution patterns of average slope value relation to absolute shows that the height categories of less than 100m, 100m-200m, 200m-300m, 300m-400m, 400m-500m and over 500m account for 31.72%, 25.81%, 10.75%, 16.13%, 15.59% and 00.0% of the area under level slope categories respectively.

The level slope category includes the upper Mor valley (488m) Dhanadih Ravine area (300m), Dumka (288m), Asansol (130m), Agola (120m) peneplain, Nakti Pahar (274m), Kurua Tableland (154m), Rajapather upland (440m) in Northern west Asanbari (220m) Ardbuni (100m) Nalhata (100m) Ardbani.
(140m), Palasi (80m), Nawadih (100m) Tableland, Santi (100m), Manbazar (94m), Bharkata (80m), Sanakpur (108m) Palasi (89m), Mayureshwar (98m), Dhaba (180m), Mayurakshi Nager (120m) peneplain, Lower Mor valley (180m) in southern east and Kusumhata (474m), Masanjor (400m) Pahar Kalahar table land (200m), Mayurakshi Reservoir area (300m), Kendghata upland (320m) in the south western part of the study area.

6.3.1.2 Gentle slope (Sg : 2°-5°) –

Gentle slope characterizes of 1495.04Km² or 33.56% of the study area. It is the second largest category informs of areal coverage. It covers mainly the undulation separating the flat countries and the margins of the ranges. Table VI.2 reveals that 31.51%, 21.92%, 6.85%, 0.96%, 10.27%, and 18.49% of the area under gentle slope are associated with the altitudinal zones of less than 100m, 100-200m, 200-300m, 300-400m, 400-500 and over 500 m. respectively. Gentle slope category includes the Bhurkhar (400m), Pusaro (300m), Bhamri (250m), Kandgnata upland (320m), Ravine area (300m), Amba (420m), Naunihar (440m), Sadhudih (278m) Pahar, Kathjuria (200m), Mohanpur (400m) scarp, Kanto (400m), Pargadih (240m), Nawadih (220m), Kharsuri Table Land (180m), in north west. Brahmapabaria (100m), Muhammabazar (52m), Raniswari
(200m), Kumardiha (100m) Peneplain, Mahapur (120m), Chandan nagar (200m), Makhkdum nagar (180m), in southern east and upper Naubil (320m), Sidheswari(100m), Lower Naubil (300m), Chandana (200m) valley, Saraydiha gorge (200m), Hathia Pahar (280m), Laberia Peneplain (120m) in the south western part of the study area.

6.3.1.3 Moderate slope (Sm : 5º-10º)

Moderate slope cover on area of about 53.248 km² or 11.95% of study area. it is mostly contained to the steeper escarpment zone of the up land Margins and isolated highlands. Table VI.2 reveal is that the altitudinal zones of less then 100m, 100-200m, 200-300m, 300-400m, 400-500m, and over 500m respectively. This slope region is confined to Kkm Patharia gorge (420m), Lakhana Penplain (380m), Nonia (398m), Sahara (362m), Amba(400m) upland, Tepra valley(362m), in northern west and Chandra peneplain (108m) and suri (120m), Sugapahari (220m), Table land. Bahadurpur upland(400m), Gara (427m), Katri(265m), in south western part of the study area.

6.3.1.4- Moderate steep slope (Sms 10º-15º)–

It Covers an area of about 317.44 km² or 7.14% of the study area. It revels that the altitudinal zone of lass then 100m,
100-200m, 200- it revels that 58.06%, 16.13% and 25.81% of study area. This slope regions confined that Karbind upland (320m) Raghuadih pahar (476m), Talljhari (430m), Mahapur (470m) in north west and Karbani painplain(220m), Naubil – Siddheswari water divid area (235m), Patanpur gorge(300m), Kujutana upland (300m) in the southeastern part of the study area.

6.3.1.5- Steep slope :- Ss : over 500m

This category covers an area of about 204.80km$^2$ or 4.59% of the study area. It revels that 55.00%, 10.00%, 20.00%, and 5.00% of the study area. That reveals lass then 100m. 100m-200m, 200m-300m, 300m-400m and over 500m. This slope region confined that Kurua upland (480m) Trikut Pahar (753m), Dhobnatanr gorge (395m) in the northern east and Karmatnr scarp (240m) Bagdaha upland (280m) Kunjora Pahar(240m) in the south western part of the study area.

6.4 Isotangent and Isosine maps-

The magnitude of slope in an area may also be portrayed by using two trigonometric funclious i.e. tangent and sine. When tangent values of the angle of slope is contoured., it is called Isotangent map and when the Isosine function is used, it is called Isosinal map Both the maps have been draw from the data
obtained by the contour cutting permile as for average slope. The equivalent values of the sine and tangent of slopes have been calculated for each grid. The Isosinal maps (Fig 6.3. & 6.4) are of great importance for the evil engineers and planners.

6.4.1 Isotangent Value

The Isotangent slope map has been called as the first derivate map by Strahler A.M. (1956), because it depicts the values of the first derivative of the slope function over the entire ground surface by using formula VH. It is also termed as the 'rate of change map' because engineers tread slope in terms of percent of grade which is identical with the tangent of the slope angle. This isotangent map can be applied to civil engineering problems.

An examination of the isotangent map (Fig 6.3) reveals that the isotangent the lines in harmony with major relief feature the lowest categories with tangent values of 0.1 and bellow grids the alluvial plains of Mor basins. Dumka (288m), Asansol (130m) Agola (120m) peneplain upper Mor valley (180m), Kurua tableland (154m), Nakti Pahar (274m) in northern west and Asanbari (200m), Ardbuni (100m), Naugarh (192m), Shekhpur (120m), Makhdum Nagar (180m), Chandan Nagar (120m), Mohanpur (120m) upland, Hingia gorge (240m)
Mayureshwar (98m), Dhaba (180m), Myurakshi Nagar (120m) Peneplain, Lower Mor valley (180m) in southern east and MasanJor Pahar (400m), Kolahar tableland (200m), Mayurakshi Reservoir area (300m) and Lower Naubil valley (300m) in the south west part of study area. Similarly the undulations separations the valley flats and uplands are represented by isotangent lines with values of 0.1 and 0.2 under this category in also in duded the isolated hills and water divides like the Bhurkhar (400m) Pusaro (300m) Bhamri (250m) valley, Amba (420m), Naunihar (440m), Sadhudih (278m) Pahar. Kathjuria (200m), Mohanpur (400m) scarp, Kanto (400m), Nawadih (220m) upland, Hansdiha (392m), Palajori gorge (240m), Kharsuri tableland (196m), Karbani peneplain (300m) in North West and Brahamberia (100m), Ranishwar (200m), Kumardih (100m) peneplain, Mahapur (120m), Chandan nagar (200m) upland in south east and upper Naubil (320m), Siddheshwari (200m) basin, Chandan (200m) valley. Saradiha gorge (200m) Hathia (280m) Kusumghata (474m) pahar in south western part of the study area. Higher Isotangent values of 0.2 and 0.3 included the area of Rahguadih Pahar (476m), Kakmpatharia gorge (420m), Karbind (320m), Nonia (398m), Sahara (362m), Amba (400m) upland. Tepra valley (362) Taljhari (438m), Mohanpur (470m) Scarp in north west and Chandra peneplain
Average Slope

(108m) in south eastern and Siuri (120m), Sugapahari (220m) tableland, Bahadurpur (400m), Kujutana (300m) upland, Katri (265m), Gara (427m) pahar, Patanpur gorge (300m), Siddheshwari Naubil water divide area (335m) in the south western part of the study area.

Table VI. 3
Isotangent value of Mor Basin

<table>
<thead>
<tr>
<th>Isotangent</th>
<th>Frequency</th>
<th>Area (Km²)</th>
<th>(%)</th>
<th>(Cum%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.10</td>
<td>182</td>
<td>1863.68</td>
<td>41.84</td>
<td>41.84</td>
</tr>
<tr>
<td>0.10-0.20</td>
<td>152</td>
<td>1556.48</td>
<td>34.94</td>
<td>76.70</td>
</tr>
<tr>
<td>0.20-0.30</td>
<td>80</td>
<td>819.20</td>
<td>18.39</td>
<td>95.17</td>
</tr>
<tr>
<td>0.30 &gt;</td>
<td>21</td>
<td>215.04</td>
<td>4.83</td>
<td>100.00</td>
</tr>
<tr>
<td>Total</td>
<td>435</td>
<td>4454.40</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

Mean : $0.06^0$  Median : $0.08^0$  Mode : $0.09^0$

Over 0.30 includes the Dhoobonater gorge (395) Trikut Pahar (753) Kurua upland in N–W of study area.

6.4.2 Isosinal Value

Isosinal map (Fig6.4) shows a somewhat similar trends as the isotangent map except that the isosinal contours appear to the more evenly distributed. This is due to rapid increase in the
angle of slope. These values in fact reaches infinity as the angle of slope approaches 90° contrast the isosinal values range between 0.3 only. The sine angle of slope has an important can notation in dynamics of slope formation. According to Strahler, A.N.(1956), it represents that part of the total gravitational force which tends to produce down hill sliding or flowage of rock particles or fluid on the surface. Where the gravitational force is considered for an unit mass the down slope force is equal to \( g \cos (\pi/2 - \beta) \). The isosinal map consisting of lines of equal sine values of slope angles, significance the distribution of that part of gravitational acceleration \( g \) which has contributed to the down slope force at any given point of surface. There fore Strahaler designated the isosinal map \( g' \) map.

**Table VI.4**

<table>
<thead>
<tr>
<th>Isosine</th>
<th>Frequency</th>
<th>Area (Km²)</th>
<th>(%)</th>
<th>(Cm%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.10</td>
<td>193</td>
<td>1976.32</td>
<td>44.38</td>
<td>44.38</td>
</tr>
<tr>
<td>0.10-0.20</td>
<td>164</td>
<td>1679.36</td>
<td>37.70</td>
<td>82.08</td>
</tr>
<tr>
<td>0.20-0.30</td>
<td>68</td>
<td>696.32</td>
<td>15.63</td>
<td>97.71</td>
</tr>
<tr>
<td>0.30 &gt;</td>
<td>10</td>
<td>102.40</td>
<td>2.29</td>
<td>100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>435</strong></td>
<td><strong>4454.40</strong></td>
<td><strong>100.00</strong></td>
<td></td>
</tr>
</tbody>
</table>

Mean : 0.07°   Median : 0.05°   Mode : 0.06°
The isosinal map is quite useful in military science because it clearly shows. The isoninal line below 0.01 consists the area of Agla (120m), Asansol (130m), Dumka (228m) peneplain, Dhanadigh Ravine area (300m), Kura tableland (154m), Nakti Pahar (274m) in Northern west of study area and Ardbhuni (100m), Nawagrah (92m), Shakhpur (120m), Makhdumnagar (180m), Chandan Nagar (120m), Mohanpur (120m), Kalahar Table land (220m) upland, Hingia gorge (240m) Mayurakshi Nagar Reservoir area (300m) Kusumhata Pahar (474m) in the southwestern part of the study area. 0.10-0.20 value consists the Pusaro (300m), Bhamri (250m), Bhurkhar (400m) valley, Amba (420m), Naunihar (440m), Sadhudih (278m) Pahar, Mohanpur (400m) Scarp in Northwest Rameshwar (200m), Kumardih (100m), Brahambhariya (100m) peneplain, Chandana nagar (200m), Mahapur (120m) upland in southeast and Sindhishwari (180m) Chandana (200m) Upper Naubil (320m) Valley, Saraydiha gorge (200m) Hathia (280m), Kusumghata (440m) Pahar in south western part of the study area.

0.20-0.30 value consists Kakmpathariya gorge (180m) Karbind (230m) Noniya (398m) Sahara (362m) Amba (400m) upland. Tepra (362m), Tajhari (438m) Mohanpur (470m) scarp in Northwest and Chandra Peneplain (108m) in Southeast Siuri (120m), Sugapahar (220m) Table land, Bagdaha (280m),
Bahadurpur (400m), Kujuhata (300m) upland, Siddheshwari Naubil ater divid area (235m), Patanpur gorge (300m), Karmatner scarp (240m) in the south western part of the study area.

The isosinal value over 0.30 consists the Dhubatnr gorge (395m) Trikut Pahar (753m) Kurua upland (480m) in Northwestern part of the study area.

6.5 Summary and conclusion –

The slope of the study area has been analysed according to Wentworth's Method of average slope. Thus 5 Broad categories of slope less then $2^0$(sl), $2^0$-$5^0$(Sg), $5^0$-$10^0$(Sm), $10^0$-$15^0$(Sms) and over $15^0$ (Ss) have been identical. Those account 42.76%, 33.36%, 11.95%, 7.14% and 4.59% of the study area respectively. It is noted that about 42.76% of the basin surface has slope of less than $2^0$ characterize the alluvial plains of Dumka (288m), Asansol (130m) peneplain, Bhurkhar (400m), Pusaro (300m), Bhamri (250m) valley, Kathjuriya (200m), Mohanpur (400m) scarp. Siddheshwari-Naubil water divid area (235m) Mayurakshi Reservoir area (300m) in the North west and south western part of the study area. There is a low positive correlation ($r = +0.286$) has been found between average slope and absolute relief. Besides isotangent and isosine values to
assess the suitability of various types of terrain for road building, military maneuvers, and planning purposes.

6.6 References -

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