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Identification of Physiographic and Erosion Prone Area of the Campus of School of Technology Situated in a Hilly Terrain of Assam

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Abstract—*Soil erosion is one of the most significant environmental degradation processes and has been accepted as a serious problem arising from construction of buildings, agricultural intensification, land degradation and possibly due to global climatic change. Addressing multitude of serious problem of soil erosion and other forms of land degradation of the hilly region, the present study was carried out for identification of physiographic and erosion prone area of the campus of the Triguna Sen School of Technology, Assam University Silchar situated in a Hilly Terrain of Assam. The campus includes three academic buildings constructed at the top of the hillocks. The physiographic characteristics and erosion risk of the study area were identified using the standard method for topographical surveying and soil loss model. The topographical survey was carried out to assess the land use, land cover and slope classes of the two study sites (1 and 2) of the campus. The land coverage of constructed, fallow and agriculture land of the total study area (9142.41 m^2) were found 75.11, 23.98 and 0.91%, respectively. Soil erosion risk for both the sites were assessed based on the priority class which were determined considering the average monthly, seasonal and annual soil losses of the study site for the five years (2009-2013). Study revealed that site is heterogeneous with slope variation from 1.54 to 8.46%. Out of 8 plots (1-8) two plots (2 and 3) are found under the slope class B (very gentle sloping) and rest under slope class D (moderately sloping). In site 1 (1-4 plots), maximum annual average soil loss was found in plot 1(154.428 t ha^{-1}) and minimum in plot 3 (22.48 t ha^{-1}). However, in site 2 (5-8 plots), maximum soil loss was found in plot 8 (165.63 t ha^{-1}) and minimum in plot 7 (74.984 t ha^{-1}). Seven plots of the study site were found in priority class I except plot 3 (class III) that indicated high erosion riskiness' of the study area. As the study site is an institutional area so at that position stability of permanent structure are more important and there is urgent need take measures for the soil conservation.*

1. NTRODUCTION

Soil erosion is one of the most significant environmental degradation processes and has been accepted as a serious problem arising from agricultural intensification, land degradation and possibly due to global climatic change [4]. Soil erosion, by water, is the resultant of interplay between catchment environmental factors such as soil, topography, drainage, rainfall and land use pattern, data upon which are available from different source and systems [1]. In India it has been estimated that an area over 80 million hectares or about one fourth of our total area is exposed to wind and water erosion out of which 40 million hectares of land has undergone serious erosion [7]. In Assam, every year flooding and river bank erosions causes devastating impacts. Total area eroded from 1954 till date is approximately 386,476 hectares which is means that about 7% of the land in the states 17 riverine districts. It is reported that about 207,287 hectares in Assam are under shifting cultivation due to water erosion [7]. In Cachar district of Assam the area are hilly and very high rainfall intensity about greater than 3000mm and Barak river flow through the district about 130 km [3]. Landslide, mudslides, collapse, of manmade terraces, soil loss from steep slopes and decline of forest / pasture areas are the main reasons for land resource degradation in the hilly resign [2]. Formation of hilly resign is geologically weak, unstable and hence highly subjected to serious problem of soil erosion [6]. So due to flooding, riverbank erosion, high slope and high rainfall the soil erosion very highly occurring here.

Addressing multitude of serious problem of soil erosion and other forms of land degradation of the hilly region, the present study was focused on identification of physiographic characteristics, and assessment of monthly, seasonal and annual soil erosion rate and erosion prone area of the campus of academic departments under Assam University Silchar situated in a Hilly Terrain of Assam.

2. MATERIALS AND METHODS

2.1 Study Area

The campus of the Triguna Sen School of Technology under the Assam University, Silchar situated in a hilly terrain of

Cachar district and in the southern part of the Assam, India was considered for the study area. The campus includes three academic buildings (Information Technology and Electronics and Communication Engineering as site I and Agricultural Engineering and Workshop as site II) situated at the top of the hillocks. The study area covers approximately 12276 m^2 hill top surface area and lies between longitudes 92.751852^o to 92.750479^o E and latitudes 24.679558^o to 24.677822^o N. The location of the study area is shown in Fig. 1.

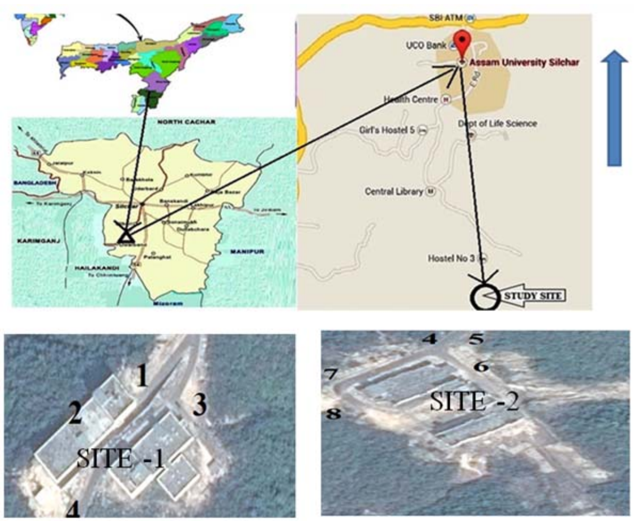

Fig. 1: Location of experimental site of the hilly terrain (Courtesy- www.google.com).

The study area experiences a subtropical monsoonal climate with an annual rainfall ranging between 2500-3300 mm. The average rainfall of the area is over 3000mm and about 80-85% of this rainfall occurs during the month of April/May-September/October. December and January are normally the driest months. During summer average and minimum temperature is 35^{o}C and 20^{o}C, respectively. In winter average maximum and minimum temperature becomes 25^o C and 11^o C respectively. Soils of the zone vary from sandy type to clay soil mostly suitable for field crops including horticultural crops.

2.2 Identification Physiographic characteristics

The physiographic characteristics of the study area were identified using the standard method for topographical surveying and soil loss model. The topographical land survey was carried out using standard surveying instruments such as Global Positioning System (GPS) and Automatic Level. The total area of the hilly terrain was found about 9682.8m^2. Because of dense jungle and deep slope, it was not possible to make demarcation in to different sections of the land. However, randomly, two sites each having 4 plots were considered for the assessment of land use, land cover and slope classes of the two study sites (1 and 2) of the campus (Fig. 1).

The topographic characteristics such as land area, soil depth, slope and elevation for each plots of the study sites were determined using standard guidelines of land capability classification [9].The Google images and the survey report were interpreted individually for the detailed information about land use and land cover. Land use and land cover of the study site was classified as agricultural land, fallow land and constructed land and the corresponding areas were determined using chain surveying. Slope class was assessed based on USDA criteria with the changes in elevation over distance (Table 1).

Table 1. Criteria for characterization of slope classes

Class	Slope Range (%)	Slope Class
A	0-1	Nearly level
B	1-3	Very gentle sloping
C	3-5	Gentle sloping
D	5-10	Moderately sloping
E	10-15	Strongly sloping
F	15-25	Moderately to steep sloping
G	25-33	Steep sloping
H	33-50	Very steep
I	>50	Extremely steep slope

Source: Soil survey manual (Anonymous, 1970)

2.3. Soil Erosion Risk Assessment

Soil erosion risk was assessed based on the priority class which was determined by the average soil loss of the study site. The Soil loss was determining by the USLE equation. This equation is a function of five input factors such as rainfall erosivity, soil erodibility, slope length and steepness, cover management and support practice. These factors vary over space and time and depend on other input variables. In the present study the monthly, seasonal and annual soil losses were determined for each site using Universal Soil Loss Equation (USLE) model. The USLE model has been widely used for both agricultural and forest watershed to predict the average annual soil loss. The method used in present study is the implementation of USLE equation in the surveyed data for the calculation of specific factor and annual soil loss from the area under investigation.

The USLE method is expressed as

$$A_{ijk}= R_{ijk} K_{ijk} LS_{ijk} C_{ijk} P_{ijk} \quad (1)$$

Where, A is the computed spatial average of soil loss over a period selected; R is rainfall erosivity factor (MJ mm ha^{-1} h^{-1} $year^{-1}$), K is soil erodibility factor (t ha^{-1}); LS is the slope length steepness factor (dimensionless); C is the cover management factor (dimensionless, ranging between 0 and 1); P is the erosion control (conservation support) practices factor (dimensionless, ranging between 0 and 1); and i, j, k denotes yearly, seasonal and monthly soil erosion, respectively.

2.3.1. Rainfall Erosivity (R)

Rainfall data of 5 years (2009-2013) collected from India Meteorological Department were used for calculating R-factor. The watershed has no record of rainfall intensity as a result monthly data were used to calculate annual R-factor using the following relation developed by Wischameier and smith [9].

$$R = \sum_{i,j,k} 1.735 * 10^{\left(1.5\ \log_{10}\left(\frac{pi}{p}\right) - .08188\right)} \quad (2)$$

Where R= Rainfall erosivity factor in MJ mm ha^{-1} h^{-1} year^{-1}, p_i =Monthly rainfall in mm and P= Annual rainfall in mm, and i, j, k, express the monthly, seasonal, annual, respectively.

2.3.2. Soil Erodibility Factor (K)

Different soil types are naturally resistant and susceptible to more erosion than other soils and are function of grain size, drainage potential, structural integrity, organic content and cohesiveness. Erodibility of soil is it's resistance to both detachment and transport. The k factor values were determined using the table created by Cooper E.L [8]. as given in Table 2.

Table 2: Soil Texture and soil erodibility factor.

Soil Texture	K at Organic Matter Content (%)		
	0.50	2	4
Fine sand	0.16	0.14	0.10
Very fine sand	0.42	0.36	0.28
Loamy sand	0.12	0.10	0.08
Loamy very fine sand	0.44	0.38	0.30
Sandy loam	0.27	0.24	0.19
Very fine sandy loam	0.47	0.41	0.33
Silt loam	0.48	0.42	0.33
Clay loam	0.28	0.25	0.21
Silt clay loam	0.37	0.32	0.26
Silty clay	0.25	0.23	0.19

2.3.3. Slope Length and Steepness Factor (LS)

The slope length factor was calculated based on the relationship developed by McCool (1987). The equation follows as:

$$L = (\lambda/22.13)^m \quad (3)$$

Where L=slope length factor, λ= field slope length(m), m= dimensionless exponent that depends on slope steepness, being 0.5 for slopes exceeding 5%, 0.4 for 4% slopes, and 0.3 for slope less than 3%.

Slope steepness factor was calculated based on the relationship given by McCool (1987) for slope longer than 4m as:

$$S = 10.8 \sin\theta + 0.03 \text{ For slopes} < 9\% \quad (4)$$

$$S = 16.8 \sin\theta - 0.50 \text{ For slopes} > 9\% \quad (5)$$

Where S= slope steepness factor and θ= slope angle in degree. The slope steepness factor is dimensionless.

2.3.4. Cover Management Factor (c)

Cover management factor is the expected ratio of soil loss from a cropped land under specific condition to soil loss from a cropped land under specific condition to soil loss from clean tilled fallow on identical soil and slope under the same rainfall condition. The type of the land cover, the manner in which it is managed and the changes that have taken place over time form the basic premise for evaluating sediment yield from watershed. Crop management factor was assigned for different land use patterns created USDA-SCS (1972), as given in Table 3.

Table 3: C-factor for different type of land covers.

Land Use/ Land Cover	C- value
Agricultural (paddy)	0.28
Degraded forest	0.008
Dense forest	0.004
Fellow agriculture	0.18
Jhum cultivation	0.33
Open forest	0.008
Settlement	1
Water body	0.28

2.3.5. Conservation Practice Factor (P-factor)

Conservation practice factor (P) is the ratio of soil loss with a specific support practice to the corresponding loss with up and down slope cultivation. In the study area no major conservation practices are followed. The values for P-factor were assigned to be 0.28 for under agriculture and 1 for other area.

2.4. Risk Analysis

Risks of the soil erosion was calculated by comparing with the priority classification [3]. as shown in Table 4.

Table 4. Priority classification based on different ranges of average soil loss.

Priority Class	Average Soil Loss (t/ha/yr)
Very low(VI)	<5
Low(V)	5-10
Medium(IV)	10-15
Mod. High(III)	15-25
High(II)	25-50
Very High(I)	>50

3. RESULTS AND DISCUSSION

3.1. Variation of Slope Classes

The slope was classified into eight slope classes (Soil survey manual, Anonymous, 1970) of <3, 3-5, 5- 10, 10-15, 15-25, 25-33, 33-50 and >50 percent of different plot as nearly sloping, very gentle sloping, gentle sloping, moderately sloping, strongly sloping, moderately steep to steep sloping, steep sloping, very steep slope and extremely steep slope respectively. Variation of slope, slope length and slope classes found for the study site is presented in Table 5.

Table 5. Variation of slope, slope length, and slope classes.

Plot	Slope (%)	Slope Length (m)	Slope Class
1	8.46	65	D (Moderately sloping)
2	2.87	55	B (Very gentle sloping)
3	1.54	33	B (Very gentle sloping)
4	5.45	62	D (Moderately sloping)
5	8.41	24	D (Moderately sloping)
6	8.3	15	D (Moderately sloping)
7	6.1	14	D (Moderately sloping)
8	7.43	30	D (Moderately sloping)

Comparing two sites, the maximum elevation with respect to mean sea level was found in plot 1 (47.5 m) and minimum in plot 8 (38.05 m). The maximum land slope was found in plot 1 (8.46%) and minimum in plot 3 (1.54). The maximum slope angle was found in plot 1(4.83^0) and minimum in plot 3 (0.8851^0). The maximum slope length was found in Plot 1 (65m) and minimum in Plot 7 (14m). The variation of land slope, slope length and slope angle indicates the heterogeneous nature of the site I with very gently to moderately slope classes.

3.2. Physiographic Characterization

The physiographic of the study site contains three major types of land use pattern such as constructed, agricultural and fallow land. The total areas of each land use, percentage of land coverage measured during topographical survey are presented in Table 6.

Table 6. Land use and land covers distribution of the study area.

Plot	Fallow Land (m^2)	Agricultural Land (m^2)	Constructed Area (m^2)	Total Area (m^2)	Land cover age
1	561.68	0	3096.00	561.68	6.14
2	72	0		72	0.79
3	626.10	0		626.10	6.85
4	160	0		160	1.75
5	94	0	3770.68	94	1.02
6	0	83.40		83.40	0.91
7	458	0		458	5.01
8	292	0		292	3.19
Total	2192.33	83.40	6866.68	9142.41	100

3.3. Identification of Erosion Prone Area

In order to identify the erosion prone area, the amount of soil loss occurred in each plot of the study site for the five years (2009-2013) was estimated using USLE method. The five input factors rainfall erosivity, soil erodibility, slope length and steepness, cover management and support practice of the USLE method were determined using standard methods and the findings are detailed in the following sections.

3.4. Spatio-Temporal Variation of Soil Loss

The spatio-temporal variation of occurrence of soil loss in the study sites were determined for each plot on monthly, seasonal and yearly basis using the standard method detailed in the following section. The monthly variation of soil loss estimated soil loss for each for the year 2009, 2010, 2011, 2012 and 2013 are presented in Figures 2, 3, 4, 5 and 6 respectively.

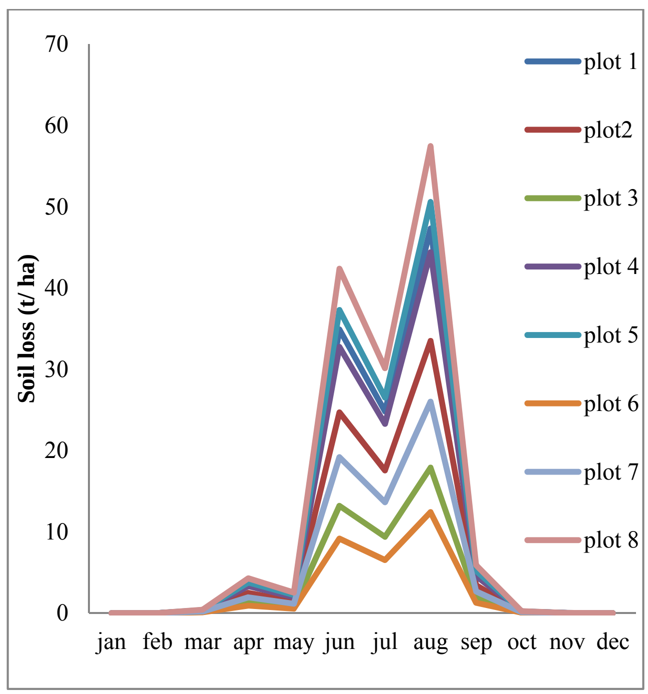

Fig. 2: Monthly variation of soil loss in each plot in 2009.

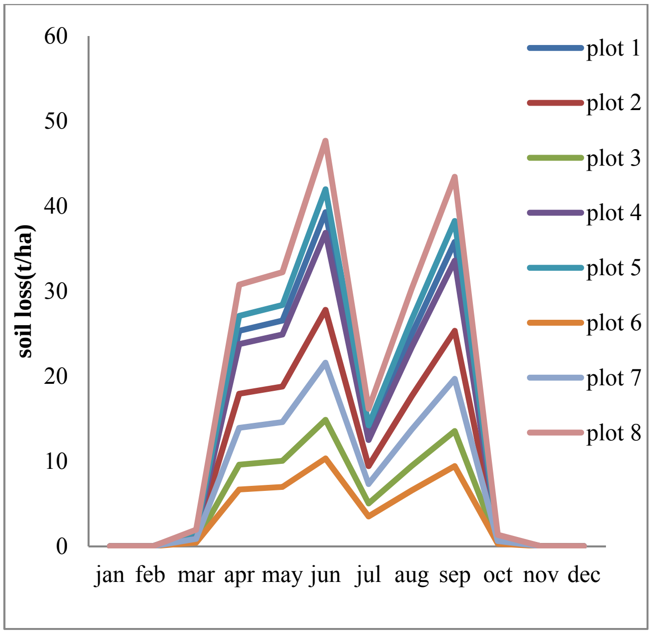

Fig. 3. Monthly variation of soil loss in each plot in 2010.

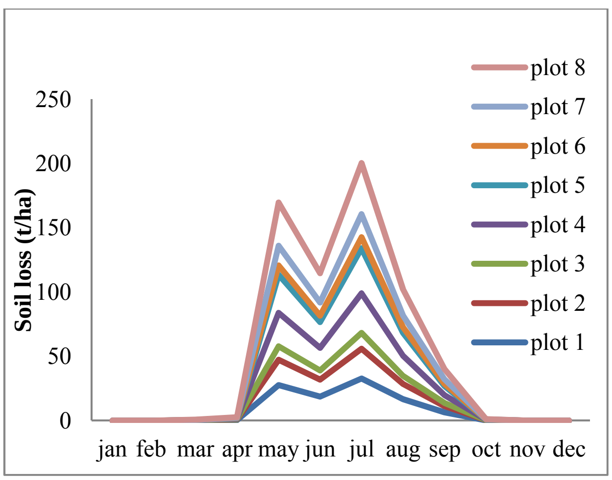

Fig. 4. Monthly variation of soil loss in each plot in 2011.

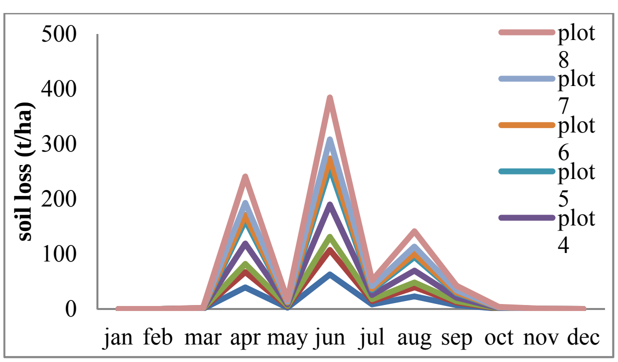

Fig. 5. Monthly variation of soil loss in each plot in 2012.

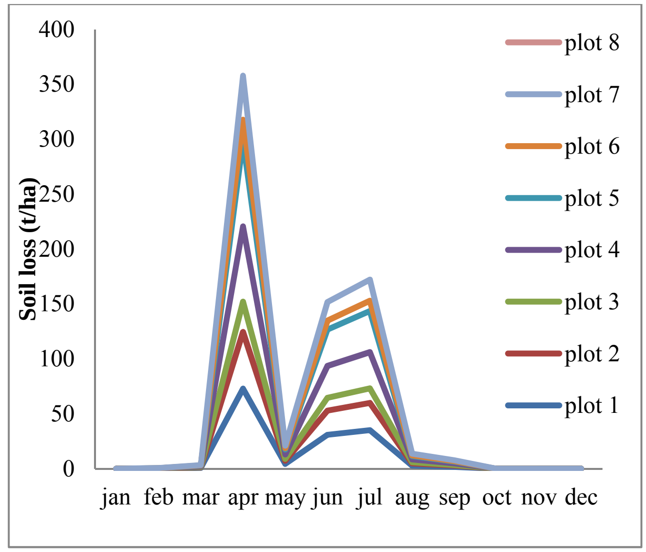

Fig. 6. Monthly variation of soil loss in each plot in 2013.

3.5. Seasonal Soil Loss Distribution

In a year in rainy season was found maximum soil loss since maximum rainfall erosivity factor and rainfall was found in this season and maximum soil loss occurred in this season. Rainy season was vary April to August. After that post rainy season was found greater soil loss than pre rainy season since maximum rainfall erosivity obtain in this season. Seasonal soil loss distribution Table 7.

Table 7. Seasonal soil loss in plots of study site.

Plot	Soil Loss (t/ha)					
	Year	2009	2010	2011	2012	2013
	Season					
1	Pre rainy	0.36	1.60	0.35	0.35	6.21
	Rainy	112.68	165.21	136.60	136.60	143.24
	Post rainy	5.08	1.11	7.57	7.57	4.34
2	Pre rainy	0.25	1.13	0.40	0.25	0.55
	Rainy	79.74	116.92	68.20	96.67	101.37
	Post rainy	3.59	0.79	4.79	5.36	3.07
3	Pre rainy	0.14	0.60	0.21	0.13	0.30
	Rainy	42.64	62.51	36.46	51.69	54.20
	Post rainy	1.92	0.42	2.56	2.86	1.64
4	Pre rainy	0.14	1.50	0.53	0.33	0.74
	Rainy	42.64	155.02	90.42	128.18	134.41
	Post rainy	1.92	1.04	6.35	7.10	4.08
5	Pre rainy	0.38	1.71	0.60	0.37	0.84
	Rainy	120.43	176.58	103.00	146.00	153.09
	Post rainy	5.43	1.19	7.23	8.09	4.64
6	Pre rainy	0.09	0.42	0.09	0.21	0.21
	Rainy	29.62	43.43	35.91	37.65	37.65
	Post rainy	1.34	0.29	1.99	1.14	1.14

	Pre rainy	0.20	0.88	0.31	0.19	0.43
	Rainy	61.93	90.80	52.97	75.08	78.73
7	Post rainy	2.79	0.61	3.72	4.16	2.39
	Pre rainy	0.44	1.94	0.68	0.42	0.95
	Rainy	136.79	200.57	116.99	165.84	173.90
8	Post rainy	6.17	1.35	8.21	9.19	5.27

3.6. Yearly Soil Loss Distribution

In year 2009 maximum soil loss was found in plot 8 (143.39 t ha^{-1} y^{-1}) and minimum in plot 3(19.46 t ha^{-1} y^{-1}). In year 2010, maximum soil loss was found in plot 8(203.85 t ha^{-1} y^{-1}) and minimum soil loss in plot 3(27.67 t ha^{-1} y^{-1}). In the year 2011, maximum soil loss was found in plot 1(193.24 t ha^{-1}) and minimum soil loss in plot 3 (17.01 t ha^{-1}). In year 2012, maximum soil loss found in plot 8 (175.45 t ha^{-1}) and minimum in plot 3 (23.81 t ha^{-1}). In year 2013, maximum soil loss found in plot 8 (180.11 t ha^{-1}) and minimum in plot 3(24.45 t ha^{-1}) (Table 8). In site 1, maximum average soil loss was found in plot 1(154.428 t ha^{-1}) and minimum in plot 3(22.48 t ha^{-1}). In site 2, maximum soil loss was found in plot 8(165.63 t ha^{-1}) and minimum in plot 7 (74.984 t ha^{-1}). Since maximum and minimum slope length factor was found in these plots. In all plots (except plot 1) maximum soil loss was found in year 2010 since maximum rainfall erosivity and rainfall was found and minimum soil loss was found in year 2011 since minimum rainfall erosivity and rainfall was found. Plot 1 was show exceptional curve. In plot 1, maximum soil loss was found in year 2011 and minimum in year 2009 (Fig. 7).

Table 8. Year wise soil loss in different plot

Year	Soil Loss (t/ha/yr)							
	1	2	3	4	5	6	7	8
2009	118.11	83.58	19.46	110.83	126.23	71.28	64.91	143.39
2010	167.91	118.83	27.67	157.56	179.46	101.34	92.29	203.85
2011	193.24	73.07	17.01	96.88	110.35	62.31	56.75	125.35
2012	144.52	102.28	23.81	135.61	154.46	87.22	79.43	175.45
2013	148.36	105	24.45	139.21	158.57	89.54	81.54	180.11
Average	154.42	96.55	22.48	128.01	145.81	82.33	74.98	165.63
Maximum	193.24	118.83	27.67	157.56	179.46	101.34	92.29	203.85
Minimum	118.11	73.07	17.01	96.88	110.35	62.31	56.75	125.35

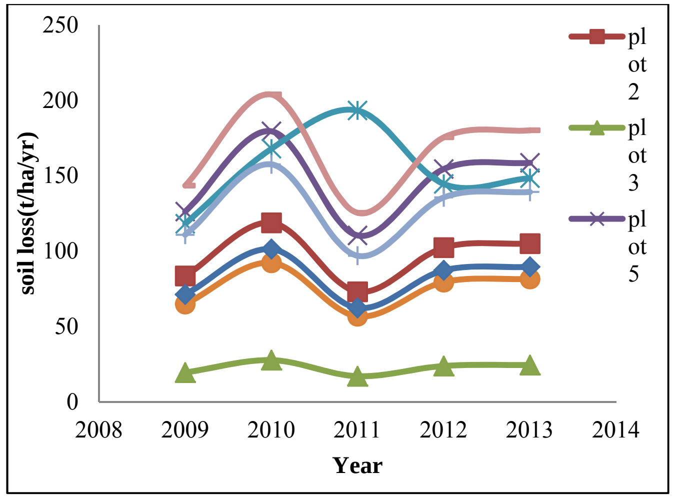

Fig. 7. Soil loss variations with yearly for different plot.

3.7. Risk Analysis

Risk analysis is very important for the study of soil erosion. For risk analysis we use the Priority class for soil erosion. Most of the plots were found in priority class I except plot 3 so study area was found very high erosion risk. Only plot 3 was found in priority class III so plot 3 was found normal erosion risk due to very low slope length factor and slope in this area. So here conservation practices are very essentially required.

4. CONCLUSIONS

Assam University falls in the Barak Valley which is surrounded by low hills and basically falls under hilly terrain. Campus of Triguna Sen School of Technology is heterogeneous hilly area. Here the slope variation is very irregular and very high rainfall also occurs. So by all these factors, the study area is found to be very high erosion risk.

Study site comes under high rainfall region with high variations in the slope that resulted high rainfall erosivity, soil erosion falls in very high erosion risk area. In site 1, maximum annual average soil loss was found in plot 1(154.428 t ha^{-1}) and minimum in plot 3 (22.48 t ha^{-1}). However, in site 2, maximum soil loss was found in plot 8 (165.63 t ha^{-1}) and minimum in plot 7 (74.984 t ha^{-1}). Six plots were found in priority class I except plot 3 (class III), so the study area was found very high erosion risk.

Soil erosion has very negative effect on agricultural process and stability of permanent structure. The study site is an institutional area so at that position stability of permanent structure are more important and there is urgent need take measures for the soil conservation.

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