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MICRO-LEVEL MORPHOLOGICAL ANAYSIS OF KHOYAI REGION (PART) IN BIRBHUM DISTRICT OF WEST BENGAL

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ABSTRACT

Birbhum district has a great importance for his geomorphic feature i.e. "Khoyai" region which is a unique lateritic landscape and is also an important tourist spot in West Bengal. Geomorphologically it is very much affected by natural denudation processes. Hence, this landscape is very much affected by rill and gully erosion since long time. The present fieldwork is a hardcore applied geomorphological work. In this present study exhibit that the erosional status of Khoyai region by measuring length, width and depth of major gully. This article has mainly focused on the intensity of soil erosion by rill and gully erosion which has being changing the natural relief of this part of Birbhum as well. This change may affect the physical as well as socio economic environment of this region. To restore this badland topography, a geographic heritage, the authors have proposed some remedial measures to improve the present consequences of this economically and socially important part of Birbhum district in West Bengal.

Keywords: Badland, Denudation process, Gully erosion, Stream Order, Moram

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INTRODUCTIION

Badlands are barren lands developed by active rills and gully erosion by running water. Some of the identified badlands are located at Purulia, Bankura, Birbhum, and West Medinipur districts of West Bengal. 'Khoyai' is a special geomorphic region located in Birbhum district built up mainly by the laterite soils. The soil in this region is highly weathered, leached and also enriched with oxides of iron and aluminium. As a result, the landscape of Khoyai area is affected by high soil erosion especially through the rill and gully erosion. The present study exhibits the nature, intensity as well as the management of laterite erosion. The study has been done to analyse the gully profile-analysis here. It is necessary to recognize the spatial distribution, degradation status and present management system of Khoyai so that it can be restored from current degraded lateritic terrain for preventing their further degradation in the future.

OBJECTIVES

The main objectives of the present study are as follows:-

(i) To know the geomorphological and geological set up of the study area.

(ii) To identify the ordering of gullies.

(iii) To determine the width, length and depth of the major gullies.

(iv) To determine the nature of erosion of the study area (Rill and Gully erosion).

(v) To analysis the intensity of gully erosion in the study area.

(vi) To propose some mitigation processes to prevent the rapid gully erosion in the study area.

METHODOLOGY

The present study is the outcome of intensive field survey. The modern methodology has been adopted for the completion of this work. Various others cartographic techniques and methods have also been used for this study. The whole field work has been conducted in three stages, i.e. (i) Pre-field Work, (ii) Field Work and (iii) Post-field Work.

❖ **Pre field Work**: - Previous literatures related to the study of the area have been studied to acquire sufficient knowledge for conducting the survey work conventionally. Published National, International Books and Journals (both offline and online) have also been followed to have a clear idea regarding the issues related with the objectives as mentioned above. Toposheet

No. 73M/10 and LISS-III satellite images of the study area have been studies and before going the field work.

❖ **Field Work**: - The field work have been done through rigorous surveying the study area with the help of Dumpy Level instrument, Clino-Compass, Tape, Measuring Staff and GPS to collect thegeographical data and other required information.

❖ **Post-field Work**: - In the post field stage collected data and information were analyzedmanually and through computer. Maps, different figures and charts have been prepared through proper statistical and cartographic methods like Strahler's Stream Ordering and Karl Pearson's coefficient of correlation method. Gully ordering maps have been prepared by using QGIS ver.3.0 software. Cross sections have been drawn by using excel. Gully density, gully frequency and gully intensity maps and diagrams have been prepared by using QGIS software.

LOCATIONOF THE STUDY AREA

The 'Khoyai' is located in the eastern part of Birbhum district of the state of West Bengal. This conducted study area (Fig. 1.a & 1.b) is located in theKhoyai region which actually falls in the eastern part of Chhotonagpur plateau, forms a part of the lower Ganga, referred to as

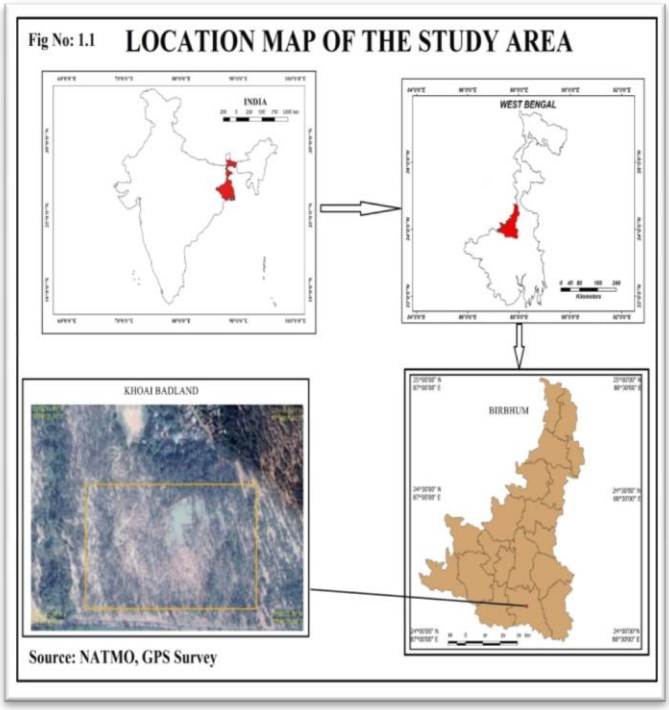


Fig. 1(a): Location of the study area

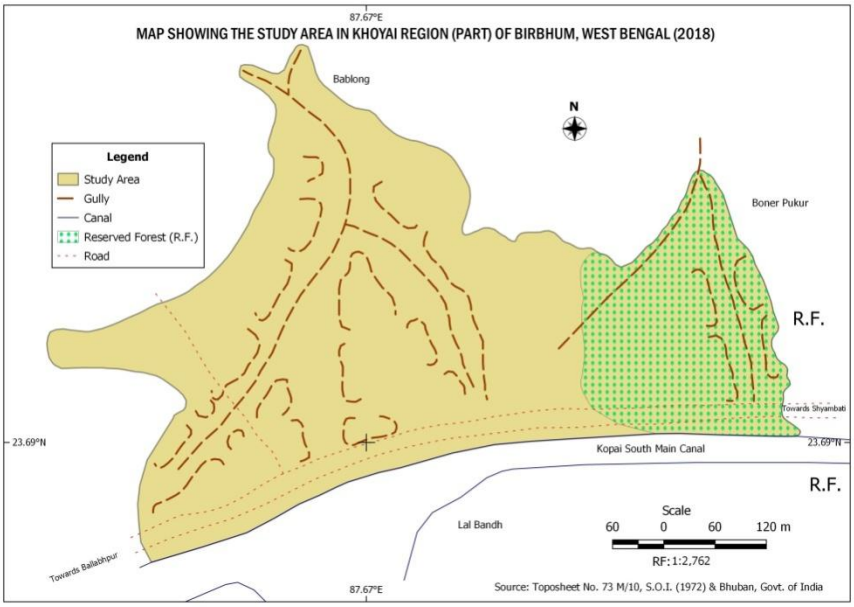


Fig. 1(b): Study area in Khoyai region of Birbhum district, West Bengal

the self of alluvium locally known as Ruhr Bengal. The latitudinal extension of the studied area is 23°41′28″ to23°41′30″ and the longitudinal extension is 87°40′21″ to 87°40′28″. Khoyai region is very distinct in the central parts of Bolpur-Sriniketan, SE parts of Illambazar and western parts of Suri-I, eastern parts of Dubrajpur, and SE parts of Mohammad Bazaar blocks. The study area covers an area of 28.34 hectares with a forest cover of 6.25 hectares of land area. The minimum elevation of the study area is 49m and the maximum elevation is 67m above the MSL. Rills and gullies are prominent in the western, north western part of this study area.

CLIMATIC CHARACTERISTICS

The study area experiences a mean annual temperature of 26°c and annual rainfall reaches to1462.73mm. The temperature remains around 26°c to 31°c during March to October but the it decreases during November to February and drops down to 6°c to 19°c. Maximum rainfall occurs during the monsoon period (June-September). Maximum intensity of rainfall is experienced during the month of July amounting 1500mm.

SOIL CHARACTER

Soil is an importance geographical attribute in analysing the regional developmentof the landscape of Khoyai.Khoyai is region, built up by laterite soil.The soils found in this part of

Khoyai are - (1) Recent alluvium, (2) Newer alluvium, (3) Older alluvium and (4) Laterite soil. Alluvium is predominant in the southern and eastern part of the study area. Erosional plain with a few mounds to the west constitute its major physiography.The soil of Kopai upland is generally lateritic mixed with alluvium. But due to the present of the Badlands in its southern parts the lateritic soils can also be found. Particularly the southern badland part is covered by *moram*, often covering the ground surface near the exposed areas of the hard crust. In this study area, the soil is highly weathered, leached and enriched with oxides of iron and aluminium. As a result the landscape of Khoyai area is effected by high soil erosion specially rills and gully erosion.

VEGETATION

The study area has very diverse flora and fauna. The principle trees of the study area are Akashmoni (*Acasiamonilliformis*), Sal (*Shorearobosta*), Sishu (Daldergia*sissoo*), Cashew (*Anacardiumoccidentale*), Behera (*Tenninaliabellerica*), Amloki (*Emblicaofficinalis*) tree Chhatim (*Alastoniascholaris*), Bakul (*Mimusopselengi*), Malati (*Aganosmadichotma*), Palash (*Buteamonosperma*), Arjun (*Terminaliarjuna*), Sonajhuri (*Acacia auriculiformis*), Eucalyptus (*Eucalyptus globulus*), Bamboo (*Bambusa vulgaris*) etc. The main plant species are Eucalyptus, Sonajhuri, and Sal. In recent times, deforestation of natural vegetation is a major problem in soil conservation.

NATURE AND FACTORS OF EROSION IN THE STUDY AREA

Various factors are responsible for erosion. The factors are unstable soil structure, climatic condition, lack of vegetation, deforestation and human intervention etc.Unstable soil structure is the main factor of erosion, and soil is poorly graded, with unstable structure like laterite, sandy and gravelled soil. Rainfall is of the important factors of erosion in this study area. Lack of vegetation also causes of the degradation of soil. Construction of metalled road andhouses, over grazing and deforestation also are the major causes behind the recent soil erosion.

Mainly three types of erosion are identified in this study area such as – (a) Splash Erosion (b) Rill Erosion and (c) Gully Erosion.

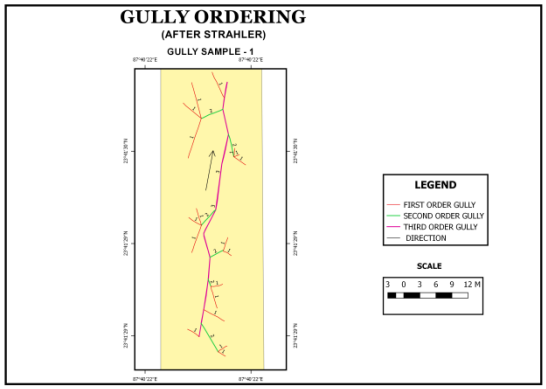
(a) **Splash Erosion:** Splash erosion is the primary stage of erosion which occurs when raindrops hit open surface of the soil. The splash particles can move up to 1.00m from the point of impact and rises to 15cm high above ground surface.

(b) **Rill Erosion:** Rill erosion is a type of erosion that forms a small short lived and well defined stream. Rills are developed when surface water concentrated in depression of lower points through erosion. Rill erosion is the intermediate stage of sheet and splash erosion.

(c) **Gully Erosion:** When many rills meet each other and they formed a well defined channel which is called gully. Gully erosion is the main factor of badland formation.

GULLY NETWORK IN KHOYAI

a.



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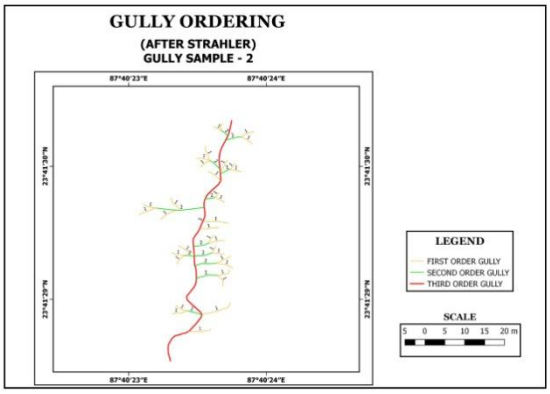

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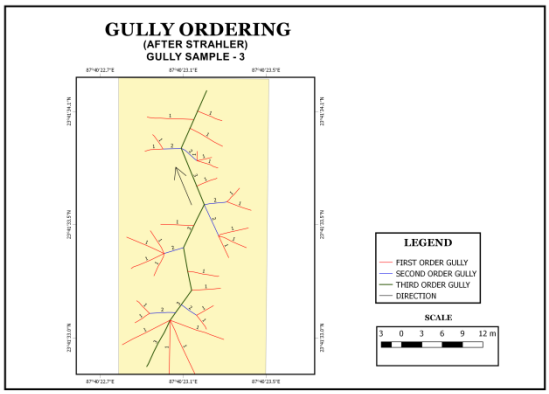

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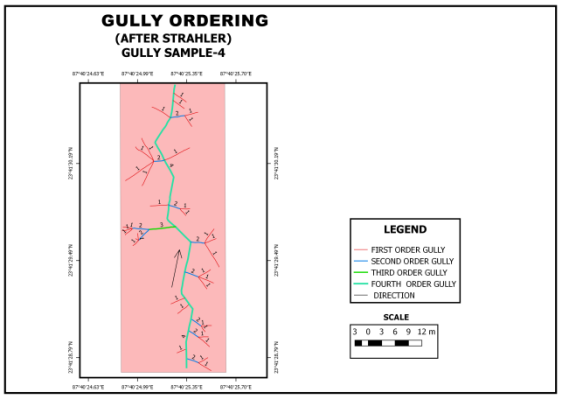
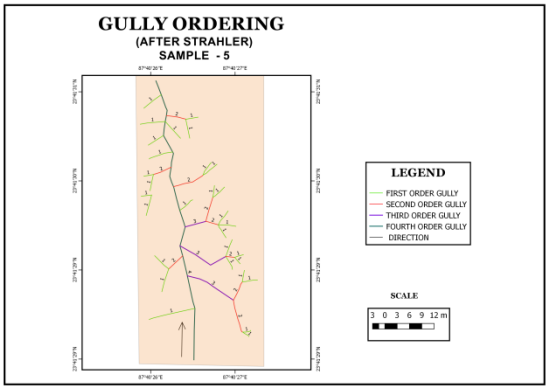


e. 

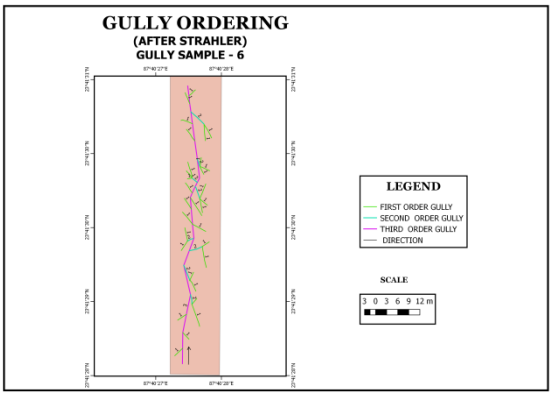
f. 

Fig. 2: Showing the ordering of (a) Sample Gully No. 1 (b) Sample Gully No. 2 (c) Sample Gully No. 3 (d) Sample Gully No. 4 (e) Sample Gully No. 5 (f) Sample Gully No. 6

The study area is covered by 6(Six) major gullies (Table no.1) which are formed by running water erosion. Morphometric analysis has been conducted to have a detailed ground-level data to identify the major gullies, sub-gullies and rill formations by measuring length, width and depth of the rills and gullies. Total 6 gullies are present here. These gullies are located parallel to each other (Fig. 2) flowing from west to east direction.

Table-1: Showing the number of order (after Strahler) of the Sample gullies (Sample1 to 6) surveyed in the study area in 2018.

Gully Order	**Sample-1**	**Sample-2**	**Sample-3**	**Sample-4**	**Sample-5**	**Sample-6**
1st	18	31	29	34	30	31
2nd	6	9	7	10	9	7
3rd	1	1	1	1	3	1
4th	0	0	0	1	1	0

Source: Field Survey, 2018

Among the 6 major gullies, Sample no.1 is situated in the westernmost part of this area. The total length of this gully is 65.1 meter. The depth of this gully has increased towards the point where it met the main gully channel from the head-ward part. The intensity of erosion has increased with the increasing depth. In the middle portion of the gully Sample 1, the width has increased as more lateral erosion has taken place. The number of 1st order gully is highest in gully Sample 1, which plays an important role in the soil erosion in this part of Khoyai.The gully Sample no. 2 is

located in the western portion in the area. The depth of the gully has increased towards the southern part of the area and the maximum depth has been observed where these gullies meet the main gully channel. The maximum width of the gully is observed in the head-ward portion. The no. of 1st order gully is quite similar inSample 1& 2. They play a significant role in the soil erosion in this studyarea. The gully Sample 3 is situated almost near the middle part of Khoyai in Birbhum, which has a total length of 47.8m. The width of the gully is minimum in the head-ward side, and maximum in the middle part. Meeting point of main gully channel has the highest depth of 3.20m. In the central part of this badland i.e. Khoyai area here, gully Sample no. 4 has a length of 76.2 meter, fore side has maximum width in comparison to the other parts. The southern part has maximum depth in comparison to northern part of this area. The width has increased in the northern part due to the increasing rate of lateral erosion. Because of the active down cutting in the southern part, the depth is maximum (3.68m)here. Gully Sample-5 is located in the eastern portion of the Khoyai badland area and has a total length of 68.4m. The width of the gully is maximum in the middle part and minimum towards the north. With the increasing intensity of soil erosion, the depth has also been increased towards northern part of the study area. The eastern most gully of this area (Sample no. 6) has a length of 68.7m. The width is highest towards the source of the gully unlike the other mentioned gullies due to higher intensity of erosion; depth has increased from north-south due to intense lateral erosion in this region.

QUANTITATIVE ANALYSIS OF GULLY EROSION

Quantitative analysis of gully erosion means the numerical analysis of length, width, depth, angle and slope of major identified gully. The gullies and rills are varying in depth, width and

Table-2: Showing the nature of sample gullies

Gully Sample	Total length(m)	Average width(m)	Average depth(m)
1	65.1	7.05	2.51
2	63.7	6.53	2.79
3	47.8	5.3	2.82
4	76.2	5.75	2.94
5	68.4	7.73	2.81
6	68.7	5.71	2.42

Source: Field Survey, 2018

length (Table No.2). All the gullies and the rills were originated from the side of canal due to the erosion performed by running water in this region. The rate of erosion has occurs at

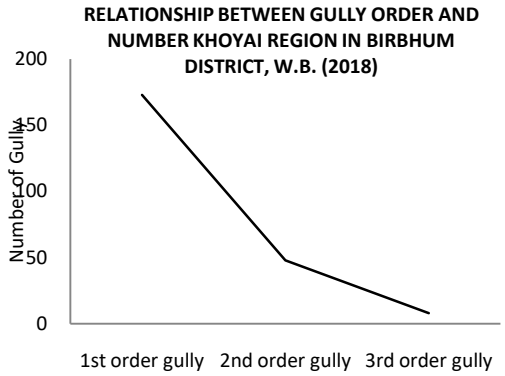


Fig. 3: Relationship between gully order and number of gullies in the study area, 2018

different rates in different times. The direction of erosion performed by gullies is from south to north, but if we consider the process of whole region than it will show that the gully erosion has taken place in the western portion rather than eastern portion. Due to the gully erosion in the mentioned region, the change in the natural landscape is notable here. The

Table-3: Showing average depth and width (in meter) of the gullies according to size and shape.

Gully Type	**Numbers**	**Percentage (%) of total Gully Network**	**Average Depth(m)**	**Average Width(m)**
Small	173	75.55	0.5-1.00	1.0-2.0
Medium	48	20.96	1.00-2.00	2.0-4.0
Large and Deep	8	3.49	> 2.00	> 4.00

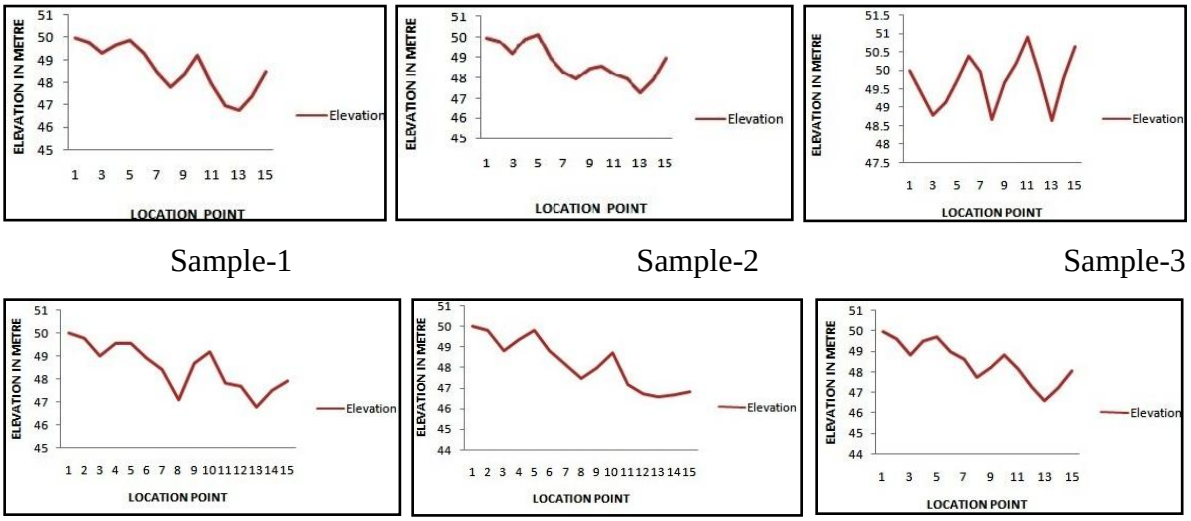
Source: Field Survey, 2018

relationship between gully order and gully number is negative (Fig. 3).On the basis of erosional intensity the gully of first order has the main role.

SLOPE AND PROFILE CHARACTER

The main objective behind showing the cross profiles are to determine the intensity of erosion and down cutting of valleys developed through gully formation. Three cross profiles have been drawn for each gully, among which one is on the gully's head, one in the middle portion and last one is the fore side of the gully. Every cross-section (Fig. No.4) of the gully has been taken in the west to eastern direction of this region. From these sections it is found that the deepest among these 6 gullies, is gully Sampleno.4, which is located on the western section of the study area, which indicates that down cutting of the erosion is more active here and the erosion is less in gully Sample no.-6, as the depth of the gully is minimum here and rest of the gullies have

moderate depth and erosion is also moderate. The gully Sample no.-6 has the highest width as the intensity of lateral erosion is highest here.



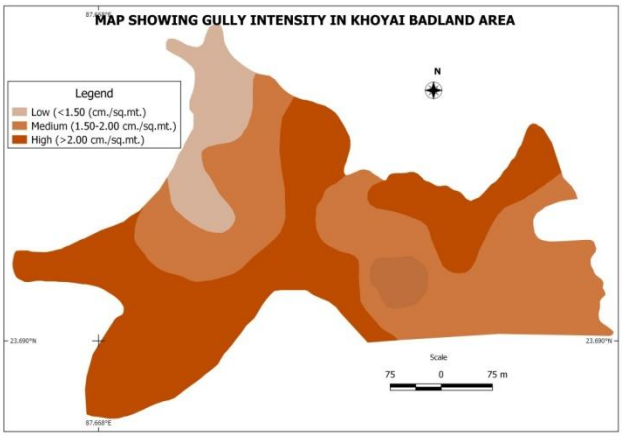
Sample-1 Sample-2 Sample-3

Sample-4 Sample-5 Sample-6

Fig. 4: Showing the Gully Profiles of Sample 1 to 6 at different location points respectively

INTENSIITY OF EROSION

The intensity of gully erosion in Khoyai has been measured by the ratio of gully density and gully frequency. The entire region is covered by six major gullies, sub-gullies and rills. Maximum intensity of erosion is 2.50m/sq.meter. which has been observed in the south-western part of this region and the minimum intensity of erosion is 1.12m/sq.meter that has been observed in the north-eastern part of the region. The intensity of erosion has increased from eastern to western part and southern to northern portion respectively.



Source: Bhuban, Govt. of India

Fig. 5: Gully Intensity Map of the study area, 2018

The study has revealed that western portion of the Khoyai badland is most erosive than the eastern portion (Fig. No.5). The intensity of erosion in this region is closely related to mean annual rainfall and soil structure. Due to the gully erosion various problems has arisen in this region, such as, landslide, soil erosion etc.

In this present study we have determined the correlation between gully frequency and density using Karl Pearson's coefficient of correlation method, the examined value of correlation is 0.8358, which indicates nearly perfect positive correlation. It is showing the relationship between gully frequency and gully density is positive.

MANAGEMENT OF EROSION WITH PROPOSITIONS

Some steps have been taken by State Agricultural Department and local bodies to solve these problems. These are as follows:

Afforestation: It is a very important process of gully management .which means plantation of tree by government and nongovernment step. Sonajhuri, Euclepotas and Sal tree plantation is a very important step to control gully erosion.

Construction of embankment: To control the gully erosion construction of embankment is an important process. In this region embankment are formed by artificial way to control soil erosion and store water which is use in domestic purpose.

Stone walling: Constriction of stone wall is an important process of gully erosion management which is form by the step wise arrangement of rock. This step was taken by local people from their indigenous knowledge to prevent the gully erosion.

Concrete plating: Arrangement of concrete plate along the both side of canal is a proper management process of gully erosion. This step was taken by Agricultural department of Bolpur block.

By adopting the above mentioned methods gully erosion can be prevented.

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