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Geo-Ecological and Fluvio-Geomorphic Aspect and its Impact in the Nona-Baralia River Basin, Assam

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ABSTRACT :
A river has a definite and well-defined areal extent which is called as the drainage basin. It conceived of representing a working system of energy input and output and rightly be recognised as a fluvial system. Geomorphic variables like relief, slope, dissection, etc. have their great impact on fluvial landform development. Fluvio-geomrphic characteristics of a drainage basin have an impact upon basin's landform, changes on geo-ecological conditions which also has great significance with the sustainability and can be correlated with habited region .The Nona-Baralia river basin holds an area of about 764 km^2 of which an area of about 338km^2 is contributed by the Baralia and rest by the Mutanga-Nona .The Nona-Baralia river basin extent latitudnally from 26^{o}18$^/$N to 26^{o}53$^/$37$^{//}$N and longitudinally from 91^{o}29$^/$E to 91^{o}41$^/$E. The Baralia river oozes at an altitude of about 2098m at the Kurmed district of the Himalayan kingdom of Bhutan. The basin covers a part of Kamrup and Nalbari district of Assam. The river flows more the 110km in the North-South direction before joining at the Pagladiya. The basin is elongated in shape and it contains different fluvio-geomorphic features like foothills, beels swamps, ox-bow lakes, paleo-channels etc. along with extensive floodplain and natural levee formation. The highest flood discharges of about 513.26 m^3 sec^{-1} (17th June 1973) road crossing near Rangia. The basin has about 309 village as per 2011 census (within its Assam part) occupies by more than 6 lakh people of different communities and creeds. The paper aims to study the prevailing geo-ecological settings, its changes due to fluvio-geomorphic condition and to develop some measure of sustainability against flood and other environment hazards. The people of chronically flood affected low lying areas fall on hazards frequently which has broad impact upon their habited areas along with changing scenario of geo-environment. The study attempted to subscribe through various statistical techniques for the analysis and synthesizes the issues.

Keywords: *Fluvio-geomorphic, paleo-channels, Geo-Ecological, sustainability*

I. Introduction:

A river has a definite and well-defined areal extent which is called as the drainage basin. It conceived of representing a working system of energy input and output and rightly be recognized as a fluvial system. Geomorphic variables like relief, slope, dissection, etc. have their great impact on fluvial landform development. Fluvio-geomorphic characteristics of a drainage basin have an impact upon basin's landform, changes on geo-ecological conditions which also has great significance with the sustainability and can be correlated with habited region. The term geo-ecology refers to the integrated approach to environmental science and targets environmental issues.

II. Objectives of the Study:

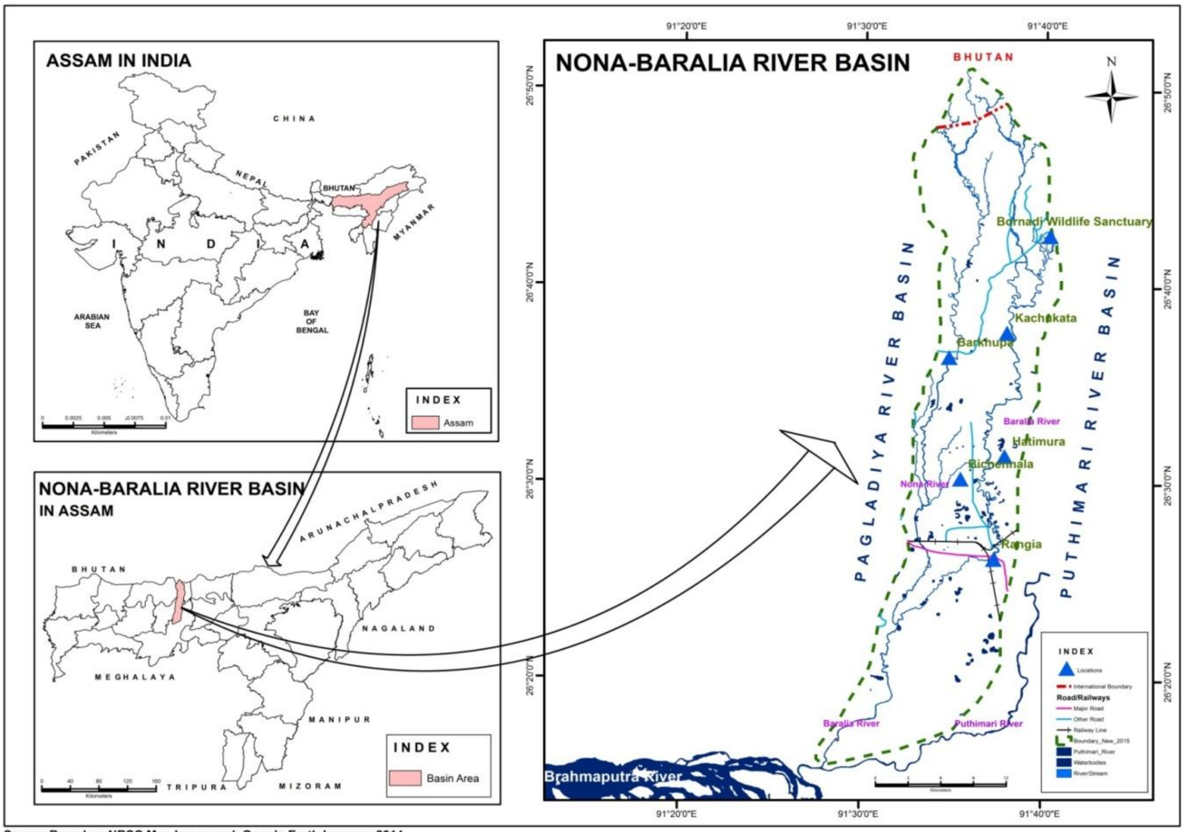
The main objectives in this paper are: -

1. To examine the geo-ecological and fluvio-geomorphic aspect and its resultant impact on the study area.
2. To find out the changes on the landform features, land-use characteristics and its impact on the habitat areas of the basin.

III. Study Area:

The Nona-Baralia river basin under study conforms to a major tributary basin of the Pagladiya river system in the Brahmaputra valley of Assam (Fig. 1.1). This basin covers an area of about 764 km^2 of which an area of 338km^2 is drained by the Baralia and the rest by the Mutanga-Nona. The Mutanga-Nona river is considered as a tributary to the Baralia river. The Nona-Baralia river basin extends latitudinally from $26^0 18^/$N to $26^0 53^/ 37^{//}$N and longitudinally from $91^0 29^/$E to $91^0 41^/$E. The Baralia, river a tributary of the Pagladiya oozes at an altitude of about 2098m at the Kurmed district of the Himalayan Kingdom of Bhutan. The basin holds parts of Kamrup and Nalbari districts of Assam in the Indian territory and parts of Bhutan Kingdom in its upper catchment. The Baralia river flows for more than 110 km in a north-south direction before joining the Pagladiya. A stretch of the Baralia before joining the Pagladiya is known as the 'ChawlkhoaNadi', which meets the Pagladiya at an elevation of 46 m near the Arangmura village. The basin shows channels characterized by anastomosing or reticulated pattern. Moreover, the channels have substantial meanders. The basin having an elongated shape contains differential fluvio-geomorphic features like foothills, beels, swamps, ox-bow lakes, paleo-channels etc. along with its extensive flood-plain and levee formations. The channels are very low in gradient. The Baralia river is marked by a channel gradient of 0.62m/km, while the Mutunga-Nona shows the gradient of 0.52m/km. The maximum absolute relief of the basin is 2052m, while the local relief is high (1183 to 150m) on mountainous and foothill areas. The Baralia river receives highest peak discharge of about 388.25m^3sec^{-1} (6th June, 1974) and the minimum of 49.39m^3sec^{-1} (6th July, 1983) at the Chamukhaghat gauge site. On the other hand, it had flood discharges of about 513.26 m^3sec^{-1}on 17th June and 51.10 m^3sec^{-1}on 19th June at the N.H. -31 road crossing near Rangia in 1973 and 1977 respectively.

The basin has about 309 villages as per 2011 census (within its Assam part) occupied by more than 5 lakh people of different communities and creeds. The foothill areas are occupied mostly by the tribals. The built-up areas are settled by the high caste Hindus, aboriginal Muslims, scheduled castes and backward communities. The chronically flood-affected low-lying areas in the southern margin of the basin have mostly been settled by the Muslim peasants of erstwhile East Pakistani immigrant origin.



Source:Based on NRSC Map Image and Google Earth Imagery, 2014

Figure 1: Study Area – Nona-Baralia River Basin

IV. Methodology:

The Study is based on empirical method of investigation. The entire paper work is framed and categorized within the definite and precise stages one after another. In this study, a number of base materials are collected and compiled as data base. The base map of the basin has been prepared from the Indian Topographical Sheets of 1:63,360 and 1:50,000 scale. Satellite images of 1988 and data from Google Earth imagery 2014 are also used for the purpose. Geological accounts and information of the basin have been collected from the geological survey of India, from the different base map. The necessary morphomatric data base have been generated from different topographic maps and imageries.

In the second phase of the work, the proper field-works and observation are conducted for the collection of primary data and information. Data were also collected from some sources based on interview about history of flood, earthquake and changing pattern of channel, etc. Field data are also recorded at the time of direct site-seeing. The secondary data are collected from different official sources, such as Department of Water Resources, Govt. of Assam, Brahmaputra Board, Govt. of India, Department of Irrigation, Govt. of Assam for hydrological data and information, Central Ground Water Board, Govt. of India, Assam Remote Sensing Application Centre (ARSAC), Guwahati, Census of India, Guwahati are also touched for relevant data and information for the work. The GIS based data sources are used from the NRSC cartoset of 2005-06. The Google earth imagery of 2014 are also used for different aspects of the work. Topographical sheets of scales 1:63,360 and 1:50,000 of different points of time are also used for identification of morphometric and hydrological situations.

In the third stage, the study basically deals with the processing of raw data into some tables, index forms, etc. Maps, diagrams, graphs, digital models etc. were then drawn with the processed by data using some statistical, simple cartographic mathematica land hydrological techniques on the processed data which are found relevant to fluvio geomorphological study.

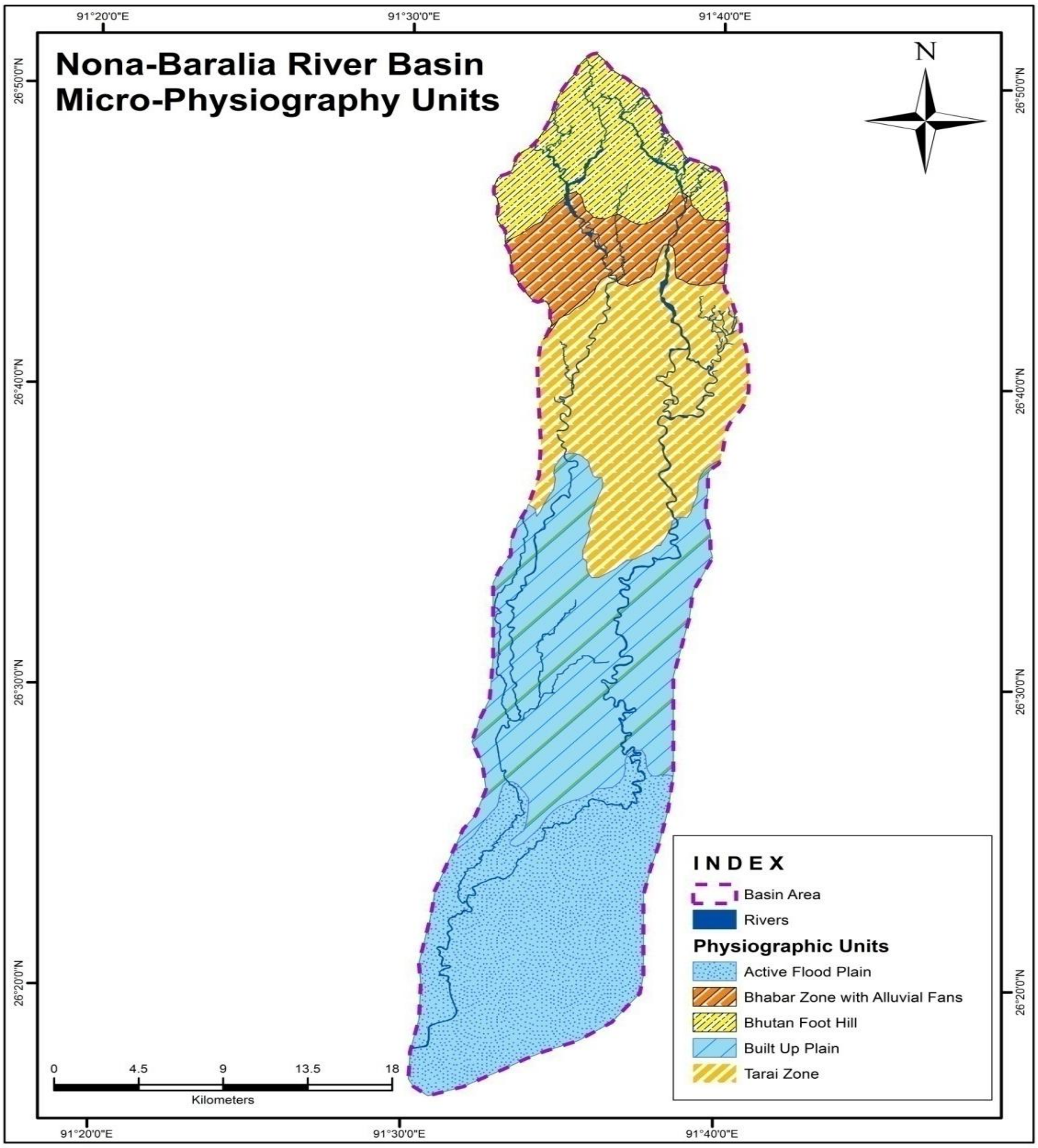
In the fourth or the final stage, the tables, maps, diagrams, field ideas, photographs etc. were arranged systematically and their analysis and explanation are done to write up this paper.

V.Result and Discussion:

The Nona-Baralia river basin has distinct physical, geological, hydrological and geomorphic entities of its own, which bears a great significance to the study of fluviogeomorphic characteristics and formulation of strategies for basin's land use development and management. The Nona-Baralia river basin has passed through a complex geological history, even as it is not too complex as compared to many other river basins in the world. The basin being a northern part of the plains in the Brahmaputra Valley bordered in the north by the Bhutan hills and foothills of tertiary rocks origin has evolved out of the thick sedimentary deposits on the narrow foreland or rift valley (Krishnan, 1982) which was covered in the geological past by the Tethian geosyncline. The basin is mainly composed of recent and sub-recent deposits. These deposits can be sub classed into (1) the older alluvium and (2) the newer alluvium. The older group known as the high level alluvium got deposited during the end of the Pleistocene period. These consist of impure sand and unsorted pebbles.

The Nona-Baralia basin has its own sequentially developed physiographic basis well reflected in relief, slope, dissection etc. Physiographically the Nona-Baralia River basin represents a flat plain composed of alluvial deposits. Though the basin in largely a monotonous physiographic unit of almost flat plain nature, it may be divided into as many as four micro-physiographic units, viz. (i) a small hilly part, (ii) the Bhutan foothills part (iii) built-up plain part and (iv) the active flood plain part (fig.1.2) based on distinct micro-geomorphic characteristics. In the extreme north of the basin, there lies the Bhutan Himalaya. Below it lies the Bhabar and the Tarai area The built-up plain lies farther south while in the extreme south there is an area of active flood plain. The classification also follows the scheme of landform development as conceived by Richard E. Murphy.

Relief acts as one of the determining factors for the development of morphometric pattern in a region, be it a basin, hill or any other area. Relief may be analysed by considering both the absolute and relative relief and the slope, dissection as well. In the study of the Nona-Baralia river basin all these elements of relief are considered. Absolute relief helps us to understand and reconstruct the nature of landform evolution and development of both the general and specific geomorphometry (Chorley, 1969) and the structural control in the basin as well. The analysis of such a morphometry is based mainly on the pattern of distribution of contours. In the Nona-Baralia river basin the contours are crenulated in the foothill and hilly outlier areas of the Bhutan Himalaya. They are closed enough. The natural contour plan of the basin shows two distinct characteristics, viz. (i) the direction of contours is almost parallel to the Brahmaputra with some crenulations only in the Bhutan hills and foothills zone, (ii) The intra contour spaces between any two consecutive contours at equal intervals become gradually wider in the basin from 92m contour level downward. The basin surface has been found to have significant falls with elevations at 300m, 150m, 130m, 100m, 80m and 60m levels. Every fall is marked by gentle slope southward until incipient levee on the bank of the Brahmaputra is reached.



Source: Based on Murphy P.C 1967 & Taher M 1975

Figure 1.2: Micro - Phsiography Unit

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Table 1.1

Nona-Baralia River Basin : Area under Absolute Relief Groups.

Absolute relief (in meters)	Total Area (Km^2)		Percentage of Area to		Change in Area (percentage)	Relief Category
	1911-13	1954-60	1911-13	1954-60		
< 58	296.87	304.97	38.88	39.94	+1.06	Low
58 – 68	138.05	100.21	18.08	13.12	- 4.96	Moderate
68 – 80	72.66	75.30	9.52	9.86	- 0.34	
80 – 100	57.08	70.63	7.48	9.25	+1.77	
100 – 150	89.78	103.33	11.76	13.53	+1.77	Moderately high
150 – 300	34.25	34.25	4.49	4.49	No change of relief area	High
300 – 400	30.36	30.36	3.98	3.98		Very high
400 – 700	28.23	28.23	3.70	3.70		
> 700	16.33	16.33	2.11	2.11		
Total	**763.61**	**763.61**	**100.00**	**100.00**		

Source : Based on data derived from topographical sheets of 1911-13 and 1954-60.

The spatial distribution of relative relief as depicted by the maps indicates that there is a great gap of relative relief between the areas of the Bhutan Hills and foothills (piedmont zone) in the north and the flat built up and active flood plains in the south. In the extreme north, the Himalayan outliers show relative relief of 1183m, while in most of the areas in the hilly zone of the basin, the relative relief is within 200m. Relative relief decreases abruptly as one goes southward to the plains of different altitudes Table 1.2 show the breakup of area under different relative relief groups and the changes of areas under the groups.

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Table 1.2 : Nona-Baralia River Basin : Relative Relief, 1991-13 and 1954-60

Relative Relief(m)	Area (Km^2)		Percentage of Area		Change in percentage of area
	1911-13	1954-60	1911-13	1954-60	
< 2	398.50	42.48	52.15	44.66	-7.49
2-4	129.38	62.88	16.93	21.25	+4.32
4-6	23.76	2.66	3.11	6.87	+3.76
6-8	25.07	5.67	3.28	4.65	+1.37
8-10	35.46	0.49	4.64	2.67	-1.97
>10	151.99	52.63	19.89	19.90	-0.01
Total	**764.16**	**766.81**	**100.00**	**100.00**	

Source: Based on data derived from the topographical sheet of 1911-13 and 1954-60.

Slope is one of the major constituent elements of all the geomorphic features (Schieddeger, 1961) developed due to exogenetic or endogenetic nature of forces. Slopes have wide variations in their morphology, genesis and development. There are two types of slopes, viz. Primary, which owes its origin to endogenetic processes. The other type of slope is caused by exogenetic processes. The physical structure and processes, geological history, climatic events, relief and, to a certain extent, the human interference all contribute to the development of slope.

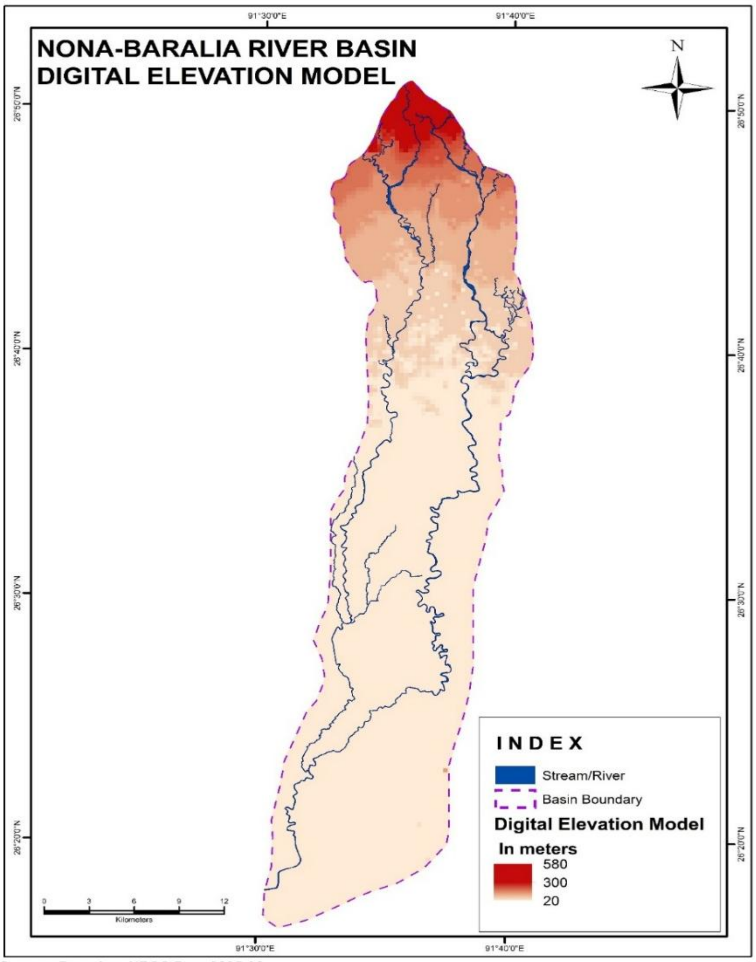
The basin under study covers an area of about 93 percent of the basin's total with local relative relief of less than 20 m, and out of this about 70 percent of the area have almost reliefless plain. For the reason of less relief amplitude the average slope method devised by Wentworth is used here. For the convenience of the study of slopes, the whole Nona-Baralia basin is classified into morpho units viz. hills and plains. All the area is divided into equal grids of 1.50 Km length and breadh for both the hills and plains. Average slopes are calculated by taking 50 meters of contour interval for hills and foothills and 2 m for plain areas. Average slopes are then plotted on the centers of the grids of the map. Finally isometric lines are drawn and the isopleth maps (figs. 2.10 and 2.11) for the basins are prepared to show and analyse the spatial pattern of slope distribution. Slope values are also tabulated under different groups as shown in table 1.3.

Table 1.3 : Nona-Baralia Basin : Slope Distribution, 1911-13 and 1954-60

Slope in degree	Area (Km^2)		Percentage of Area		Change in percentage of area
	1911-13	1954-60	1911-13	1954-60	
< 1	585.50	607.81	76.62	79.26	+ 2.64
1-2	77.29	55.69	10.11	7.26	- 2.85
2-3	18.23	18.23	2.93	2.38	- 0.01
3-4	9.00	11.13	1.18	1.45	+ 0.27
> 4	74.14	73.95	9.70	9.65	+ 0.05
Total	**764.16**	**766.81**	**100.00**		

Source : Based on data generated from the topographical sheets of 1911-13 and 1954-60.

Table 1.3 show the slope distribution and its change in the Nona-Baralia basin. The slope map based on 1911-13 data reveals that slope ranges between a minimum of less than one minute and maximum of 35°. A majority of area in the tune of 585.50 Km^2 equivalent to 76.62 percent of the total area of the basin comprises average slope of less than 1° (table 1.3) Such low slope areas lie on the active flood plain, comparatively flood free built up lands and the parts of tarai area of the basin. The average slope group of 1° to 2° comprises an area of 77.29 Km^2 or 10.11 percent of the basin's total area. Such areas are best observed mainly on the northern part of the tarai belt and the bhabar belt marked by alluvial fans and cones. The average slope groups of 2° to 3° and 3° to 4° comprise very small areas of 2.93 and 1.18 percents respectively. Such areas have their spread partly on the Bhutan foothills. The Bhutan foothills and hills slope zone combinedly covers an area of 74.11 Km^2 or 9.70 percent of the basin's total area under average slope of more than 4°. The abrupt fall in the trend of average slope from the Bhutan hills and foot-hills in the north to the south towards the bank of the Brahmaputra is closely linked with the direction of the master stream Brahmaputra and its tributaries along and across the valley wall. There are at least three minor terraces on the Nona Baralia basin wall which have slope fall areas at 2°-1°, 1°-30′ and less than 30′. The slope distribution as revealed by table 1.3 based on 1954-60 topographical map indicates the slightly changed characteristics in each slope category. The slope group of less than 1° shows a slight increase in area by 2.67 percent of the basin as of 1954-60 map compared to that of 1911.13. On the other hand, the land cover under slope group of 1° to 2° shows a decline by 2.85 percent of area marked on the 1954-60 map as compared to the area in the same group of slope shown by 1911-13 map. The areas under 2°-3°, 3°-4° and more than 4° slopes remained almost static (table 1.3) at both the points of time.



Source: Based on NRSC Data,2005-06

Figure :1.3

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The GIS based digital elevation model (fig. 1.3) prepared for the Nona-Baralia river basin uses the NRSC cartoset data of 2005-06. The model shows at least five relief facets of ranging between 20 and 580 meters of elevation. The colour TIN surface method under GIS is used to identify different elevation categories. The model however shows three distinct categories of elevation, viz. 580 to 300 meters, 300 to 20 meters and below 20 meters. The map has shown that more than 67 percent of the basin's total area lies under 20 meter of elevation and remaining 33 percent above 20 meters.

The dissection index which expresses the dimension of vertical erosion in an area has its relationship of the real area with the projected area between certain sets of contours (Dubey, 1986). The distributional pattern of dissection and characteristics has its far reaching impact on the overall geomorphic behaviour of an area. Therefore, studies on such a line bear a great significance. Dissection index is generally used as a morphometric determinant of the stages of terrain evolution where the index values of 0.10, 0.10 to 0.30 and above 0.30 generally indicate respectively the penultimate, equilibrium and inequilibrium stages of landform development (Pandey, 1983) as observed by Dubey (1986).

The dissection indices are then tabulated (Table 1.4).

Table 1.4
Nona-Baralia River Basin; Dissection Index and Area Coverage, 1911-13 and 1954-60.

Dissection Index					Change of Area coverage in percentage	Category
	1911-13	1954-60	1911-13	1954-60		
< 0.10	621.56	620.20	81.34	80.88	- 0.46	Very low
0.10 – 0.20	54.57	54.75	7.14	7.14	--	Low
0.20 – 0.30	17.25	20.42	2.26	2.66	--	Moderate
> 0.30	70.78	71.44	9.26	9.32	+ 0.06	Moderately
Total	**764.16**	**766.81**	**100.00**	**100.00**		

Source : Based on data generated from topographical sheets, 1911-13 and 1954-60.

The Nona-Baralia river basin comprises two important elongated drainage basins, viz. the Mutanga-Nona and the Baralia basins. The Mutanga as mentioned already has in its upper part two major streams, viz. the Bagajuli in its left bank and the Dimabori in the right bank. These two streams have curved out dissected landforms on the foothills of the Bhutan Himalaya. The two streams meet each other in the Assam-Bhutan boarder area of the basin. Another small stream called the Kawli Nadi runs parallel to the Mutanga itself along the area between Balado or *Balti Nadi* that exists in the upper catchment of the Baralia river. The Kawli originates at the Bhabar belt to meet the Mutanga near the village Kawli No. 2. Another important stream called the Gayaldong which oozes at the Darranga Reserve Forest in the Bhabar area uses to flow downward by 20Km.almost parallel to the Mutanga. This stream finally meets the master stream near Tamulpur. Over the built-up areas another important stream named Ghagra Nadi flows for about 15 Km from its source near Borajol. It meets the Dadatia *beel* located at a few kilometers away from Ghagarapar.

The Baralia river basin comprises a network of a number of streams of which the Baralia is the master stream and the Baladi ('Bala' means sand and 'di' means water in Boro language) which is locally known as the Balti is important to be mentioned. The Baladi oozes at an elevation of 2098 m in the Bhutan Himalaya. This sub-tributary flowing for about 22 Km downward from its source takes a different name near the village Baladipar. The elevation of this meeting point is 90m above the mean sea level. The bed of this river remains almost dry for most part of the year except during the rainy period. The water flowing intermittently along the Baladi reappears at the surface near the village Baladipar. Hence, from this point of reappearance the waters use to flow through the Jia Baladi (i.e. the Baladi River with life). The Jia Baladi ultimately meets the master stream Baralia at a point downstream where the elevation is 96 m above the mean sea level.

VI.Conclusion:

The fluvio-geomorphic and geo-ecological appraisal of the Nona-Baralia river basin reveals that the basin functions as a dynamic fluvial system where relief, slope, drainage characteristics, and channel processes collectively govern landform development and environmental stability. The elongated basin, characterized by low gradients, extensive floodplains, paleo-channels, wetlands, and levee formations, demonstrates a high degree of fluvial activity and geomorphic sensitivity, particularly in its middle and lower reaches. Frequent flooding, channel migration, and sediment deposition have continuously modified landforms and land-use patterns, directly influencing the geo-ecological conditions and the livelihood security of the basin's large rural population. The interaction between natural fluvio- geomorphic processes and increasing human habitation in low-lying areas has heightened vulnerability to floods and related environmental hazards. The study underscores the need for basin-specific, sustainable management measures integrating geomorphic understanding, hydrological data, and community-based planning to mitigate flood risks, conserve wetlands and floodplain ecology, and promote long-term geo-ecological sustainability in the Nona- Baralia river basin.

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