International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online)
An Online International Journal Available at http://www.cibtech.org/jgee.htm
2012 Vol. 2 (2) May-August, pp.193-205 /Prakasam and Biswas
Research Article

EVALUATION OF GEOMORPHIC RESOURCES USING GIS TECHNOLOGY: A CASE STUDY OF SELECTED VILLAGES IN AUSGRAM BLOCK, BURDWAN DISTRICT, WEST BENGAL, INDIA

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ABSTRACT
Geomorphic study is useful techniques for studying stages, development and associated features of the land forms. Present geomorphic resource evaluation has been made using GIS technology. Ausgram Block is one of the major agriculture regions in Burdwan district and it covers 493 sq.km. Present study we have selected some villages (Bhalki, Dombandi, and Radhamohanpur) in Ausgram block, Burdwan district, West Bengal. It covers 1624 hectares area, these villages we have evaluated the geomorphic resources from Survey of India (SOI) topographical map (73 M/11). Present research work we have consider as geomorphic resources like Absolute Relief (AR), Relative Relief (RR), Slope, Drainage Density (DD), Frequency of surface water bodies (FSWB), Dissection Index (DI), Ruggedness Index (RI) and geology are very important indicators used to evaluate geomorphic parameters of the present study area. Geomorphic resources evaluation has been made five hundred square meter grid wise, through GIS (Arc GIS10.0) technology.

Key Words: *Absolute Relief, Relative Relief, Slope, Drainage Density, Dissection Index*

INTRODUCTION
Geomorphic resources are the natural phenomena on the earth's surface, which have originated due to the active geomorphic processes. The resources directly or indirectly control various anthropogenic activities to a great extent. Geomorphic resource study and analysis are very much essential to understand the availability of natural resources which in turn influence the probability of economic and social development of the region as well. Absolute Relief (AR), Relative Relief (RR), Slope, Frequency of surface water bodies (FSEB), Drainage Density (DD), Dissection Index (DI) and Ruggedness Index (RI) are considered very important indicators and they are used to evaluate geomorphic parameters of the present study area. Evaluations of these resources are considered essential for implementation of any type of regional and economic planning. Geomorphic resources are ready to respond to the socio-economic needs to the world today and thus a great demand for gomorphologists to participate in diversified projects leading towards economic development and a balanced appropriate use of the natural environment.
Geomorphic resource investigation helps in delineation of large geomorphic units such as aluvial flood plains, pediment plains, outwash plains etc. Siutability for irrgitaion and ground water studies can also be done by studying geomophology of a region. Hydrographic problems in limestone terrain are best understood when geomorphology of such areas is fully comprehended. Present study area geomorphic resources are directly controlling the surface water resource and land use land cover, so evaluate the geomorphic resource is very essential here.

Objective
To evaluate the geomorphic resources i.e. Absolute Relief (AR), Relative Relief (RR), Slope, Drainage Density (DD), Frequency of surface water bodies (FSWB), Dissection Index (DI), Ruggedness Index (RI) and geology in every 500 sq. m through GIS technology.

Study Area
The study area Ausgram block I and II are located in west-central part of Burdwan district (Figure: 1). The region is considered as water stressed region. Average annual rain fall of the region is 1500mm and

average annual temperature is 21.29^{0}C. Maximum rainfall occurs in the months of July (314mm) and the minimum occurs in the months of December (4.13 mm). Highest average temperature occurs in the months of June while the lowest occurs in the months of January. Topography of the Block is rugged. Highest relief of 70 m is found in the west-central part of the Block. Minimum relief of 32m is found in the east-central part of the Block. Generally the blocks are inclined form the west to east. Important rivers of the blocks are Kunur Nadi, Ajay River. They are flowing from west to east. Total population of the blocks is 212921 (2001, Census of India) of which 43 per cent population belongs to Scheduled Caste category and 16 per cent belongs to Scheduled Tribe category 62 per cent of the total population of the blocks is literate. The present study aims to evaluate the geomorphic resources of some selected villages of Ausgram Block of Burdwan District. The villages are selected as per the list of backward villages of Govt. of West

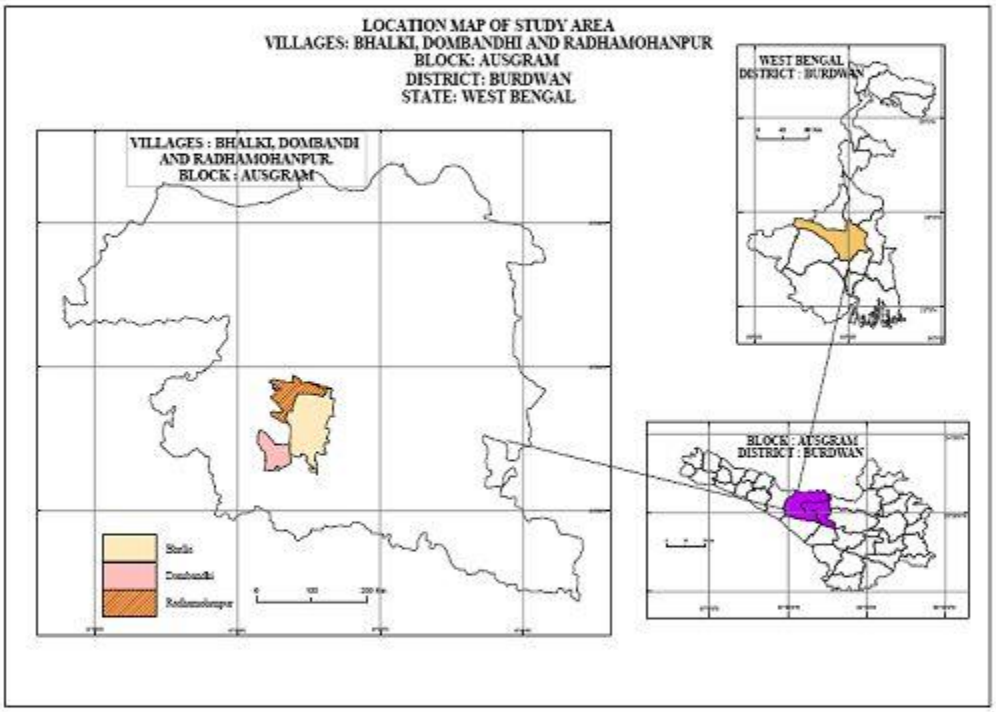

Figure 1: Study area Location

Bengal. The selected three villages from Ausgram are Bhalki, Dombandi and Radhamohanpur.

The village Bhalki is having five cadastral sheets. It covers 961 hectare area and the total population of the village is 2272 persons (2011). The main worker of the village constitutes 38% of total population and 16% of the total workers are agricultural labourers and 19 % of the workers are cultivators.

The village Dombandhi is having two cadastral sheets. It covers 300 hectare area and the total population of the village is 294 persons (2011). The main worker of the village constitutes 54% of total population and 51% of the total workers are agricultural labourers and 2 % of the workers are cultivators.

The village Radhamohanpur is having four cadastral sheets. It covers 403 hectare area and the total population of the village is 90 persons (2011). The main worker of the village constitutes 62% of total population and 62% of the total workers are agricultural labourers and no cultivators are present here.

The three villages are contiguous and altogether they cover 1624 hectare area. For comprehensive study, the three villages are combined together and evaluated the geomorphic resources.

MATERIALS AND METHODS

For evaluation of geomorphic resources and study we used Survey of India (SOI) topographical sheets (73 M11; published in 1972) as a base data base at 1:50000 scale. Physical information are extracted from every 500 square meter grids. Features like contours, spot heights, bench marks, drainage lines and surface water bodies (pond, tank, lake) are taken into consideration for characterisation of the physical resources of the region. These phenomena were measured and analysed to generate information on Absolute Relief (AR), Relative Relief (RR), Slope, Drainage Density (DD), Frequency of surface water bodies (FSWB), Dissection Index (DI), Ruggedness Index (RI) and geology using GIS technology. GIS technology can give the accurate result for analysis the geomorphic resources in present study area. These geomorphic resources are considered important parameters for their deterministic role in surface water bodies and seasonal land use land cover of the region. These resources are directly or indirectly controlling and influencing the availability of surface water resources which in turn dictate the land use land cover, water stressed situation and agriculture resources in selected village of Ausgram Block, Burdwan District, West Bengal.

RESULT AND DISCUSSION

Geomorphic resources are measured and analysed using Survey of India (SOI) topographical map. Five hundred square metre grids are generated and grid wise information are measured and collected for analysis. The importance of geomorphic resources is discussed and they are evaluated as per objective of the present paper.

Absolute Relief (AR)

The absolute relief, a function of the geotectonics, provides clue towards estimating the intensity of forces at work (Singh, 1980).

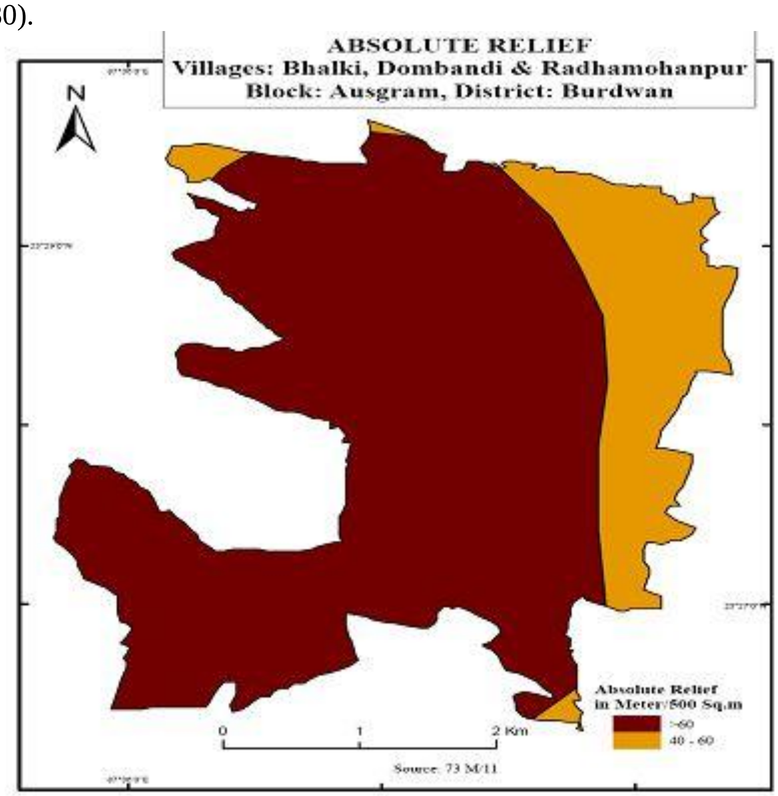

Figure 2: Absolute Relief

It is the maximum elevation of any area with reference to the mean sea level (MSL). The main objective of absolute relief is to determine how much erosion has taken place in relation to the present summits of the study area, because a summit is generally the last vestige of vanishing relief (Prasad, 1985). It is useful in delineating the terrain morphology, including the existence of erosion surfaces. Absolute relief we generated from every 500 sq. m grid. It the highest point of the grid. Present study area we created two class of absolute relief i.e. > 60m / 500 sq. m and 40 – 60 m / 500 sq. m. More than 60 m absolute relief distributed in western part of the study area and it covers 80.35 per cent. 40 – 60 m absolute relief distributed in eastern, north western parts of the study area, it covers 19.65 per cent area (Table:1 and Figure: 2).

Table 1: Absolute Relief

Class	**Absolute Relief in Meter** **Area in Hector**	**Area in %**
>60	1337	80.35
40--60	327	19.65
Total	**1664**	**100**

Relative Relief (RR)

Relative relief is one of the various methods evolved to measure the average slope. The term was invented and used by Smith (1935) to ascertain the amplitude of available relief to relate the altitude of the highest and the lowest points of any particular area.

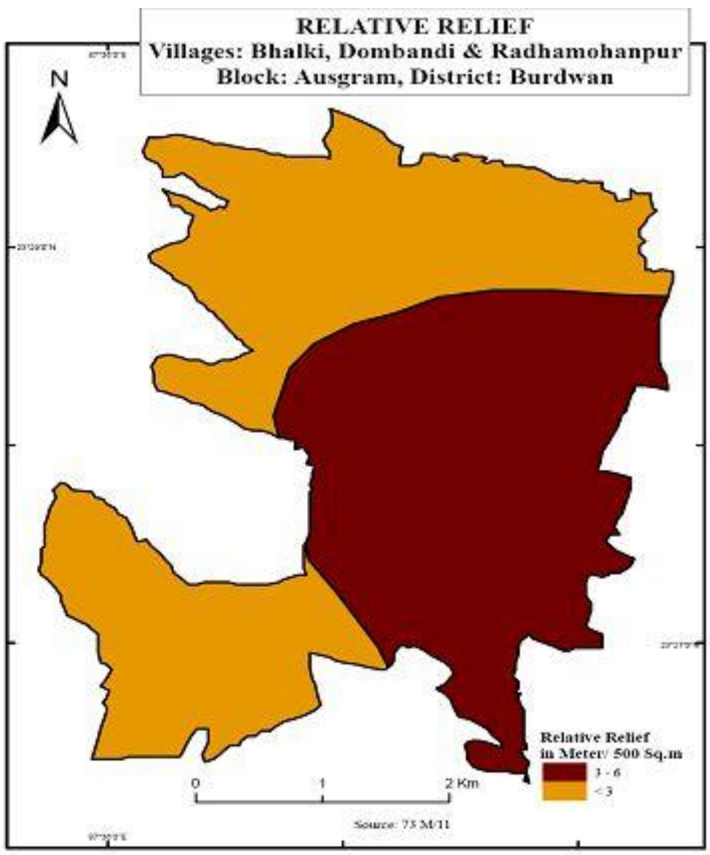

Figure 3: Relative Relief

The study of relative relief depicts the relief of an area in relation to the surrounding areas; probably so, it is called relative relief. The relative relief map gives a clear conception of the nature and amount of the slope of the area under study.

Relative Relief = Maximum Elevation (M) – Minimum Elevation (M)

Relative relief is one of the methods to depict the local relief of any part of the earth surface. Maximum elevation 70m is found in the central west part of the study area and minimum elevation 60 is found in the east of the study area. Relative relief of the villages has been studied using two categories i.e. <3 m and 3 to 6m per 500 sq. m grid. North and south west part of study area, the relative relief is less than three meters per 500 sq. m and it covers 53% of total area. In the east and central part of the study area, relative relief is three to six meters per 500 sq. m and it covers 47% of total area (Table: 2 and Figure: 3).

Table 2: Relative Relief

Class	Relative Relief in Meter Area in Hector	Area in %
<3	879.6	52.86
3--6	784.4	47.14
Total	**1664**	**100**

This low relative relief indicates that the region is almost flat land and appearing mature stage of geomorphic evolution. Lower relative relief suggests that if availability of water is made, the region can be converted to a very good agricultural region. Although maximum area is covered under <3m/500 sq. m relative relief zone but the presence of surface water resources are few. As a result the low relative relief zone could not be converted into good agricultural zone.

Lope (Raisz and Henry Method)

The term slope in its broadest sense means an element of earth's solid surface, including both terrestrial and submarine surfaces (Strahler, 1956). Terrain morphology is characterized by slope condition which is governed by a number of factors including climatic, geologic and tectonic condition. There is also a close relationship between slope condition and morphometric attributes of terrain i.e. absolute relief, relative relief, dissection index, drainage density and drainage frequency. Slopes are ubiquitous elements of the landscape (King, 1962). Slopes are the fundamental types of landscape feature. Slope may be defined as the tangent of the angle of inclination of a line or plane defined by a land surface. It is the result of a complex and continuous interaction between internal and external forces acting upon the earth's surface. It depends on rock and climatic conditions, which may in certain regions be constant over long periods of time and on the thickness, texture and mobility of surface layers of soil, organic matter etc. (Baulig, 1959). In a drainage system, valley side and channel slopes control directly the potential and kinetic energy of water flows and thus the intensity of runoff, erosion and transport processes. These factors tend to be in a state of equilibrium in relation to overall local geographical conditions. The slope angle indicates the magnitude of the component of the gravitational surface acting to produce movement of solid bodies, water or soil particles down a slope (Strahler, 1956). Slope also plays an important role in river processes. Neither the formation of runoff, the movement of floods, the power potential of river courses, the modelling and evolution of river channels, nor the erosion and transport processes occurring in the latter can be approached without knowing the slopes of the land surface and river network (Zavoianu, 1985).

$$\text{Slope (Raisz and Henry method)} = \text{Tan}\ \theta = \frac{\text{Vertical}}{\text{Base}}$$

(Monkhouse and Wilkinson, 1994)

An understanding of slope distribution is essential, as a slope map provides data for planning, settlement, mechanization of agriculture, reforestation, engineering structures, conservation practices etc. Though various methods are used to carry-out the slope analysis, here we have used Raisz and Henry method (Monkhouse and Wilkinson, 1994) of slope analysis. Raisz and Henry has divided the large scale topographical map into small region, within each of which the contour lines have the same standard spacing.

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Slope of land is one of the important physiographic aspects influencing the agricultural land use of an area. Slope of the study villages is not very high. Slope of the villages has been classified in five zones i.e. < 10’, 10 – 20’, 20 – 30’, 30 – 1^0 and >1^0. Maximum slope is found in south, west and central part and minimum slope is fond over north, east and south-east part (Table: 3 and Figure: 4). Minimum slope zone, < 10’ is distributed over the east of the study area and it covers one per cent of total area. 10’ – 20’ slope zone covers 61% of the total area. The low slope land can easily be used for agricultural activities if other required resources for it are available.

Table 3: Slope

Slope in Degree		
Class	Area in Hector	Area in %
>1^0	3.37	0.20
30’-1^0	24.13	1.45
20’-30’	602.30	36.20
10’-20’	1015.00	61.00
<10’	19.20	1.15
Total	**1664.00**	**100.00**

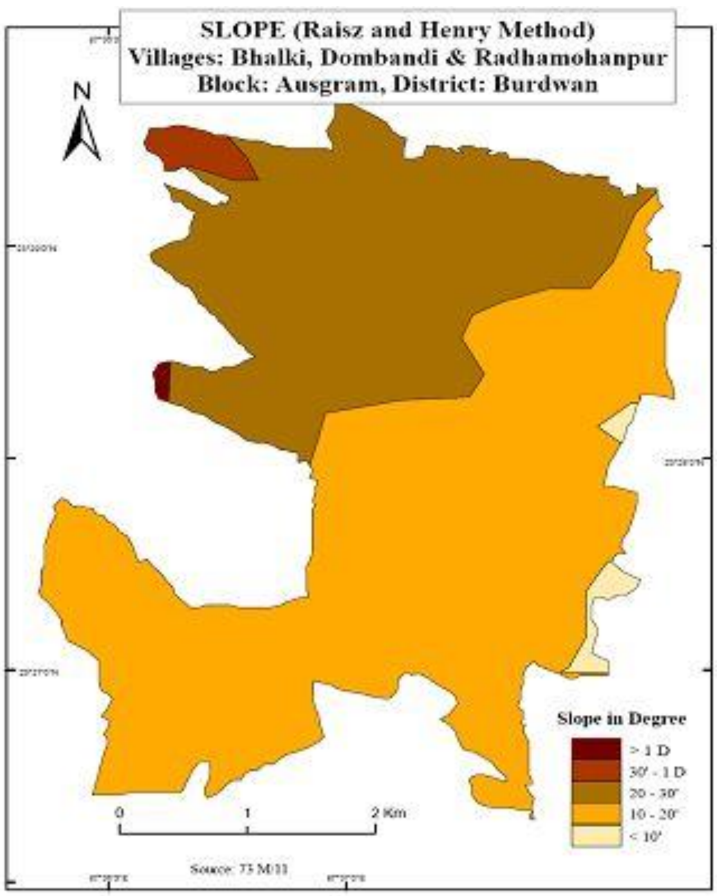

Figure 4: Slope

Drainage Density (DD)

Drainage density is defined as the total length of streams/ 500 sq. m. Density factor is related to climate, rock type, relief, infiltration capacity, vegetation cover, surface roughness and run-off intensity index. The drainage density explains the stage of fluvial eroded landscape. The importance of drainage density in this analysis is due to two reasons. Firstly, it reflects the potential rate of discharge of water to be transmitted through the respective region or basin and secondly, it reflects climatic conditions of particular area. The drainage density indicates the closeness of spacing of channels (Horton, 1932).

Drainage density (D) = $\left(\frac{Lu}{A}\right)$

Lu = Total length of stream channels per unit area (Km)
A = Area of the unit (500 sq. m) ---- (Horton, 1932)

Drainage density is defined as the total length of streams of all orders per unit area. Drainage density of the study area has been measured, and isolines are drawn to classify the region in two categories, <1 km/ $500m^2$ and 1-2 km/$500m^2$. Less than one km/ $500m^2$ drainage density zone is distributed in the south, central and north east parts of the study area and it covers 54% of total area. One to two km/$500m^2$ drainage density zone is distributed in the north central and south east parts of the study area and it covers 46% of total study area (Table: 4 and Figure:5).

From the study of the drainage density it may appear that the area may have significantly good amount of surface water resources. But the ground reality shows that the highest drainage density is due to origin of some first order streams from the highlands and it does not add significantly to the availability of water in the region.

Table 4: Drainage Density

	Drainage Density Km/500m²	
Class	**Area in Hectare**	**Area in %**
01- 02	760.50	45.70
<1	903.50	54.30
Total	**1664.00**	**100.00**

Frequency of Surface Water Bodies

Frequency of surface water bodies can be defined as the number of water bodies per 500 sq. m area. Water is an important locating factor for settlement and it remains present on the earth's surface in the form of rivers, ponds and lakes. The quantity of water directly used by man is comparatively small, but the quantitative used by man for agriculture in the form of irrigation is very large.

Lots of water bodies, both natural and manmade are available in the villages. Number of water bodies per 500 square meter grid has been calculated. Isolines of the data have been drawn and the region is classified into four zones as per the drainage frequency. Drainage frequency zones are <2, 2 – 10, 10 – 15 and > 15. Maximum study area falls under the < 2 category of drainage frequency. The zone is distributed in the south west, west, North West, north and north east parts of the study area and it covers 67% of total area.

Table 5: Frequency of Surface water bodies

	Frequency of Surface Water Bodies	
Class	**Area in Hectare**	**Area in %**
>15	116.00	6.97
10-15	210.80	12.67
2-10	214.20	12.87
<2	1123.00	67.49
Total	**1664.00**	**100.00**

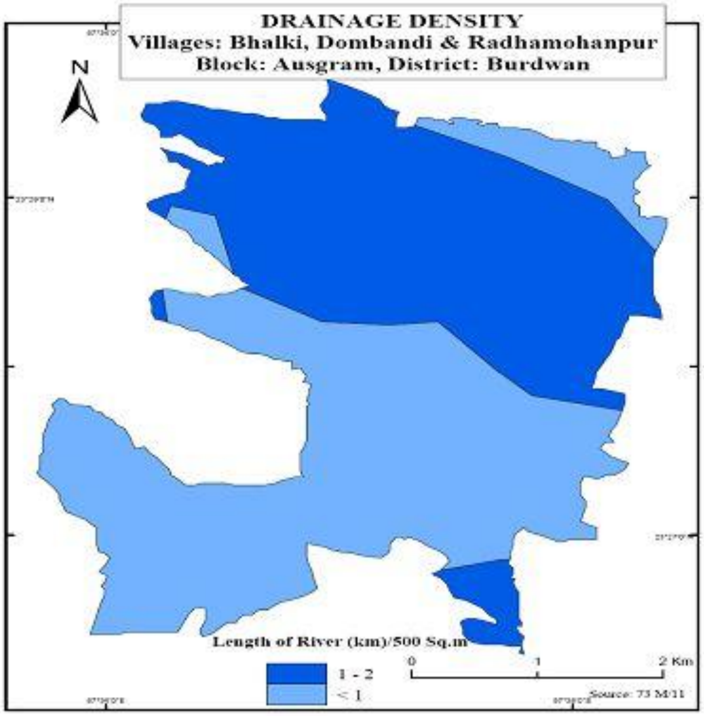

Figure 5: Drainage Density

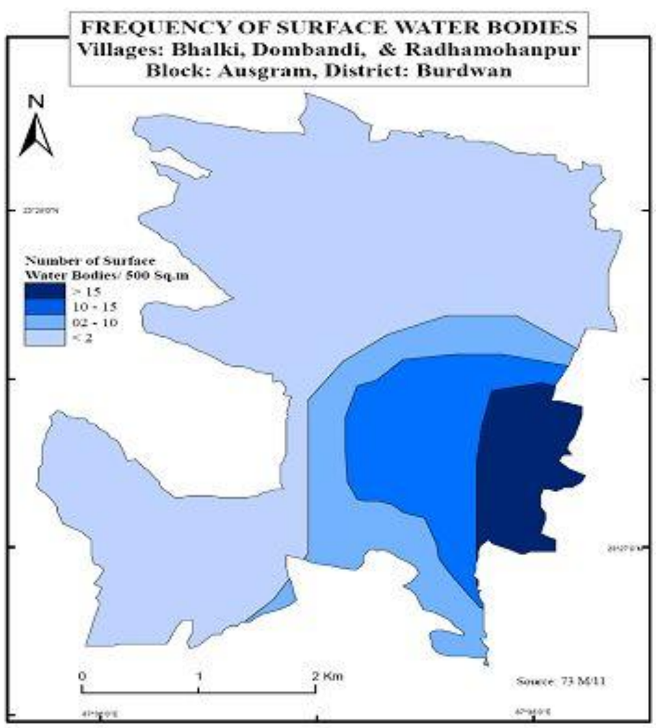

Figure 6: Frequency of Surface water Bodies

Two to ten water bodies per sq.km zone is distributed in the south, south central and east central part of the study area and it covers 13% of total area. 10 -15 water bodies per sq.km zone is distributed in the

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central east part of the study area and it covers 13% of total area. More than 15 water bodies zone per sq.km is distributed in the eastern part of the study area and it covers 7% of total study area (Table: 5 and Figure: 6).

It may be true that the study area is having many water bodies. Unfortunately the poor management of the water bodies makes the unable to hold the much needed water in most of time of a year. The ground reality shows that these water bodies add little water to the region in drier periods.

Dissection Index (DI)

Dissection Index is defined as the ratio between the relative relief and absolute relief. It is an important geomorphological tool for estimating vertical balance of erosion (Sen, 1993). It is an important parameter of any region and useful in the study of the terrain, dynamics and stages of landscape evolution (Mukhopadhyay, 1984).

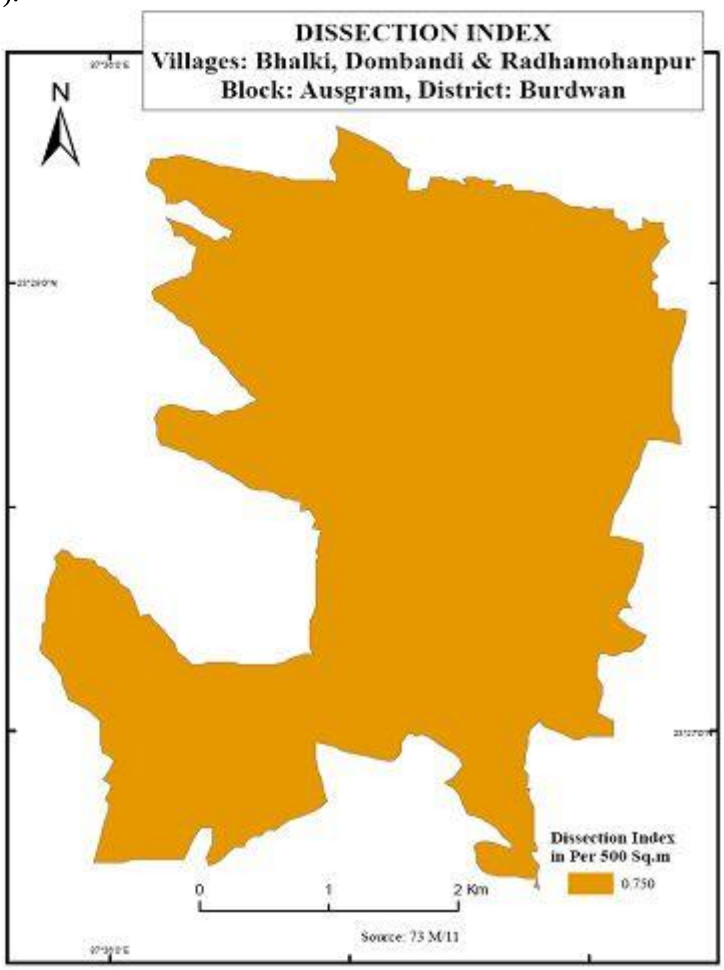

Figure 7: Dissection Index

The dissection index gives clue to the development of landforms under the purview of fluvial geomorphic cycle of erosion (Prasad, 1985). The extra merit of dissection index is that it is related not only to the elevation, but also to relief, dissection and slopes. It means that area of lower elevation may be characterised by high degree of dissection index, if the area is dissected by deep river-valleys or is characterised by frequent and isolated hilltops. There is every possibility of obtaining equal relative reliefs for two areas with variable characters. But the dissection index varies very much in such circumstances.

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The study of dissection index (DI) determines the nature and availability of water resources for agricultural land.

$$\text{Dissection Index (DI)} = \frac{\text{Maximum Elevation - Minimum Elevation}}{\text{Maximum Elevation}}$$

Total study area dissection index is 0.750 / 500 sq. m, (Figure: 7) it distributed entire study area. This low dissection index value suggests that the river erosion is very low and the total area is growing towards the mature stage of development in the cycle of erosion.

Ruggedness Index (RI)

Ruggedness Index describes the complexity of the topography and the roughness of the terrain. The ruggedness indicates the degree of dissection of a region where drainage has also been taken as an important parameter. Chorley (1972) has devised the formula of ruggedness index as:-

$$\text{Ruggedness Index} = \frac{\text{Relative Relief(M) * Drainage density (km/km2)}}{1000}$$

(Chorley, 1972)

This index is being widely used by the earth scientists in connection with the morphological studies of terrain and it leads to better understanding of the surface configuration evolved under complex geomorphic processes. Actually, it is more than development of slope or dissection index as it incorporates a number of determinant factors related to the development of landforms. This index reflects the combined effects of evolutionary rhythmic processes in the development of relief (Mukhopadhyay, 1984).

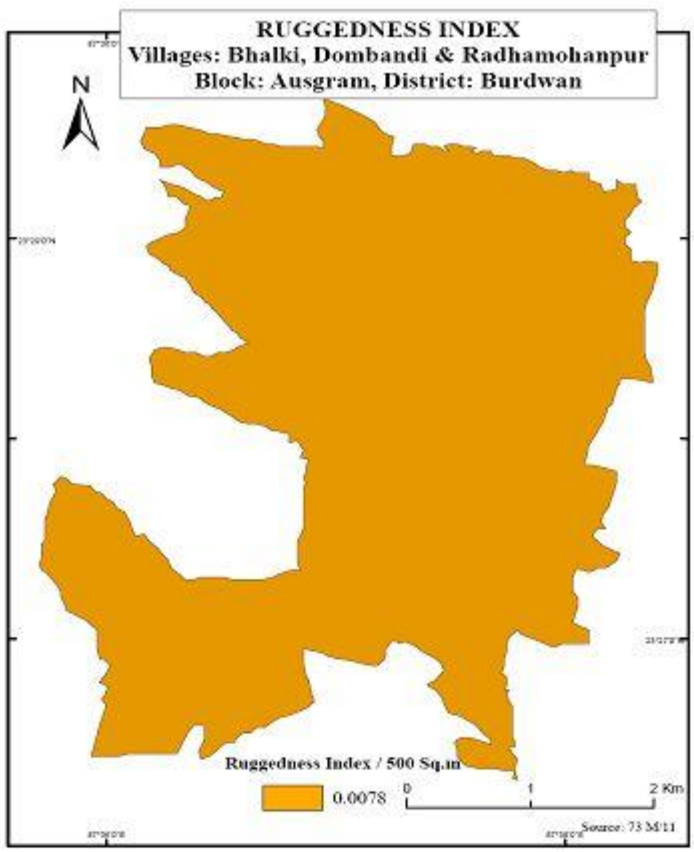

Figure: 8 – Ruggedness Index

Roughness index follows the same trend and indicates a close relationship with other morphometric attributes like relative relief, slope and dissection index (Mukhopadhay, 1973, 1979).

Present study area ruggedness index is 0.0078 per 500 sq. m, (Figure: 8) it is poor ruggedness index of whole study area and it indicating the minimum effort is needed to manage surface water which can make the region a good agricultural region.

Geology

Ausgram Block, with their varied tectonic elements and riverine features are contiguous transitional zone between the Jharkhand Plateau which constitute a portion of Peninsular shield in the west and Ganga-Brahamaputra alluvial plain in the north and east. In general the Jharkhand Plateau consists of the met-sedimentary rocks of Precambrian Age, Gondwana Sedimentary rocks, Rajmahal Basalts and upper Tertiary Sediments. Laterite has developed on these older rocks as well as on early Quaternary Sediments. Towards south, the alluvial plain merges with Damodar-Kasain-Subarnarekha deltaic plains.

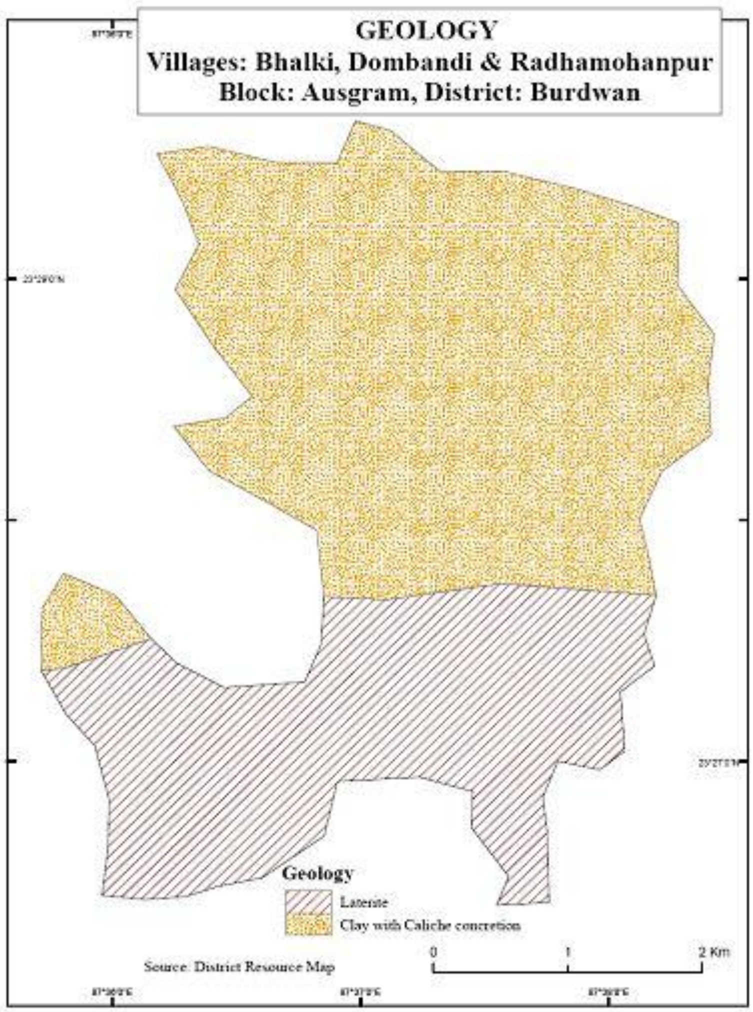

Figure 9: Geology

The western half of the district resembles a promontory, jutting out from the hill ranges of Chotonagpur Plateau and consists of barren, rocky and rolling country with a laterite soil rising into rocky hillocks. The gradient is from the west to east. It is northerly towards Ajay and southerly towards Damodar below the latitude. The Ajoy- Damodar inter-stream tract is made up of several stows consisting of vales and low convex spurs which run in almost all directions thus lends a very complicated character to local relief.

Present study area is covered with laterite covers south part, Clay with caliches concretion covers north part of the Villages (Figure: 9)

RESULTS AND CONCLUSIONS

The geomorphic resource evaluation means measurement and quantification of the Absolute Relief (AR), Relative Relief (RR), Slope and Frequency of surface water bodies (FSEB), Drainage Density (DD), Dissection Index (DI) and Ruggedness Index (RI). The region is evaluated as to be in the late maturity stage of the geomorphic cycle of evolution.

From the above discussion, it can be concluded that the region in approaching old stage of landscape evolution. Still some absolute relief are there and they make the area undulating. Absolute relief influence the distribution and availability of surface water resources. As a result, the low relative relief zone has not been converted into good agricultural zone. Dissection index value shows the river erosion is very low and the total area is growing towards the old stage of development in the cycle of erosion. Slope is controlling the nature and distribution of surface water resources. Where the slope is <30' in the study area, those parts have lots of surface water bodies (ponds, tanks, river and canals). Where the slope is 1^0 or more, the surface water bodies are few in these areas. Frequency of surface water bodies shown maximum area covered low number of surface water bodies (<2/500 sq. m), but some areas show high water bodies (30 / 500 sq. m) also. The ground reality shows that the water bodies may be present but there is no water in maximum time of a year. The drainage density shows that this portion of the block is having significantly good amount of available surface water resources. But maximum time of a year the water body remains dry. Ruggedness index is low in present study area and minimum effort is needed to manage the surface water which can make it a good agricultural region. The higher relief does not allow the rivers of the region to from flood plain features and so the amount of surface water resources are low.

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