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IMPACT OF LAND USE CAPABILITY CLASSES AND PRESENT LAND USE ON SOIL PROPERTIES AND ERODIBILITY BEHAVIOUR OF SHEETALPUR WATERSHED IN DISTRICT HAMIRPUR OF BUNDELKHAND REGION (U.P.), INDIA

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Abstract

This case study was carried out in Sheetalpur watershed in district Hamirpur of Bundelkhand region of Uttar Pradesh (India) under Operational Research Project for Resource Development to assess the erodibility for strategic planning to obtain maximum possible production on sustained basis. Soil erodibility characterization in different soil series of Sheetalpur watershed in district Hamirpur (Uttar Pradesh) representing typical black soil were richer in water stable aggregates and less erodible as compared to red soil. The results of this investigation represent that erodibility among the project area increases from land use capability class II to VII. Ravines lands are most erodible followed by cultivated lands while orchards and woodlots are least erodible. On the basis of water stable aggregates, dispersion and erosion ratio as principal indices of erodibility, soils under various land use capability classes may be arranged in the order of Class VII> Class VI> Class IV > Class III > Class II. The erodibility of soils under different present land use was found in the order: Deep ravines>Fallow land > Range lands>Cultivated land > Orchard and woodlots land. Erosion ratio was significant and negatively correlated with clay (r = -0.856**), silt+clay (r = -0.445*), moisture equivalent (r = -0.684**), water holding capacity (r = -0.703**), organic carbon (r = -0.809**) and clay/moisture equivalent ratio (r = -0.714**) while positively correlated with easily dispersible silt+clay (r = 0.792**), dispersion ratio (r = 0.946**) and erosion index (r = 0.970**). A significant and positive correlation was recorded for water stable aggregates with clay (r = 0.823**), silt+clay (r = 0.803**) and moisture equivalent ratio (r = 0.807**) and a negative correlation with easily dispersible silt+clay (r = -0.561*), dispersion ratio (r = -0.807), erosion index (r = -0.739) and erosion ratio (r = -0.653). Among various land use capability classes, soil erodibility decreased substantially with increasing clay content but increased with increasing slope percentage, advancing capability class and fallow land use. Soils of Sheetalpur watershed are erosive in nature and require warrant and prompt attention for implementing intensive soil conservation measures in the entire watershed in order to subside the havoc of soil erosion within safe limits because adopted soil conservation measure are variably effective to control the erosion.

Key words : Erodibility, Bundelkhand soils, land use capability classes.

Introduction

Soil and water are two most valuable endowment of nature for the growth and sustenance of life because soil is a important dynamic body to all beings as it provides the foothold and anchorage to plants and serves as a reservoir for the majority of the essential and beneficial nutrients, organic matter, moisture, air and micro nutrients needed for the satisfactory growth and production. Water is also considered to be sine-quo-non for the living beings as it forms a larger component of the living matter and as a natural carrier of in the uptake process for the nutrients.

Soil erosion is one of the most serious problems of the moment throughout the sphere threatening of making the precious planet unfit for life. In India, more than half of our arable land is estimated to suffer through it. Fertility loss by erosion has been estimated to be 20 times greater than those through crop removal and leaching. Out of 328.7 million hectare total geographical area, about 187 m ha (representing 57%) suffering from different soil degradation problems resulting about 16.35 t/ha/year of average soil lost annually amounting to 6000 million tonnes for the whole country that carry away with it 2.5 million tonnes of nitrogen, 3.8 tonnes of phosphorus and 2.6 million tonnes of potassium. Of this about 29% is lost permanently

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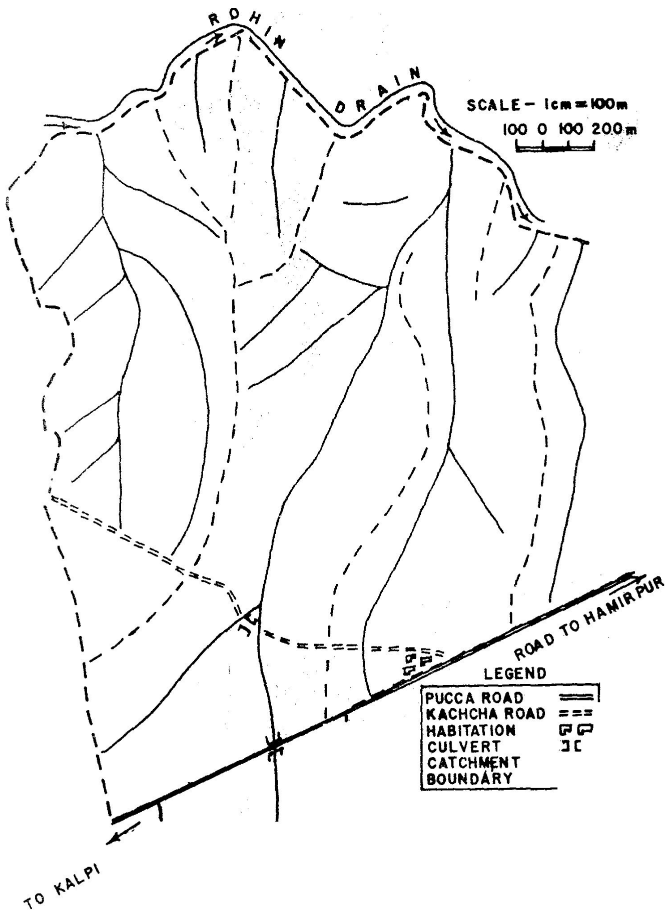

Fig. 1 : Map ofland capability classes of Sheetalpur watershed.

in to the sea, 10% gets deposited in the reservoirs reducing their storage capacity by 1-2% every year and the remaining 61% is dislocated from one place to another causing various land degradation problems. Soil erodibility as described earlier depends upon physical properties of the soil and land management practices used. The physical properties of the soil play an important and long term role on soil erosion, compared to the land management practices. Therefore, the effect of physical properties of the soil should always be evaluated more precisely to determine the erodibility than the land management practices. Bouyoucos (1935) suggested that the soil erodibility depends on mechanical composition.

Materials and Methods

The present investigation was carried out to assess the "Impact of land use capability classes and present land use on soil properties and erodibility behaviour of Sheetalpur watershed in district Hamirpur in Bundelkhand region (U.P.), India" under Operational Research Project (ORP), National Watershed Development Project. The track of land known as Bundelkhand is situated in the South-West corner of Uttar Pradesh being separated from its main land by river Yamuna and spreading in an area of 1192510 lac hectare. It lies between 24^0 – 12 to 26^0 – 36' N latitude and 78^0 – 12' to 81^0 - 36' E longitude. It comprises of the districts of Hamirpur, Banda, Jalaun, Lalitpur, Chitrakoot and Jhansi. The soils of this track are entirely different from those of the remaining part of the state owing their genesis to Vindhyan rocks.

Sixty soil sample, thirty each from disturbed and undisturbed state among different land use and Land Capability Classes from surface (0-15 cm) and sub surface (15-30 cm) were collected from the project area. The mechanical analysis of air dried sample was carried out international pipette method (Piper, 1950), bulk density as outline in U.S.D.A Hand Book sixteen water stable aggregate more (>0.25 mm) were determined by following modified wet sieving techniques of Yodder (1936), suspension percentage was determined to Middeton (1930), moisture equivalent was determined using Bouyooucos (1955), suction method by Piper (1950). Soil properties *viz*. pH, E.C, organic carbon and water holding capacity were determined by using standard method of analysis (Piper 1950), suspension percentage and dispersion ratio, clay and colloid/ moisture equivalent were compare as suggested by Middleton (1930) substituting colloids with clay in colloids/ moisture equivalent ratio. Erosion index was calculated by dividing the dispersion ratio by clay / water holding capacity while erosion ratio is obtain by dividing by clay moisture equivalent.

Results and Discussion

Physico-chemical properties and erodibility

Appraisal of the data (table 1) among land use capability classes indicate that the texture of soil very significantly, in general class VI and VII are silty loam and have lower value of water holding capacity, moisture equivalent and water stable aggregates (>.25 mm) as in compare to under capability classes II, III and IV. These values are grates in nearly level and slightly eroded soil under capability class II, III and IV decrease with increasing slope and degree of erosion in various land use capability classes VI and VII. Higher values of water holding capacity and water stable aggregates in nearly level and slightly eroded classes of II and IIIrd may be attributed to grates amount of finer fraction and organic matter content. The deep ravines, fallow land and cultivated land were found to be more erodible by these under orchard & woodlot and range land.

The project one us presented by under land use

Table 1(A) : Physical properties of the soils of Sheetalpur watershed.

S. no.	Land capability units	Particle size distribution			Texture	Easily dispersible silt+clay %	Bulk density Mgm^{-3}	Moisture equivalent %	Water holding capability %	Water stable aggregates (>0.25mm)
		Sand %	Silt %	Clay %						
1	2	3	4	5	6	7	8	9	10	11
					Sheetalpur Series (STP)					
Land capabilty class										
1	II -d_5/B-e_1	34.00	42.00	23.60	l	24.40	1.38	25.20	43.21	35.92
2		28.00	43.70	27.80	l	21.02	1.35	25.23	46.40	39.67
3		26.00	32.00	41.50	cl	13.73	1.32	35.80	61.57	48.90
Mean		**29.33**	**39.23**	**30.97**	**cl**	**19.71**	**1.31**	**28.74**	**50.39**	**41.49**
4	III -d_5/C-e_2	36.00	44.00	19.70	l	31.76	1.39	25.64	40.10	23.00
5		20.00	44.10	35.60	cl	19.16	1.31	29.26	51.36	45.19
6		31.60	36.00	32.10	cl	17.24	1.34	28.32	48.68	42.33
Mean		**29.20**	**41.37**	**29.13**	**cl**	**22.72**	**1.34**	**27.74**	**46.71**	**36.84**
7	IV -d_5/F-e_3	23.20	52.00	23.40	sil	32.36	1.39	23.55	44.55	31.16
8		36.20	39.30	24.10	l	34.16	1.37	25.10	43.67	29.84
9		48.00	29.10	22.40	l	33.45	1.46	20.35	38.87	31.76
Mean		**35.80**	**40.13**	**23.30**	**l**	**33.32**	**1.41**	**23.00**	**42.36**	**30.92**
10	VI -d_5/G-e_4	17.60	46.00	35.30	sic	18.64	1.31	30.85	52.58	36.36
11		51.50	31.80	15.90	sl	33.01	1.49	19.75	34.34	24.29
12		59.45	27.65	12.40	sl	28.91	1.51	14.16	28.89	23.26
Mean		**42.85**	**35.15**	**21.20**	**sil**	**26.85**	**1.43**	**21.58**	**38.60**	**27.97**
13	VII -d_5/H-e_4	53.75	30.45	14.60	sl	34.01	1.49	19.75	34.34	14.29
14		47.90	31.70	19.30	l	35.92	1.50	22.46	39.89	16.55
15		55.40	29.60	15.20	sl	32.18	1.48	17.26	34.38	15.01
Mean		52.35	30.58	16.37	sl	34.04	1.49	19.82	35.50	15.28

Table 1(B) : Physical properties of the soils of Sheetalpur watershed.

S. no.	Present land use	Particle size distribution			Texture	Easily dispersible silt+clay %	Bulk density Mgm^{-3}	Moisture equivalent %	Water holding capability %	Water stable aggregates (>0.25mm)
		Sand %	Silt %	Clay %						
1	2	3	4	5	6	7	8	9	10	11
Present land use										
16	Fallow land	46.70	34.80	18.20	sl	33.10	1.46	17.50	31.41	17.46
17		46.80	35.30	17.90	sl	34.75	1.42	18.85	33.70	19.25
18		42.20	36.80	21.00	scl	32.68	1.42	22.12	37.25	20.48
Mean		**45.23**	**35.63**	**19.03**	**sl**	**33.51**	**1.43**	**19.49**	**34.12**	**19.06**
19	Range land	38.60	42.60	18.40	sl	30.48	1.52	16.47	31.78	18.23
20		28.00	44.00	28.00	l	25.15	1.36	23.89	45.76	23.83
21		24.00	46.00	30.00	cl	23.76	1.30	24.04	46.01	26.40
Mean		**30.20**	**44.20**	**25.47**	**l**	**24.46**	**1.39**	**21.46**	**41.18**	**22.82**

Table 1 (B) continued...

Table 1 (B) *continued...*

22 23 24	Orchard & wood lots	18.30 29.40 33.10	32.80 38.20 36.20	48.40 32.40 29.60	c cl cl	14.67 25.20 28.46	1.28 1.27 1.39	35.19 26.55 29.92	51.36 38.70 36.20	41.75 26.45 25.78
Mean		**26.93**	**35.73**	**36.80**	**cl**	**22.77**	**1.31**	**27.55**	**42.08**	**31.32**
25 26 27	Cultivated land	37.40 40.20 23.80	35.95 34.80 36.70	26.60 24.00 39.30	l l cl	31.25 34.16 19.90	1.38 1.40 1.28	27.20 14.76 28.12	33.60 29.70 46.68	25.30 22.60 34.70
Mean		**33.80**	**35.82**	**29.97**	**cl**	**28.43**	**1.35**	**23.36**	**36.66**	**27.53**
28 29 30	Deep ravines	53.40 49.00 60.00	32.20 33.35 28.00	14.10 17.35 11.55	sl sl sl	36.86 33.81 38.91	1.63 1.49 1.48	12.26 16.35 11.16	21.38 27.45 19.09	13.70 18.51 13.26
Mean		**54.13**	**31.18**	**14.33**	**sl**	**33.19**	**1.53**	**13.25**	**22.64**	**15.15**

Table 2 (A) : Physico-chemical properties of the soils of Sheetalpur watershed.

S. no.	Land capability units	pH (1:2.5)	E.C.(1:2.5) dSm^{-1}	Ex Ca^{++} C mol (p+) Kg^{-1}	Ex Mg^{++} C mol(p+) Kg^{-1}	Organic carbon g Kg^{-1}
1	**2**	**3**	**4**	**5**	**6**	**7**
			Sheetalpur series (STP)			
Land capability Classes						
1 2 3	II -d_5/B-e_1	7.37 7.5 7.6	0.16 0.18 0.27	18.12 23.3 26.7	2.8 3.2 3.6	3.2 4.1 6.8
Mean		**7.49**	**0.2**	**22.7**	**3.2**	**4.7**
4 5 6	III -d_5/C-e_2	7.41 8.16 7.9	0.14 0.3 0.18	21.7 18.7 19	2.6 1.8 3.2	2.8 5.2 3.4
Mean		**7.82**	**0.2**	**19.2**	**2.53**	**3.8**
7 8 9	IV -d_5/F-e_3	7.1 7.34 7.79	0.23 0.15 0.19	21.8 17.2 17.4	2.1 2 3.2	3.3 2.7 2.5
Mean		**7.41**	**0.19**	**18.8**	**2.43**	**2.8**
10 11 12	VI -d_5/G-e_4	8.25 8.21 8.4	0.54 0.39 0.58	26.5 19.3 13.4	1.4 3.1 1.6	4.6 1.9 1.6
Mean		**8.28**	**0.5**	**19.7**	**2.03**	**2.7**
13 14 15	VII-d_5/H-e_4	8.14 7.9 8.3	0.42 0.36 0.47	18.6 17.2 16.3	1.9 2.1 1.6	1.8 2.6 1.4
Mean		**8.11**	**0.14**	**17.36**	**1.86**	**1.9**

Table 2(B) : Physico-chemical properties of the soils of Sheetalpur watershed.

S. no.	Present land use	pH (1:2.5)	E.C.(1:2.5) dSm^{-1}	Ex Ca^{++} C mol(p+) Kg^{-1}	Ex Mg^{++} C mol(p+) Kg^{-1}	Organic carbon g Kg^{-1}
1	2	3	4	5	6	7
			Sheetalpur series (STP)			
Present land use						
16	Fallow land	7.48	0.14	16.21	2.80	2.40
17		7.90	0.18	19.00	3.20	2.20
18		8.22	0.20	14.30	2.60	2.80
Mean		**7.86**	**0.17**	**16.50**	**2.86**	**2.40**
19	Range land	8.21	0.39	19.30	3.20	2.50
20		7.90	0.29	22.20	2.30	2.80
21		7.62	0.15	18.95	1.00	3.10
Mean		**7.91**	**0.27**	**20.15**	**2.16**	**3.10**
22	Orchard & wood lots	7.23	0.11	17.20	3.00	5.60
23		7.36	0.19	31.50	2.80	4.30
24		7.51	0.20	17.80	2.25	3.50
Mean		**7.36**	**0.16**	**22.16**	**2.68**	**4.40**
25	Cultivated land	7.40	0.20	27.10	3.80	3.20
26		7.79	0.19	17.40	3.20	3.40
27		7.34	0.15	17.20	2.00	4.70
Mean		**7.51**	**0.18**	**20.50**	**3.33**	**3.60**
28	Deep ravines land	8.16	0.30	18.70	1.80	1.20
29		8.25	0.54	15.50	1.40	2.00
30		8.04	0.30	14.60	1.80	1.50
Mean		**8.15**	**0.38**	**16.27**	**1.67**	**1.50**

Table 3(A) : Erodibility Indices of the soils of Sheetalpur watershed.

S. no.	Land capability units	Clay ratio	Clay/ moisture equivalent ratio	D.R. %	E.R. %	Erosion index
1	2	3	4	5	6	7
			Sheetalpur series (STP)			
Land use capability class						
1	II -d_5/B-e_1	2.77	0.93	37.19	39.98	33.20
2		2.57	1.10	29.00	26.36	24.36
3		1.77	1.15	18.00	15.65	13.43
Mean		**2.37**	**1.06**	**28.06**	**27.33**	**23.66**
4	III -d_5/C-e_2	3.23	0.76	49.00	64.47	50.00
5		2.23	1.21	24.00	19.83	17.39
6		2.12	1.13	25.00	22.12	19.08
Mean		**2.52**	**1.03**	**32.66**	**35.47**	**28.82**
7	IV -d_5/F-e_3	3.22	0.99	42.00	42.42	40.00
8		2.63	0.96	53.00	55.20	47.74
9		2.29	1.10	64.00	58.18	55.65
Mean		**2.71**	**1.01**	**53.00**	**51.93**	**47.79**

Table 3 (A) continued...

Table 3 (A) *continued...*

10	VI -d_5/G-e_4	2.30	1.14	22.00	19.29	16.41
11		3.00	0.80	97.00	121.20	105.43
12		3.22	0.87	72.00	82.75	83.72
Mean		**2.84**	**0.93**	**63.66**	**74.41**	**68.52**
13	VII-d_5/H-e_4	3.08	0.73	75.00	102.70	88.23
14		2.33	0.85	70.00	82.35	72.91
15		2.94	0.88	71.00	80.68	80.68
Mean		**2.78**	**0.82**	**72.00**	**88.57**	**80.60**

Table 3(B) : Erodibility Indices of the soils of Sheetalpur watershed.

S. no.	Land capability units	Clay ratio	Clay/moisture equivalent ratio	D.R %	E.R. %	Erosion index
1	**2**	**3**	**4**	**5**	**6**	**7**
			Sheetalpur series (STP)			
Land use capability class						
19	Fallow land	2.91	1.04	62.40	60.46	54.26
20		2.97	0.94	65.31	69.46	61.60
21		2.75	0.94	56.53	60.13	44.86
Mean		**2.87**	**0.97**	**61.41**	**63.19**	**53.56**
22	Range land	3.31	1.11	49.96	45.00	43.44
23		2.57	1.17	34.93	29.85	28.63
24		2.53	1.26	31.26	24.80	24.04
Mean		**2.80**	**1.18**	**38.71**	**33.21**	**32.03**
25	Orchard & wood lots	1.67	1.37	18.06	13.18	9.60
26		2.17	1.22	35.69	29.25	21.37
27		2.22	0.98	43.25	44.13	26.53
Mean		**2.02**	**1.19**	**32.33**	**28.85**	**19.16**
28	Cultivated land	2.35	0.97	49.96	51.50	31.62
29		2.45	1.62	58.09	35.85	50.07
30		1.93	1.39	26.18	18.83	15.58
Mean		**2.24**	**1.32**	**44.74**	**35.39**	**32.42**
31	Deep ravines land	3.28	1.15	79.61	69.20	60.77
32		2.92	1.06	66.68	62.90	52.92
33		3.42	1.03	98.38	95.51	81.30
Mean		**3.20**	**1.08**	**81.55**	**75.86**	**64.99**

capability Class II and Orchard & Woodlots as well range land use having lower pH, EC, B.D. and easily dispersible silt clay in Comparison to class III, IV, V, VI & VII and cultivated land, fallow land and deep ravines (tables 1, 2, 3 and 4).

Erodibility indices

Erosion indices with clay ratio, dispersion ratio, erosion ratio and erosion index of the soils of Sheetalpur watershed (table 3) and values of correlation coefficient of erosion ratio with soil properties have been depicted in table 4.

Table 4 (A) : Correlation between erosion ratio and water stable aggregate with physical soil properties.

S. no.	Correlation between soil properties X	Erosion ratio Y	Correlation coefficient	Regression equation
1	2	3	4	5
		Erosion ratio V/s		
1.	Sand (%)	-do-	r=0.888**	Y= -23.360 + 1.970 X
2.	Silt (%)	-do-	r = -0.554**	Y= 143.929 - 2.506X
3.	Clay (%)	-do-	r = -0.856**	Y= 116.020 – 2.661X
4.	Suspension (%)	-do-	r = 0.792**	Y= -38.437 + 3.160X
5.	Bulk density (Mgm^{-3})	-do-	r = 0.782**	Y= -302.578 + 251.850X
6.	Moisture equivalent (%)	-do-	r = -0.684**	Y= 120.915 – 3.033X
7.	Water holding capacity (%)	-do-	r = -0.703**	Y= 132.775 – 2.083X
8.	Water stable aggregate (>0.25mm)	-do-	r= -0.738**	Y= 107.256 – 2.079X
		Water stable aggregate V/s		
1.	Sand (%)	W.S.A	r = - 0.769**	Y= 49.855 – 0.605X
2.	Silt (%)	-do-	r = 0.345*	Y= 6.364 + 0.554X
3.	Clay (%)	-do-	r = 0.823**	Y= 4.784 + 0.895X
4.	Suspension (%)	-do-	r = - 0.868**	Y= 61.836 – 1.230X
5.	Bulk density (g/cc)	-do-	r = - 0.741**	Y= 145.892 - 84.693X
6.	Moisture equivalent (%)	-do-	r = 0.807**	Y= -2.270 + 1.271X
7.	Water holding capacity (%)	-do-	r = 0.853**	Y= - 8.230 + 0.898X

Table 4 (B) : Correlation between erosion ratio and water stable aggregate with physico-chemical soil properties.

S.no	Correlation between soil properties X	Erosion ratio Y	Correlation coefficient	Regression equation
1	2	3	4	5
		Erosion ratio V/s		
1.	pH	-do-	r = 0.467*	Y= -215.178 + 34.21X
2.	E.C (dSm^{-1})	-do-	r = 0.419*	Y= 27.689 + 88.078X
3.	Exchangeble Ca^{++}	-do-	r = -0.418*	Y= 106.575 – 2.841X
4.	Exchangeble Mg^{++}	-do-	r = -0.149*	Y= 65.436 – 5.724X
5.	Organic carbon	-do-	r = -0.809**	Y= 105.033 – 17.269X
		Water stable aggregate V/s		
6.	pH	W.S.A	r = - 0.395*	Y= 106.99 - 10.285X
7.	E.C (dSm^{-1})	-do-	r = - 0.308*	Y= 33.058 – 23.057X
8.	Exchangeble Ca^{++}	-do-	r = 0.360*	Y= 9.959 + 0.869X
9.	Exchangeble Mg^{++}	-do-	r = 0.283*	Y= 17.436 + 3.846X
10.	Organic carbon	-do-	r = 0.853**	Y= 6.782 + 6.463X

The higher values of clay ratio, dispersion ratio, erosion ratio, erosion index in class VI, VII soil and lower value of class II while capability class III are intermediate in nature. According to criteria of Middleton (1930), soils having dispersion ratio and erosion ratio greater than 15 and 10, respectively, are erosive in nature and thus, all the land use capability class of the Sheetalpur watershed are erodible. Similar findings also observed by Sparovek and Demaria (2001). Based on various erodibility indices, various land use capability class may be ranked in order or erodibility :

Class VII > Class VI > V > IV > III > II.

Similarly, among various present land uses adopted in the project area of Sheetalpur watershed, erodibility varied in the order Orchard and Woodlots < cultivated < Rangeland < Fallow land < Deepravins.

Soils of the Sheetalpur watershed area being erosive in nature and warrant prompt attention for taking simple to intensive soil conservation measures in the entire watershed in order to keep down the havoc of soil erosion within safe limit.

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