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Impact of Land Capability Classes and Land Use on Properties and Erodibility Behaviour of Soil of Ghatampur Watershed

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was carried out in Ghatampur Watershed district Kanpur under National Watershed Development Project Area. The soils of Ghatampur watershed region are erodible in nature. Soil erodibility increased from land use capability class II to VI in the project area. Fallow land is most erodible followed by Rangeland, woodlots, cultivated land while orchard & grooves lands are erodible on the basis of water stable aggregates, dispersion and erosion ratio as principal indices of erodibility, soil under various land use capability classes may be arranged in the order of class VI > class V > class III > class II. The erodibility of soil under different present land use was found in the order Fallow land > Rangeland > Wood lots > Cultivated land > Orchard & grooves land, Erosion ratio was significantly and negatively correlated with clay (r = -0.920***) moisture equivalent (r= -

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0.669), water holding capacity (r=-0.685**), water stable aggregate (r=- 0.834***), organic carbon (r=-0.780***) and clay/moisture equivalent ratio (r=- 0.660***) but a positive correlation was recorded with sand (r-0.777***), Bulk density (r=0.709**), easily dispersible silt+clay (r= 0.888***), clay ratio (r=0.745***),dispersion ratio (r= 0.908***), Erosion index (r=0.432**),the correlation between erosion ratio and silt (r=-0.432**) was recorded to be negative but significant. Among various land use capability classes, soil erodibility decreased substantially with increasing clay content but increased with increasing advancing capability class and fallow land use. Soil of Ghatampur watershed area in erodible 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 adapted soil conservation measure variably effective to control the erosion.

Keywords: Erodibility indices; Aggregation indices; PH. E.C; correlation indices; land use capability classes.

1. INTRODUCTION

Soil and water are most essential finite resources which need to be conserved. Being exhaustible, they are liable to be short of demand if used improperly. Without soil there would no plant, without plants there would no food and without food no living being would survive. Thus soil is the very beginning of the soil plant-animal food chain. Soil erosion is a function of erosivity of rainfall and erodibility of soil. The soil erodibility refers to the soil inherent susceptibility to erosion by rain water and runoff. This is a function of complex interaction of physical and chemical properties of soils affecting detachability, transportability and infiltration capacity. Soil erodibility dependant on soil properties, soil aggregation, organic matter, vegetation, climate, topography besides, human factors influencing the present land use. The present land use alters the soil properties making it either resistant or susceptible to soil erosion. Soil erodibility is the vulnerability or inherent susceptibility of the soil to erosion and is a function of soil properties; vegetation, climate, and topography, besides present land use and their management. The study was conducted with the following objectives: (i) To study the pattern of physical, Physico-chemical properties erodibility indices of soils of Ghatampur watershed, and (ii) The erodibilty indices and aggregation indices in relation to various soil properties. The Ghatampur watershed is situated in Kanpur Nagar central part of Uttar Pradesh. The watershed lies between 26 ^{0} 30' N to 27 ^{0} N latitude and 79 ^{0} 30' to 80 ^{0} E longitude of the villages: Samuhi, Aswarmau, Lahurimau, Bagariya, Sindhol, Sirsa, Bandh, Anupur and Rampur of Ghatampur Block of district Kanpur Nagar. The study was conducted to accomplish the physical properties and erodibilty behavior of soils of Ghatampur watershed. The geographical area of watershed was 5084 ha and area not available for cultivation was 84 ha. The project area suffers from the threat of heavy sheet and rill erosion through small to medium size gullies formed. The whole watershed area lies in the catchment of the Jawahar nala of river Yamuna. Area under land capability classes (LCC) varies from class II to VI and whole area was treated with different soil and water conservation measures like : Land leveling, contour bunding, field bunding, field bunding+ vegetative barrier, contour farming, filter strip, gully plugging, sunken structure, agroforestry & rainfed horticulture etc.

2. MATERIALS AND METHODS

The present investigation entitled " Impact of land capability classes and land use on properties and erodibility behavior of soil of Ghatampur watershed in district Kanpur under National watershed Development Project for Rainfed Area. It comprises of Districts of Hamirpur, Fatehpur and Banda. The soil of this track entirely different from those of the remaining part of the state. Sixty soil sample, thirty each from disturbed and undisturbed state among different land use and 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 [1], bulk density as outline in U.S.D.A. Hand book sixteen, water stable aggregate more (> 0.25mm) were determined by following modified wet sieving techniques of Yodder [2], suspension percentage was determind to Middeltan [3], suction method by pipper [1]. Soil properties viz. PH, E.C., organic carbon and water holding capacity were determined by using standerd method analysis

Table 1a. Pattern of Physical properties and erosion indices of the soils of Ghatampur Watershed

Sl. No.	Land capability unit	Particle size distribution			Easily dispersible silt+clay %	Moisture equivalent %	Water holding capability	Water stable Aggregates (>0.25 mm)	Clay ratio	Clay/moisture equivalent ratio	D.R %	E.R %	Erosion index
		Sand % (0.05-0.002mm)	Silt % (0.05-0.002mm)	Clay % (< 0.002 mm)									
Land use capability classes													
1	II Wl	20.9	40.3	38.8	15.30	30.34	52.54	36.45	2.03	1.27	19.34	15.23	13.16
2		20.0	40.6	40.4	17.46	28.95	43.85	34.15	2.00	1.39	21.56	15.51	11.17
3		18.1	33.5	48.4	14.67	33.19	57.36	41.75	1.69	1.45	17.91	12.26	10.66
Mean		**19.3**	**38.1**	**42.5**	**15.81**	**30.82**	**51.25**	**37.45**	**1.89**	**1.37**	**19.61**	**14.21**	**11.88**
4	III el	31.8	40.4	27.8	27.60	18.20	38.80	21.40	2.45	1.52	40.46	26.62	28.29
5		24.2	36.3	39.5	21.58	25.23	47.13	33.10	1.91	1.56	28.46	18.24	16.94
6		19.1	38.6	42.3	23.73	22.46	44.85	31.45	1.92	1.87	29.33	15.60	15.60
Mean		**25.0**	**38.4**	**35.5**	**24.30**	**21.96**	**43.59**	**28.65**	**2.08**	**1.61**	**32.79**	**20.24**	**20.24**
7	V ewl	34.7	44.0	21.3	33.72	21.45	42.07	26.76	3.06	0.99	51.63	52.15	51.12
8		28.5	47.5	24.0	40.74	23.85	42.15	23.89	2.97	1.01	56.97	56.97	50.42
9		24.2	43.6	32.4	28.96	24.40	44.97	29.55	2.34	1.34	38.10	28.43	26.45
Mean		**29.1**	**45.0**	**25.9**	**34.47**	**23.13**	**43.06**	**26.73**	**2.73**	**1.12**	**48.62**	**43.80**	**40.52**
10	V el	28.7	35.1	16.2	38.76	13.40	30.60	15.81	3.16	1.21	75.55	62.96	71.27
11		36.3	35.5	28.5	26.35	20.04	38.45	27.49	1.60	1.42	57.78	40.69	39.04
12		48.6	31.8	19.6	33.18	18.55	35.80	21.84	2.62	1.05	64.55	61.47	59.22
Mean		**45.5**	**34.1**	**21.4**	**32.76**	**17.33**	**34.95**	**21.71**	**2.59**	**1.23**	**59.03**	**47.99**	**48.38**
13	VI es2	53.6	43.0	12.4	35.10	13.45	25.89	12.36	3.74	0.92	75.65	82.23	79.63
14		41.6	39.9	18.5	36.12	14.35	26.30	13.90	3.15	1.28	61.85	48.32	44.18
15		43.2	33.7	21.1	33.36	19.55	31.40	15.30	2.59	1.07	60.88	56.89	45.43
Mean		**46.1**	**35.8**	**17.3**	**34.86**	**15.78**	**27.86**	**13.85**	**3.06**	**1.09**	**65.65**	**60.22**	**52.94**

Table 1b

Sl. No.	Land capability unit	Particle size distribution			Easily dispersible silt+clay %	Moisture equivalent %	Water holding capability	Water stable Aggregates (>0.25 mm)	Clay ratio	Clay/moisture equivalent ratio	D.R %	E.R %	Erosion index
		Sand % (0.05-0.002 mm)	Silt % (0.05-0.002mm)	Clay % (< 0.002 mm)									
Present Land Use													
16	Fallow land	53.6	32.0	14.4	36.46	14.26	25.89	13.80	3.22	1.00	75.58	78.58	70.79
17		46.9	35.2	17.9	33.65	16.85	31.64	19.25	2.97	1.06	63.37	59.78	56.08
18		40.5	38.3	21.2	29.50	21.40	36.70	19.35	2.81	0.99	49.58	50.00	42,74
Mean		**47.0**	**35.1**	**17.8**	**33.20**	**17.50**	**31.41**	**17.46**	**2.97**	**1.02**	**62.76**	**62.14**	**54.99**
19	Range land	42.8	36.2	21.0	32.68	22.12	37.25	20.48	2.67	0.95	58.15	61.86	51.46
20		52.2	29.4	18.4	35.25	13.28	33.48	14.58	1.89	1.39	101.29	73.40	92.08
21		38.6	42.6	18.4	30.48	18.47	24.78	18.23	3.32	1.00	50.49	51.00	33.89
Mean		**44.5**	**36.0**	**19.2**	**32.80**	**17.95**	**31.83**	**17.76**	**2.88**	**1.07**	**59.42**	**56.06**	**49.52**
22	Wood Lots	36.6	32.7	30.7	36.26	15.25	23.58	19.62	2.07	2.01	57.19	28.45	21.10
7523		41.3	34.8	23.9	29.18	19.78	32.34	17.72	2.45	1.21	49.71	41.43	33.59
24		34.2	39.3	26.5	32.02	23.13	42.10	24.10	2.48	1.15	48.66	42.68	38.62
Mean		**37.4**	**35.6**	**27.0**	**32.48**	**19.38**	**32.67**	**20.48**	**2.32**	**1.39**	**51.88**	**37.32**	**31.44**
25	Cultivated land	40.3	34.8	24.9	34.16	13.76	29.80	21.20	2.40	1.81	57.22	31.79	34.26
26		37.3	36.2	28.5	31.25	26.10	33.60	23.30	2.34	1.09	46.78	42.92	27.52
27		33.1	36.2	30.6	28.46	18.92	36.20	25.78	2.19	1.62	42.54	26.42	25.17
Mean		**36.9**	**35.7**	**28.0**	**31.29**	**19.59**	**33.20**	**23.76**	**2.28**	**1.42**	**49.12**	**34.35**	**29.06**
28	Orchard & grooves land	18.1	32.5	48.4	14.67	35.19	51.36	41.75	1.17	1.38	18.13	13.23	9.64
29		24.2	39.6	36.2	16.80	25.65	48.20	33.70	2.09	1.41	22.16	15.72	14.77
30		29.2	38.1	32.7	25.10	20.53	38.70	26.45	2.17	1.27	35.45	22.30	20.98
Mean		**23.8**	**36.7**	**39.1**	**18.80**	**27.12**	**46.08**	**33.96**	**1.93**	**1.44**	**24.8**	**17.22**	**12.40**
Correlation of erosion ratio with soil properties and erosion indices													
		*** 0.777	-** 0.432	-*** 0.920	*** 0.808	*** -0.669	*** -0.685	*** -0.834	*** 0.745	*** -0.660	*** 0.908		*** 0.946

Pipper [1], suspension percentage and dispersion ratio, clay and colloid/ moisture equivalent were compare as suggested by Middltan [3] substituting colloids with clay in collids/ 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.

3. RESULTS AND DISCUSSION

The result of some important physical properties of the soil have been presented in (Table 1) sand fraction was found to be more in class V land which may be because of washing away of finer particles in much greater proportion the coarse soil particles in these eroded soil. Wilson and Schuberd (1949) have also reported that the finer soil particles wear washed in a much greater proportion than coarse soil particle during water erosion. Present land use sand fraction was found lowest in orchard & grooves land and there was more clay fraction of in the soil. Orchards provide sufficient amount of canopy to the soil which reduce the runoff and beating action of rain drops leading to reduced power of raindrops, detach soil particles and thus minimizing the loss of finer fractions. The water holding capacity, moisture equivalent, water stable aggregates (>0.25mm) was highest recorded in class II land and lowest in class VI land as in compare to under capability class fallowing order II > III > IV >V >VI. These values are grates in nearly level and decreased with increasing slope, and degree of erosion and finer fraction of organic matter various land use capability classes. The present land use fallow land and range land wear found to be more erodible by these under orchard & grooves land wood lots and cultivated lands. These results are conformity with findings of Talukdar and Das [4], Bhatia and Vardani [5], Kumar et al. [6], Munendra et al. (2014), Mahendra et al. [7] and Melkamu et al. [8].

3.1 Physico-Chemical and Chemical Properties

The project area presented data by under land use capability class II, III and orchard & grooves land having lowest PH, E.C., B.D. and easily dispersible (silt+ clay %) in comparison to land use capability classes IV, V, VI and present land use classes as cultivated land, wood lots, range land and fallow land (Table 1a,1b and 2a, 1b).

Table 2. Pattern of Physico-chemical and chemical properties of the soils of Ghatampur watershed

Table 2(a)

Sl. No.	Land Capability Units	PH (1:2.5)	E.C. (1:2.5)	Organic Carbon%
Land Use Capability Classes				
1	II w I	7.39	0.31	0.53
2	II w I	8.10	0.47	0.41
3	II w I	7.31	0.51	0.61
Mean		**7.60**	**0.43**	**0.52**
4	III e I	8.17	0.33	0.37
5	III e I	7.90	0.30	0.38
6	III e I	8.06	0.42	0.45
Mean		**8.04**	**0.35**	**0.40**
7	IV e w I	8.65	0.51	0.26
8	IV e w I	8.21	0.46	0.29
9	IV e W I	8.45	0.49	0.32
Mean		**8.43**	**0.48**	**0.29**
10	V e I	8.70	0.23	0.29
11	V e I	8.55	0.54	0.30
12	V e I	8.14	0.48	0.27
Mean		**8.46**	**0.42**	**0.29**
13	VI e s2	8.95	0.76	0.23
14	VI e s2	9.05	0.68	0.21
15	VI E s2	7.80	0.61	0.24
Mean		**8.60**	**0.68**	**0.23**

Table 2(b)

Sl. No.	Land Capability Units	PH(1:2.5)	E.C.(1:2.5)	Organic Carbon%
Land Use Capability Classes				
16		9.1	0.65	0.19
17	Fallow	8.7	0.54	0.23
18	Land	8.5	0.43	0.26
Mean		**8.7**	**0.80**	**0.23**
19		8.4	0.42	0.34
20	Range	9.2	0.62	0.22
21	Land	7.8	0.58	0.18
Mean		**8.4**	**0.54**	**0.24**
22		7.9	0.38	0.20
23	Wood Lots	8.8	0.43	0.39
24		8.2	0.39	0.36
Mean		**8.3**	**0.40**	**0.31**
25	Cultivated	8.3	0.41	0.35
26	Land	8.5	0.39	0.38
27		7.8	0.36	0.41
Mean		**8.2**	**0.38**	**0.38**
28	Orchard &	7.6	0.31	0.68
29	Grooves	7.9	0.38	0.54
30	Land	8.1	0.43	0.49
Mean		**7.8**	**0.37**	**0.57**

Table 3(a). Correlation between erosion ratio and soil properties

Sl. No.	Correlation between Soil properties X	Erosion ratio Y	Correlation coefficient	Regression equation
1	Sand %	-do-	r=0.777***	Y= -13.796+1.481X
2	Silt %	-do-	r=-0.432**	Y= 84.443- 1.169X
3	Clay %	-do-	r=-0.920***	Y= 94.797-1.953 X
4	Easily dispersible % Silt+clay	-do-	r=0.808***	Y= - 24.981+2.272 X
5	Bulk density g/cc	-do-	r=0.709***	Y= - 154+141.579 X
6	Moisture equivalent %	-do-	r=0.669***	Y= 91.611-2.394 X
7	Water holding capacity	-do-	r=-0.685***	Y= 101.511-1.629 X
8	Water stable aggregate (>0.25mm)	-do-	r=-0.834***	Y= 92.854-2.140 X
9	PH	-do-	r=0.698***	Y= -197.605+28.884 X
10	E.C (dsm-1)	-do-	r=0.591***	Y= -5.117+100.336 X
11	Organic carbon	-do-	r=-0.780***	Y= 85.105-127.665 X
Correlation between erosion ratio and erosion indices				
1	Clay ratio	-do-	r=0.745***	Y= 24.400+26.747 X
2	Clay/ moisture equivalent	-do-	r=-0.660***	Y= 103.386-48.93 X
3	Dispersion ratio	-do-	r=0.908***	Y= -5.492+0.945 X
4	Erosion index	-do-	r=0.946***	Y = 6.883 +0.909 X

Table 3. (b) Correlation between water stable aggregates and soil properties

Sl. No.	Correlation between Soil properties	W.S.A (>0.25mm)	Correlation Coefficient	Regression equation
1	Sand %	-do-	r =-0.718***	Y = 43.750-0.534 X
2	Silt %	-do-	r=0.407**	Y = 9.110+0.406 X
3	Clay %	-do-	r=0.933***	Y = 2.960+ 0.772 X
4	Easily dispersible Silt+ clay %	-do-	r=0.870***	Y = 51.948-0.955 X
5	Bulk density g/cc	-do-	r=0.796***	Y= 109.709-62.005 X
6	Moisture equivalent %	-do-	r=0.890***	Y = -2.017+1.242 X
7	Water holding capacity %	-do-	r=0.914***	Y = -7.740+0.847 X
8	PH	-do-	r=-0.684***	Y= 115.209-11.014 X
9	E.C,(dsm-1)	-do-	r=-0.489***	Y= 39.079+32.335 X
10	Organic carbon	-do-	r=0.858***	Y= 5.308+54.764 X
Correlation between water stable aggregates and erosion indices				
1	Clay ratio	-do-	r=-0.742***	Y= 49.583-10.371 X
2	Clay/ moisture equivalent	-do-	r=0.363***	Y= 10826+10.357 X
3	Dispersion ratio	-do-	r=-0.877***	Y= 41.722-0.356 X
4	Erosion ratio	-do-	r=-0.791***	Y= 35.336-0.296 X

**** Significant at 0.1 % ** Significant at 1 %*

3.2 Erodibility Indices

Erosion indices with clay ratio, dispersion ratio, erosion ratio and erosion index of soils of Ghatampur watershed and values of correlation coefficient of erosion ratio with soil properties have been depicted in (Table 1a,1b). The higher value of clay ratio, dispersion ratio, erosion ratio, erosion index wear observed recorded in class VI, and lower value of class II land. According to criteria of Middletion [3], soil having dispersion ratio and erosion greater than 15 and 10, respectively are erosive in nature and thus, all the land use capability classes of the Ghatampur watershed are erodible. Similar findings also observed by Bhatia and Vardani [5], Kumar et al. [6], Kumar et al. [9], Munendra et al. [7], and Janshaipharstep et al. [10], Halim Akbar [11] and Purnima et al. [12], Based on various erodibilty indices, various land use capability class may be ranked in order or erodibility [13,14].

Class VI > V > IV > III > II

Similarly, among various present land uses adopted in the project area of Ghatampur watershed erodibility varied in the order

Fallow land > Range land > Wood lots > Cultivated land > Orchard & grooves land

4. CONCLUSION

It is concluded that the soils of Ghatampur watershed region are erodible in nature. Soil erodibilty increased under land use capability class II to VI in the project area. However, fallow land is most erodible (ER = 62.14%) fallowed by rangeland (ER = 56.06%), woodlots (ER= 37.52%), cultivated land (ER= 34.35 %) while orchard & grooves land are least erodible (ER= 17.22%). Dispersion ratio and erosion index values substantiate foresaid results. 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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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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