THE INTERNATIONAL JOURNAL OF HUMANITIES & SOCIAL STUDIES

Morphology of Lateritic Badlands of the District of Medinipur (West), India

Dr. Subhendu Ghosh
Researcher, Department of Geography and Disaster Management
Tripura University (A Central University), Suruamaninagar, Tripura (West), India

Abstract:
Gully is an extended form of rill, a narrow channel worn in the earth immediately after the rainfall occurs. It is especially a miniature valley resulting from a heavy downpour of rain. Soil erosion caused by formation of gully channel resulting from a sudden heavy downfall of rain which cuts channels (gully) in soil or soft rock, is major problem soil erosion today. The area seeking erosion to gully and rills is changing with time in terms of morphologic set-up. Many micro-geomorphologic features are formed with the extension of gullies. The rills formed immediately after the rainfall is extended by width and depth ensuring the loss of soil in a rapid way. Geomorphologic structure like topography, slope and existing geology, soil character, vegetation cover and anthropogenic factors are responsible for the changing variation over the badlands area. Soil loss due to erosion is alarming us about the future disastrous impact on our limited land resource. Extension of gully over the agricultural land, forest land as well as build-up area is a major cause of rapid decrease of land and it's covering floral and faunal species including manmade structure. This is most prominent in my study area especially along the banks of Kansaboti, Silaboti and Subarnarekha River. Rapid gully expansion over the bare surface is alarming us to regulate soil erosion and ensure land conservation. Beside gully erosion, there are another three types of erosion processes which are rill erosion; sheet erosion and bank erosion have effectively carried the erosion process. The present study deals with the morphological change of the lateritic badlands. Many micro-geomorphologic features have been described with examples.

Keywords: *Badlands, Micro geomorphology*

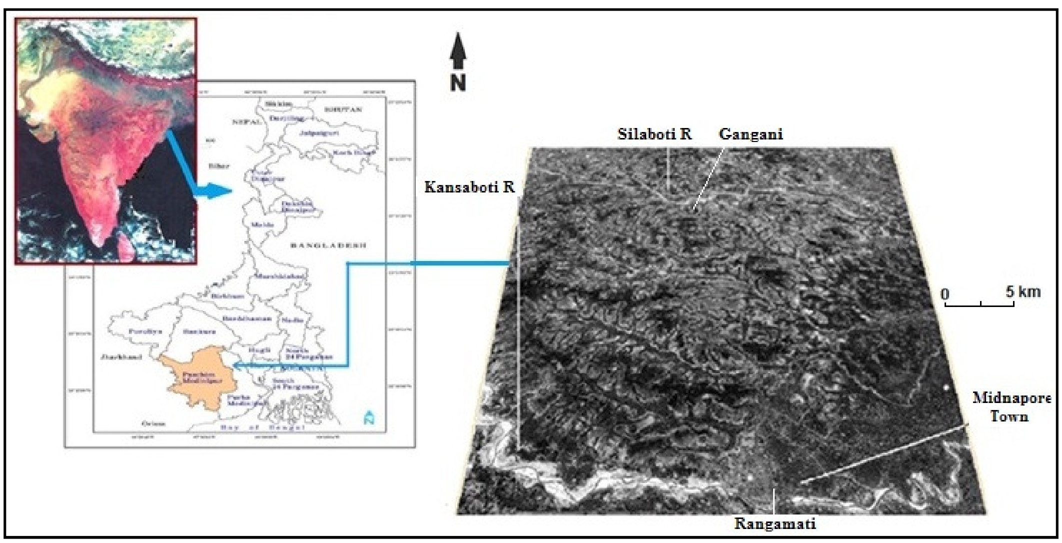

Figure 1: Location of the study area

1. Introduction

Gullies are "relatively permanent steep-sided water courses which experience ephemeral flows during rainstorm" (Morgan, 1995). The size of the gullies varies from shallow 0.3-1 meters deep gullies to over 20 meters deep ravines (Bergsma, 1996). Gullies normally have a distinctive propagating head, which is the morphological expression between stable and unstable re-grimes (Rebeiro-Hargrave, 2000) and where overland flow from the catchments above enters or falls into the gully. The important processes of gully propagation are concentration and the incision of overland flow, gully wall collapse (slumping) and piping (e.g. Morgan, 1995). In figure 2 gully development has been beautifully showed. It has been revealed in field investigation that the headword extension of gully occur in the monsoon period by forming alluvial cone on the gully head wall (Figure 3). The study has been conducted on the lateritic highland of the district of Paschim Medinipur Which covers the lower basins of Kansabati, Silabati from south-west to north-east (Figure -1) especially at Rangamati area in Midnapore and gangani near Garhbeta.

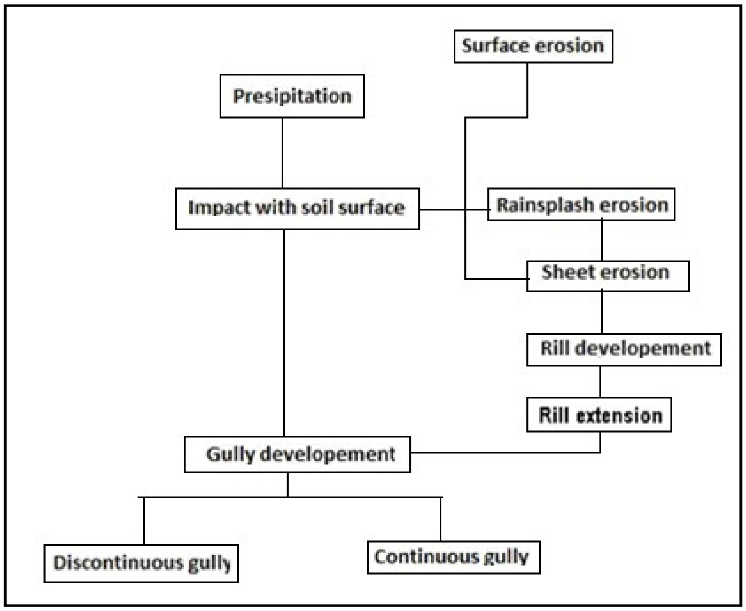

Figure 2: Gully Development Model

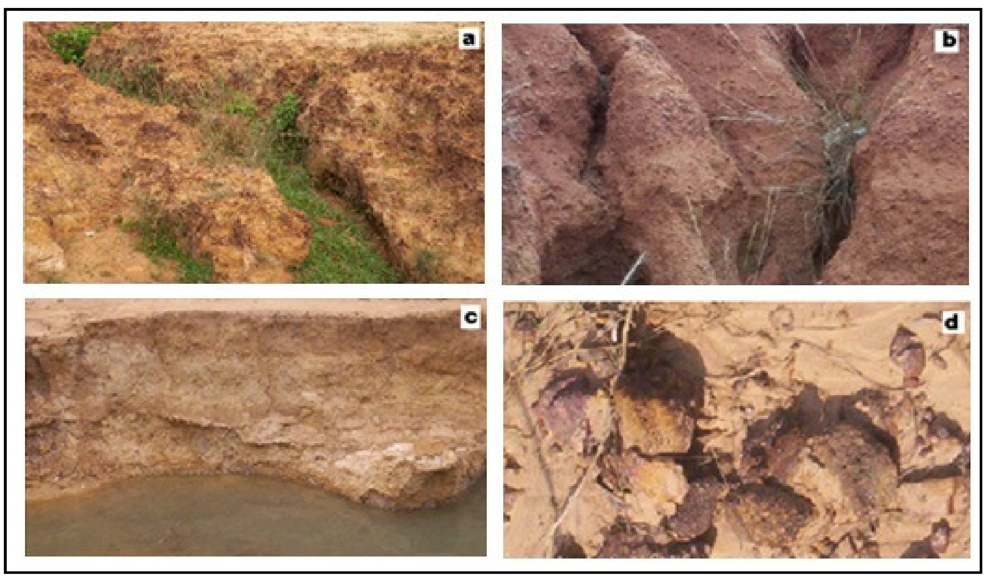

Figure 3: Ground photograph of different types of erosion in the study area.
a)Gully Erosion b) Rill Erosion c) Bank Erosion d) Sheet Erosion

2. Methodology

The data were collected mainly from field surveying done by traditional surveying instruments like clinometers, prismatic compass and dumpy level survey to define the pattern of drainage and distribution of gully erosion. Prior to visit the study area the author had reviewed past literature and data of various govt. And non-govt organization.som typical photograph has been taken into consideration to know the ground reality of landforms. Land sat ETM+ data and Google image of the study area has been used to prepare the drainage maps by ILWIS 9.0 software to show distribution of rills and gullies in the lateritic uplands.

3. Gully Morphology

- Gully morphology deals with the study of different shape of gully channel, channel slope, gully types, pattern of gully drainage and other landforms formed in the way from gully head to local base level. Here the study area has shown the headword extension of gully by forming angular fan at the foot of the gully head (Figure 2).The author has attempted to classify the channel slope from gully head to gully valley following the Dalrymple's nine unit land surface model (Figure 4). Here a profile has been done at Rangamati gully site for good interpretation of this above model (Figure 5 & 6).

- Two distinctive types of gully morphology are apparent for first order channels in the study areas: (1) entrenched gullies with a characteristic flat U-shaped cross- section and steep head cut above which the catchments is drained by shallow rills; and (2) dendrite gullies characterized by a dendrite network of rills incised within a broad V-shaped cross-section(Figure 8a). The channel system grades with or without distinct head cuts to the catchments divide. Both site relief and host materials appear to control gully morphology. Entrenched gullies, confined to the Garhbeta Basin, are associated with incised main channels along the fan axes and silt rich soils. Dendrite gullies are characteristic of the entire gully basin in the study area. On the flats they are commonly found at the fan margins in association with saline clay-rich soils.
- According to Zonn (1986) variation of elevation within 0.2 m to 1 m is called micro-relief. Height or elevation influences surface slope angles. The present author have measured the micro-relief conditions along gully channel (Figure 1, Table 1) in order to understand the influence of elevation change upon surface slope in very small area or micro geomorphic area. It has been observed that the change of elevation within a very small area results the change of surface slopes, which create rugged condition of landform at micro level. These micro level changes of slopes also influence whole shape of the studied cross profiles. Table-1 shows some evidences of general condition of gradient at micro-level by the influence of micro-relief in the study area. This data has been shorted out according to the value of micro-relief because it is not possible to show all the data of the field area in a short space.

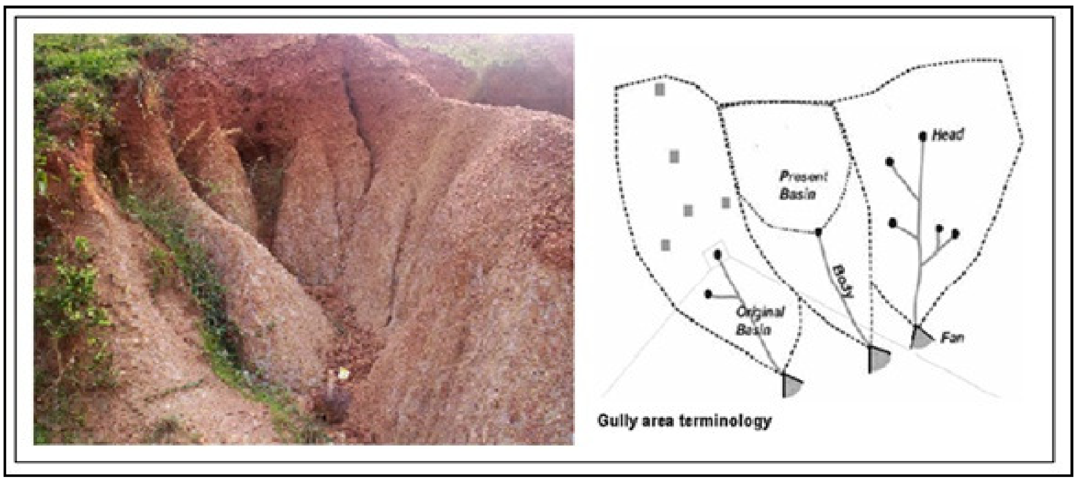

Figure 4: Gully Development and terminology related to gully landscape

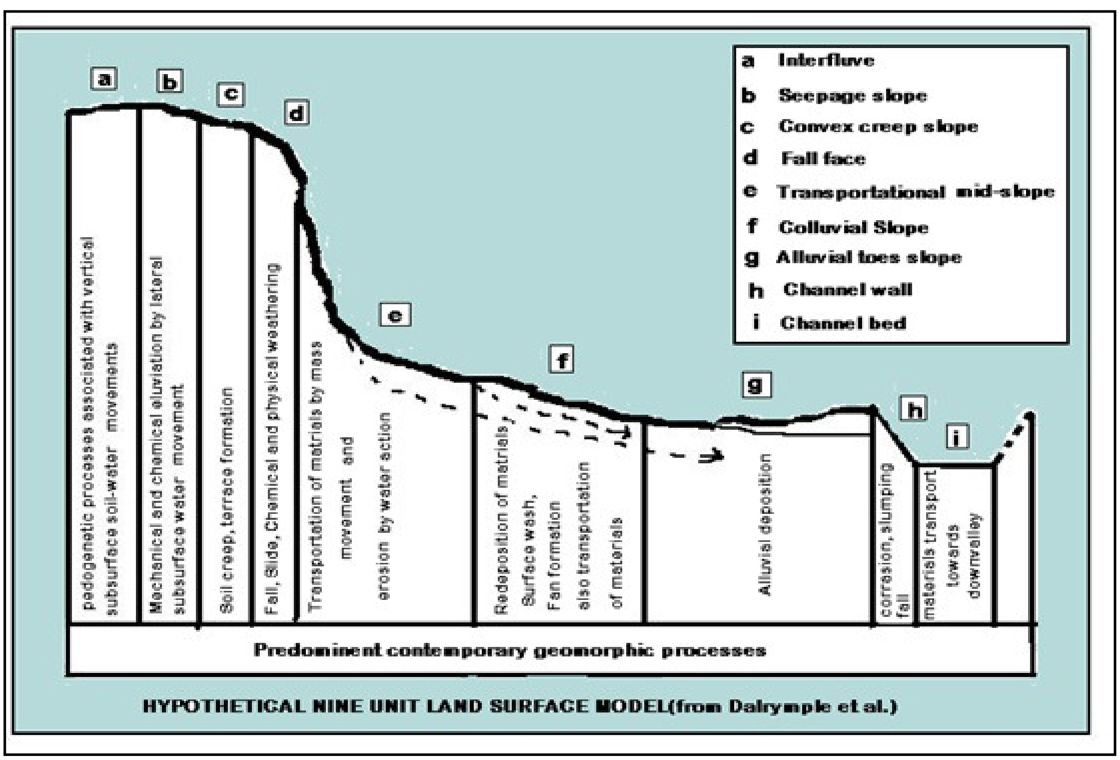

Figure 5: Hypothetical nine unit land surface model
Source: - Dalrymple et al.

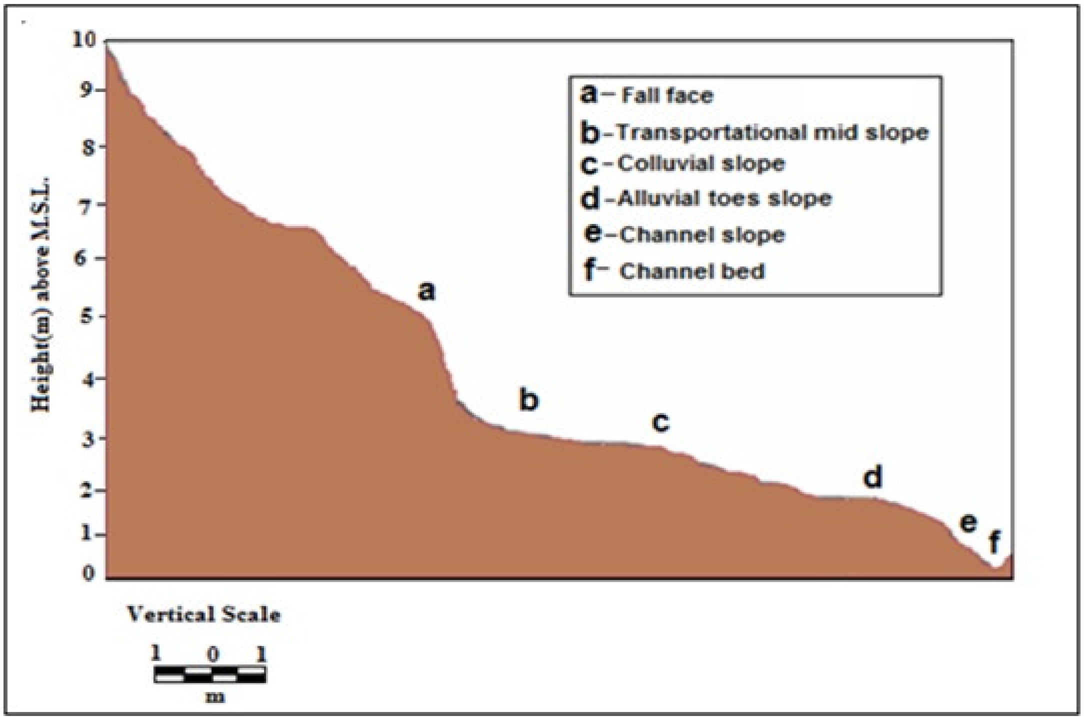

Figure 6: Cross sectional profile to show channel slope variation at Rangamati badland region

Station	Length (m)	Depth (m)	Distance With Angle(NE-SW)						Scale
			1.5	1.7	1.7	1.9	1.7	1.5	
Gopegarh-1	10.6	1.8	34	12	27	32	38	68	1cm to 1m

Station	Length (m)	Depth (m)	Distance With Angle						Scale
			1.5	1.5	1	1	1.5	1.5	
Gopegarh -2	8	2.3	32	26	4	23	36	45	1cm to 1m

Station	Length (m)	Depth (m)	Distance With Angle						Scale
			1.2	1	1.1	1	1.2	1	
Ggopegarh-3	6.5	2.8	52	42	12	34	42	105	1cm to 1m

Station	Length (m)	Depth (m)	Distance With Angle (E-W)						Scale
			1.5	1.5	1.5	1.5	1.5	1.5	
Rangamati	9	1.7	36	33	21	12	25	53	1cm to 1m

Station	Length (m)	Depth (m)	Distance With Angle N-S						Scale
			2.1	2	2.3	2	2	2	
Guguripal	12.4	4	22	43	46	85	73	36	1cm to 1m

Station	Length (m)	Depth (m)	Distance With Angle NW-SE						Scale
			2.5	2.5	2	2	2.5	2.5	
Gangani	14	6.5	64	48	34	43	49	56	1cm to 1m

Table 1: Measurement of Shape of the Gully Channel Valley by Cross Section at different site of the study area

3.1. Morphological Measurements of the Gully Channel

In the selected profiles some micro level angles on the surface of the profiles are recorded more than 90°, which create small overhang slopes. During the field study it has been observed that overhangs cause gravity sliding and removal of upper layer sediments. Finally, it changes micro level shape. The present author's view is that these are very important geometric forms as development of many micro-overhang slopes which may cause large removal of upper layer sediments and modify the original shape of profiles. Vertical slopes, almost 90° angles, are very common where the elevation is very high within a very small area. Some steep micro-slopes are found which have more than 40° angles. Some sketches of different types of geometric features of micro-slope conditions found in the present study area are shown in the following figure. All these are the evidences of the ruggedness of this area at micro level often ignored in the geomorphic explanations. Measurement of gully depth and width and angle of slope have been recorded by simple clinometers and measuring tapes (Table 1). The very common pattern of gully valleys found in the study area has been shown in figure 7 and for this some ground photograph has also been taken in the southern bank of Silabati River and shown in Figure 8 and Figure 9. In this study area it has been commonly seen that most of area have experienced V shaped channel valley in the upper course which has converted as Flattened V shaped or nearly U shaped valley at the lower course of gully.

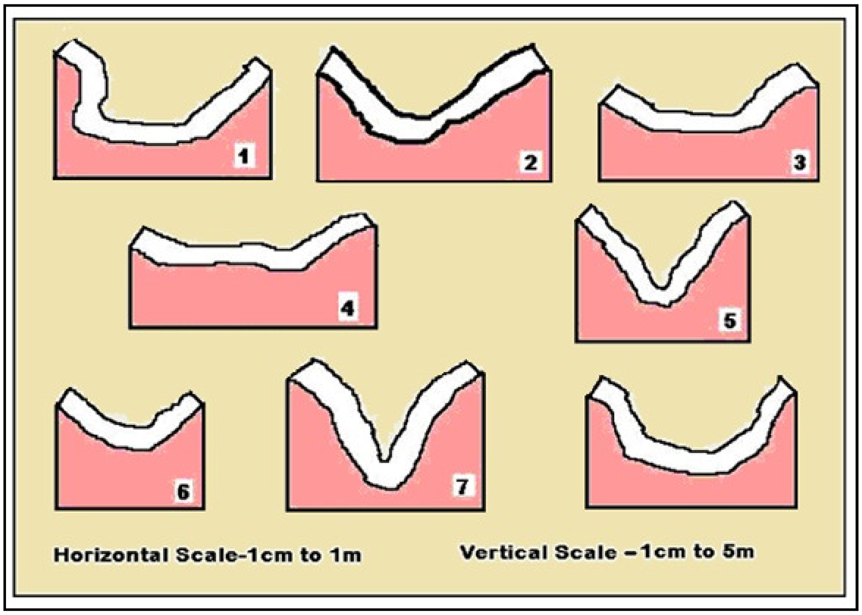

Figure 7: Various shape of gully valley found in the study area

Successful mapping depends on knowing the characteristics of a gully, and using that Information to define the appropriate mapping technique (King, 2002). Gullies have been characterized by a number of different criteria. The Food and Agriculture Organization (FAO) (1965) and Hudson (1985) described gullies simply as geomorphic features that do not allow for normal ploughing. The shape of gully cross-sections and soil material in which a gully develop have also been used to characterize gullies, with V- and U-shaped gully cross-sections subdivided according to the type of sedimentary material present (Imeson and Kwaad, 1980). Morgan (1979) gave a more landscape-based approach defining gullies as "relatively permanent steep-sided eroding water courses that are subject to flash floods during rainstorms." Gullies have been characterized based on the shape/pattern produced by the physical and land use factors influencing drainage as seen in Figure 1 (Ireland *et al.*, 1933; Twidale-2004.) Some important topographical properties that control the erosion processes are slope steepness, length and shape (Morgan, 1986). Topography is an important determinant of erosion potential since it controls the energy gradients. Gullies can develop on very gentle to steep slopes, but are most numerous on strongly sloping land (Bergsma, 1974). The gully channel is similar type of morphological unit like river. The author have surveyed and taken cross-sectional measurement in different part of the study area. These cross sectional profiles reveals very clear pictures of channel variation of different gully and different parts of a particular gully. Stage-wise change of channel shape depending upon the controlling factors has been measured and recorded. In the youth stage or on the upper course near origin of a gully the channel shape is commonly like a 'V' shaped in spite of 'I' shaped valley is also generated in some of the cases where the channel-bed erosion is very high due to softer bedrock and rapid water- borne weathering. It is very common in Gangani lateritic gully basin and sometimes could be seen in the other badlands area in the study area. Later these 'V' shaped valley started to move laterally by the process of sub-areal denudation and gradually it becomes wider. The angle of channel slope which are steep, gentle, moderate, sometimes overhang are different in different cases. For better understanding the basin geomorphology two contour maps has been prepared by using ASTER satellite data respectively at Gangani and Rangamati in the study area. These contour maps reveal the distribution of elevation from gully head to gully floor which helps to realize the change of height towards gully valley and base level. Different cross section profiles have also been prepared to show the actual surface position spatially and temporally. In the southern bank of Silaboti River the elevation is increasing towards north-west to south-east direction where as in the northern part of Kangsaboti River the surface height is decreasing north to south direction.

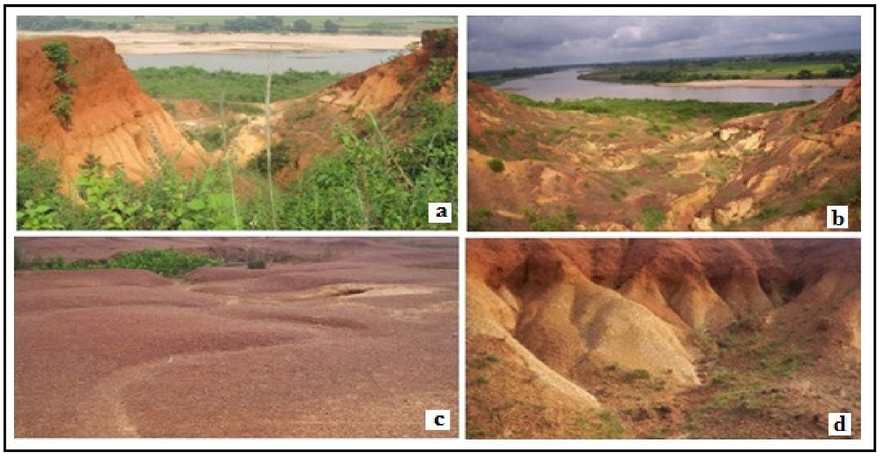

Figure 8: Photograph showing Figure a)'V' shaped gulley valley at the origin and b)flatend 'U' shaped valley near the mouth of the gully c) A rill drainage pattern d) Common fan shaped formation at the foot of the gully head

The general instrumental survey has been also done in time of grid wise data collection and maximum and minimum elevation have been recorded and the manually a contour map (figure 12) has been prepared. Actually the width is increasing with the increase of length of a gully. A positive relationship is also found between length and depth. Depth and width is quite linear near the break point and thereafter the depth and width is suddenly increased. The gully floor becomes maximum in width and flattened in the lower course of gully channel. The changes of depth and gradient throughout the 3rd order channel are not so high.

Figure 9: Slope segments in gully topography developed due to materials transportation.

3.2. Gully Head & Gully Floor

Gully heads were these points of active erosion where water penetrated in the gully network like waterfalls. Gully heads were essentially present in the high-erosion activity zone and to a lesser extent in the intermediate-erosion activity zone. They were absent from the low-activity zone downstream region. Gully heads were not activated during the summer when runoff became insignificant. Gully floor is the surface where the steep slope comes to an end and water is coming down like waterfalls (Figure 10).

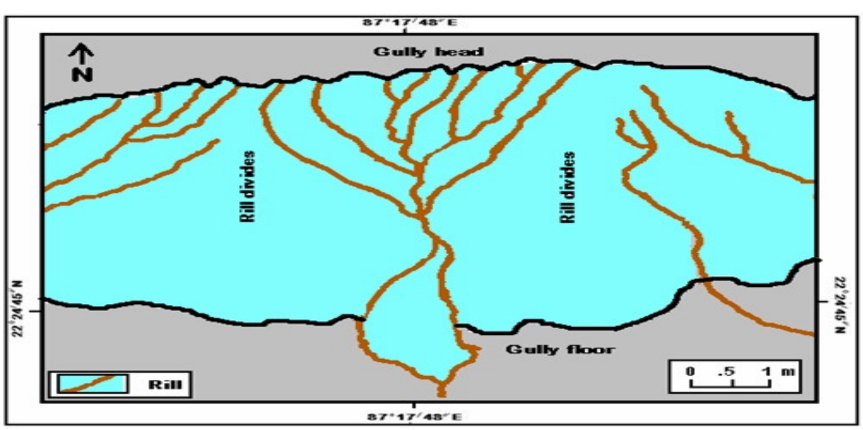

Figure 10: Location of gully head and gully floor

Gully No :	Length of the segment	Width in m.	Depth in m.
Main Gully-1	0-18m	13.5	4.1
	19-30m	11.2	3.7
	30-40m	9.4	3.1
	40-55m	7.7	2.6
	55-85m	6.9	2.4
Main Gully No 2	0-9m	11.4	3
	9-14m.	8.7	2.2
	14-40.5m	8.5	2.2
	40.5-50m	8.2	2.0
	50-70.5m	7.3	2.0
Main Gully No 3	0-15m	7.5	2.9
	15-27m	4.3	2.1
	27-55.5m	4.3	2.0
	55.5-80m	4.2	1.8
	80-117m	3.7	1.8

Table 2: Different measurement value measured by dumpy level at Gopegarh gully area

3.3. Surface Modification by Erosion

Surface lowering consists of local terrain subsidence adjacent to the gully margins. This phenomenon was mainly due to the joint action of both conductive and convective heat transfer following water flow over the peaty surface of the polygons. Zones subject to surface lowering were lower than the surrounding ground not submitted to surface run-off and with gentle slopes conformable to the direction of the water flow. Surface lowering was not as common near the gully head in the high-erosion activity zone and the intermediate-erosion activity zone, but more frequent in the low-erosion activity zone. Drainage of low-centre polygons following gully formation was very often associated with this phenomenon. Tunnel-collapse and associated active layer slumps were observed essentially in the intermediate-erosion activity zone and to a lesser extent in the low-erosion activity zone (Figure 10 and 11, Table 2).

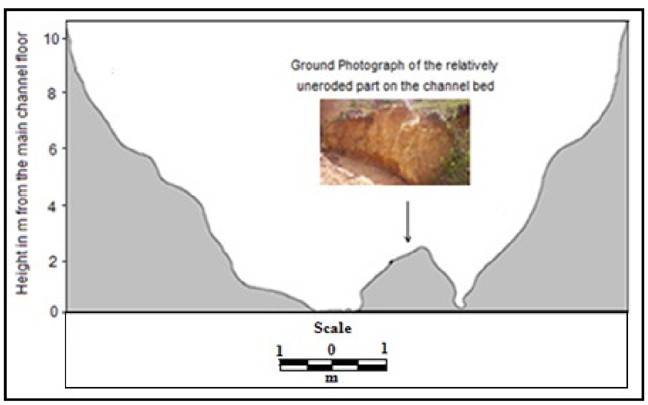

Figure 11: A profile across a gully at Gangani gully area

This profile attempts the measurement of micro-relief condition of Rangamati gully basin area. In this profile only two overhang slopes at micro-level are found which indicates that this profile is still in developing stage and comparatively stable in condition. On the middle of the channel bed deposition occurs. The width of the gully bed is 9m on the bottom and 20m on the top. So the variation of the width of the channel from to bottom is 11m. The general angles of the slope are in which micro-angles are developed (Figures 8, 9,Table 3).

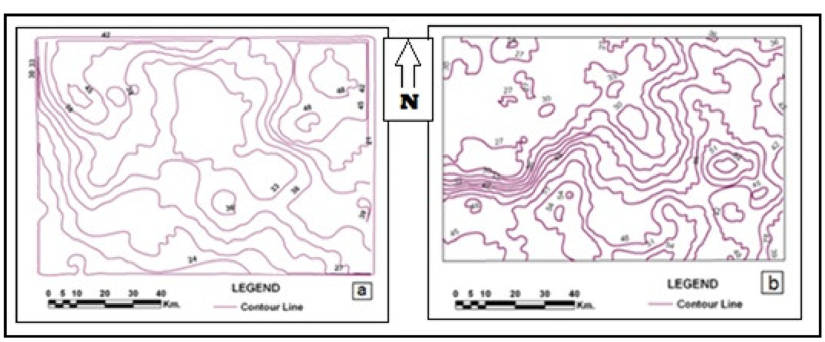

Figure 12: a) Contour map of Rangamati badland and b) Contour Map Of Garhbeta Badland

Grid No.-	Maximum elevation (m)	Minimum elevation (m)	Mean elevation (m)	Relative relief(m)
1	52	48	50	4
2	50	44	47	6
3	47	41	44	6
4	42	39	40.5	3
5	55	48	51.5	7
6	54	46	50	8
7	46	38	42	8
8	43	35	39	8
9	57	53	55	4
10	51	43	47	8
11	48	40	44	8
12	42	38	40	4
13	56	51	53.5	5
14	45	44	44.5	1
15	44	39	41.5	5
16	43	37	40	6

Table 3: Different elevation (m) measured by Dumpy Level at Gopegarh Gully Basin

3.4. Gully Divide and Rill Divide

Gully divides are the very common topographic features in this study area. It refers to the ridges lying between two successive gully channels. The shape, length and the diameter of these divides are varying from space to space and time to time respectively. Existing relief, Climate, slope, Soil character, Vegetation cover and many anthropogenic factors affect on this processes of development of ally related features including gully divides. Here in this study area , in the soft lateritic gully basin at Gangani gully divides become very steep sided and sometimes it lies as Gour like topography Whereas in other area of the study area gully divides are arise like rounded shape features (Table 4, Figure 13).

Station	Length (m)	Depth (m)	Distance With Angle (E-W)						Scale
			1.5	1.5	1.5	1	1	1.5	
1	8	2.3	27	48	34	52	39	46	1cm to 1m

Table 4: Measurement of gully divides
Source:-Field data observation

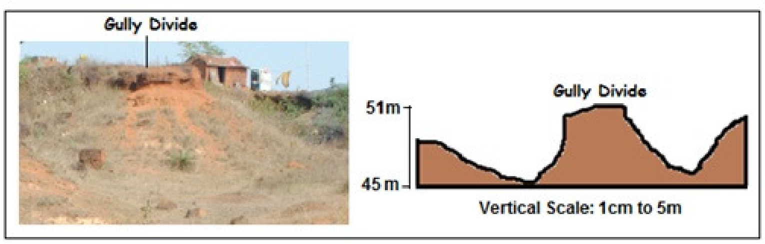

Figure 13: Photograph showing gully divide in the study area

Rill divides are similar as gully divides which are formed in between the two distinctive rills. It is a narrow and relatively small. It is also changing temporally and spatially. Headword extension of gully is very rapid in the study area especially at Gangani, Rangamati, Gopegarh, and Gurguripal which leads to the rapid lowering and ultimate extinction of these types of rill divides (Figure 13). The changes in gully divides and rill divides are the maximum in the rainy season by the process of sub aerial denudation and the minimum change occurred in the other season. I had selected some gully divides for different measurement by measuring tape, clinometers and taken digital photograph to identify the ground reality. Due to absence of vegetation cover of the study area erosion is a continuous processes in the study area. Here some bock diagrams of these relief features of different study sites are given. The rill and gully erosion has assumed alarming proportion and transformation of good land to bad land topography. So, it has become a serious geo-environmental hazard in India. In the field micro-geomorphologic variation including Channel pattern, Shape. Altitude and other morphometric measurement has been done and recorded. Sediment sample has been collected along the gully in a regular interval which has been analyzed later in our laboratory.

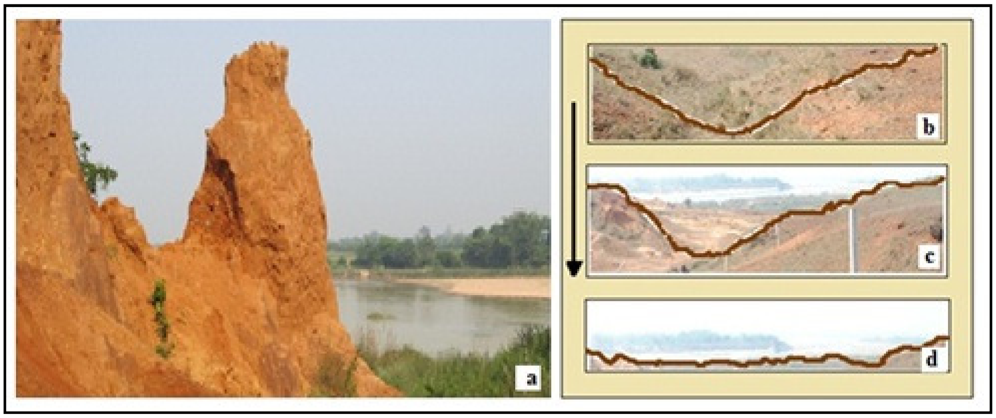

Figure 14: Photograph showing typical showrd- like landform formed by erosion on a gully divide at Gangani , Change of valley pattern in different course in a valley at Rangamati gully basin -b)Upper course c) Middle course d) Lower course (Prepared by author)

4. Conclusion

The data, either primary or secondary has been analyzed using different techniques including remote sensing mapping. Therefore computation of data, preparation of maps and diagrams have been done. The digital photographs have been taken in different season and different year to identify the temporal changes. The gully channel is similar type of morphological unit like river. The author has surveyed and taken cross-sectional measurement in different part of the study area. These cross sectional profiles reveals very clear pictures of channel variation of different gully and different parts of a particular gully. Stage-wise change channel shape depending upon the controlling factors has been measured and recorded. In the youth stage or on the upper course near origin of a gully the channel shape is commonly like a 'V' shaped in spite of 'I' shaped valley is also generated in some of the cases where the channel-bed erosion is very high due to softer bedrock and rapid water- borne weathering (Figure 14b,c,d.). It is very common in Gangani lateritic gully basin and sometimes could be seen in the other badlands area in the study area. Later these 'V' shaped valley started to move laterally by the process of sub-areal denudation and gradually it becomes wider.

Major station along the NH-60	Distance(Km)	Height (m) Above M.S.L.
Midnapore(Rangamati)	0	44
	3	43
	6	42
	9	42
Godapiasal	12	41
	15	41
	18	41
	21	39
	24	38
Salboni	27	38
	30	40
	33	41
Chandrakona Road	36	43
	39	45
	42	47
	45	48
Garhbeta	48	51
Gangani	51	51

Table 5: Measurement of elevation of some station from Gangani to Rangamati

The angle of channel slope which are steep, gentle, moderate, sometimes overhang are different in different cases. The study area has a similarity in term of landform evolution which has been described in the previous chapter but there is some disparity in elevation. Here elevation of different location has been measured by GPS and for this the Google height has bee also considered. From the Kansaboti River in the south to Silaboti River in the North maximum elevation and minimum elevation are measured as follows (Table 5, Figure 15):

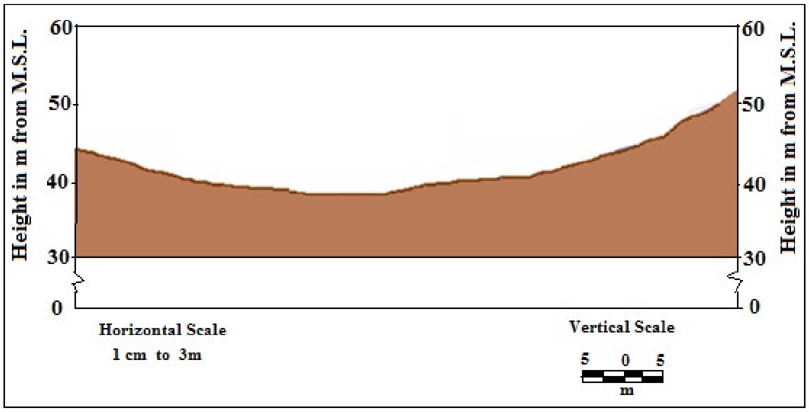

Figure 15: Profile from Midnapore to Gangani from northern bank of Kansaboti River to southern bank of Silaboti River

5. References

i. Bergsma, E. (ed.), 1996. Terminology for Soil Erosion and Conservation. International Society of Soil Science, Grafisch Service Centrum, Wageningen, 313 pp.
ii. Bergsma, E. (1974). Soil erosion sequences on aerial photographs. The ITC Journal, (3), 342-376.
iii. Brierley, GJ & Fryirs, KA (2005), Geomorphology and river management: applications of the river styles framework, Blackwell, Malden, MA.
iv. Crouch, RJ (1987), 'The relationship of gully sidewall shape to sediment production', Australian Journal of Soil Research, 25(4), pp. 531–539.
v. Imeson, A. C. and Kwaad, F. J. (1980). Gully types and gully prediction. Geografisch Tijdschrift, XIV(5), 430-41.
vi. Ireland, H. A., Sharpe, C. F. and Eargle, D. H. (1939). Principles of gully erosion in the piedmont of
vii. South Carolina. Technical Bulletin, (633)
viii. Hooke, J & Mant, J (2002), 'Morpho-dynamics of ephemeral streams', in Bull, LJ & Kirkby MJ (eds), Dryland Rivers: Hydrology and Geomorphology of Semi-arid Channels, John Wiley and Sons, West Sussex.
ix. MORGAN, R. P. C. (1996) – Erosión y conservación del suelo. Ediciones Mundi-Prensa. Madrid. 343p.
x. Morgan, R.P.C. (1995). Soil Erosion and Conservation. Longman Group Ltd., Essex, England.
xi. Morgan, R. P. C., Morgan, D. D. V. and Finney, H. J. (1984). A predictive Model for the assessment of Soil Erosion Risk. Journal of Agricultural Engineering Research, 30: 245 -253
xii. Morgan, R. P. C. (1986). Soil Erosion and Conservation. Longman Scientific and Technical, England. 298p
xiii. Olley, JM & Wasson, RJ (2003), 'Changes in the flux of sediment in the Upper Murrumbidgee catchment, south-eastern Australia, since European settlement', Hydrological Processes, 17(16), pp. 3307–3320.
xiv. Pellikka, P., B. Clark, P. Hurskainen, A. Keskinen, M. Lanne, K. Masalin, P. Nyman- Ghezelbash & T. Sirviö (2004). Land use change monitoring applying geographic information systems in the Taita Hills.
xv. Poesen, J., J. Nachtergaele, G. Verstraeten & C. Valentin (2003). Gully erosion and environmental change: importance and research needs. Catena 50, 91-133.
xvi. Rebeiro-Hargrave, A. (2000). Large Scale Modelling of Drainage Network Evolution in a Tectonically Active environment. 323 p. Ph.D. Thesis. University of London.
xvii. Soil Conservation Service NSW, (1991), Earthmovers training course, Chatswood, NSW. Bergsma,