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Evaluation of Soil Erodibility status under different Land Uses in Sechu-Zubza subdivision of Kohima, Nagaland

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ABSTRACT: The study was conducted in the Department of Soil and Water Conservation, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema to evaluate the impact of different land uses on erodibility characteristics in Sechu-Zubza subdivision of Kohima, Nagaland. Knowledge of soil erodibility status of a particular location with respect to various land uses is one of the important prerequisites to formulate proper soil water conservation strategy for sustainable productivity. Soil samples under three different land uses i.e terrace, *jhum*, and forest land from eight villages, *viz*., Khonoma, Sechuma, Khono-Basa, Sechu-Zubza, Dzulekema, Kiruphema, Peducha, and Mezoma were collected and analyzed for various parameters to evaluate the erodibility characteristics of the soil. The textural class were found to be clay loam, clayey, loamy and sandy clay loam with clay loam being the most dominant. Dispersion ratio of the soils ranged from 12.4 to 19.6, which were categorized as fairly erosive. Erosion index of the soils ranged from 8.3 to 12.6, which were recorded to be higher than the threshold limits. There was a positive correlation between Dispersion ratio (DR) and Erosion index (EI) (r= 0.35). Dispersion ratio showed significant positive correlation with sand (r= 0.63*). EI was negatively correlated with silt (r= -0.19) and clay (r= -0.36). Most of the soils were subjected to erodible class and need to adopt proper conservation measures.

Keywords: Dispersion ratio, erosion index, conservation measures.

INTRODUCTION

Soil erodibility is an assessment of the soil's vulnerability to dissociation and transport by erosion agents. It is the cumulative impact of mechanisms that determine rainfall acceptance as well as soil resistance to particle detachment and subsequent transport. Land-use changes due to urban sprawl, agricultural intensification, forest destruction, and intensive agricultural production have expedited erosion in the region. Erodibility varies with soil textures, aggregate stability, soil structure, infiltration capacity, soil depth, bulk density, soil organic matter and farming practices (Agassi and Bradford 1999; Ahmad *et al*., 2020). Estimation of spatial distribution of soil erosion is very much essential for conservation and management planning processes, at the policy level by land use planners (Thapa, 2020). Soil erodibility can be determined using various soil erodibility indices based on soil characteristics employed by different authors (Middleton, 1930; Oguike and Mbagwu 2009; Emenyonu and Onweremadu 2011). These indices are notably important in high annual rainfall where soil erosion is extreme. Yilmaz *et al*. (2007) found that at cultivated and forested sites, the erosion ratio and dispersion ratio increased with increasing soil depth. Sechu-Zubza block under Kohima district receives an annual rainfall of 2899 mm and due to this heavy rainfall, the district is being forced by serious erosion problems. Therefore, it is important to study the soil erodibility status and there are needs to provide the data that will enable agriculturists, engineers, and other land users to know the areas prone to erosion, for optimal and sustainable utilization of land resources. This will enable them to provide control measures and embrace sustainable land-use practices that will help to check the menace in the future. The region lacks information on the complex interaction of land use and erodibility status. Hence, the study was undertaken to evaluate the soil erodibility status affected by different land-use types in Sechu-Zubza subdivision of Kohima, Nagaland.

MATERIALS AND METHODS

The study was conducted during 2021-22 to investigate the erodibility status of soils under different land use systems in Sechu-Zubza subdivision of Kohima district, Nagaland. The latitude 25°42′N and longitude

94°2′E are the geo-coordinates of Sechu-Zubza with an average elevation of 156 meters (above sea level). The total area of Sechu-Zubza circle is 358 sq. km. The climate here is mild and generally warm and temperate with a mean annual temperature of 17.3°C. Soil samples from 0-15 and 15-30cm depths were collected from three different land uses, *viz.,* Terrace, *jhum* and forest from 8 different villages under Sechu-Zubza subdivision of Kohima *viz.,* Khonoma, Dzulekema, Khono-Basa, Mezoma, Sechuma, Kiruphema, Peducha and Sechu-Zubza. From each land use, two numbers of soil samples, each from both the soil depths were collected and composites were made. The soil samples were then air dried in shade with a good air circulation facility. The ground sample was passed through a 2mm sieve and about 500g of processed soil samples were stored for further laboratory analysis. Particle-size distribution was determined following International Pipette method (Piper, 1996) using 0.5N Sodium Hydroxide (NaOH) as a dispersing agent. Water holding capacity (WHC) was determined as per the procedure outlined by Piper (1996). Dispersion ratio (DR) and Erosion index (EI) was computed by using the relationship proposed by Middleton (1930); Sahi *et al.* (1976), respectively:

$$DR = \frac{\%\text{ water dispersed (silt + clay)} \times 100}{\%\text{ (silt + clay) Particle} - \text{size analysis}}$$

$$EI = \frac{DR}{\text{Clay/0.5 water holding capacity}}$$

Correlation coefficient was computed using the procedure outlined by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

A. Mechanical composition

The sand, silt and clay content in the surface soils ranged from 19.5 to 44.7%, 25.0 to 40.0% and 25.0 to 40.0% respectively. Again, in sub-surface soil the sand, silt and clay content varied from 23.2 to 48.5%, 25.0 to 40.0% and 20.0 to 40.0%, respectively (Table 1). The textural class of the studied soil were found to be clay loam, clayey, loamy and sandy clay loam with clay loam being the most dominant.

B. Dispersion ratio (DR)

The DR of the surface soils of different villages varied from 13.2 to 16.4, 12.4 to 19.6 and 13.5 to 15.6 with a mean value of 14.4, 14.5 and 14.3 under terrace, *jhum*, and forest land use, respectively (Table 2). The DR of sub-surface soils varied from 12.8 to 16.0, 12.6 to 19.1, and 13.3 to 16.9 with a mean value of 14.1, 14.7 and 14.9 under terrace, *jhum*, and forest land use, respectively. The highest DR was recorded in the surface soil under *jhum* land use of Peducha village (19.6) and the lowest was recorded in the surface soil under *jhum* land use of Kiruphema village (12.4). Soils with a dispersion ratio greater than 15 are erosive, according to Middleton's 1930 criterion. The study found that almost all of the villages' soils were fairly erosive, regardless of land use (Fig. 1).

Dispersion ratio of <5, 6-10, 11-15, 16-25, 26-30 and >30 was categorized as very stable, stable, fairly stable, somewhat unstable, unstable and very unstable. Out of 48 soils, 40 samples were found to be fairly stable, and 8 samples were somewhat unstable. Under terrace land use, DR of surface soil was found to be fairly stable having a mean of 14.4. The highest was recorded in Peducha village (16.4), which was somewhat unstable, followed by Mezoma (15.3), fairly stable and the lowest was observed in Sechuma (13.2), fairly stable.

Similarly, in the sub-surface soils, the DR was found to be fairly stable with a mean of 14.12, where the highest DR was recorded in Peducha (16.0) somewhat unstable, followed by Mezoma (14.8), fairly stable. The lowest was recorded in Sechuma (13.1), fairly stable Under *jhum* land use of surface soils, the overall dispersion ratio was recorded to be fairly stable with a mean of 14.5. Peducha village recorded the highest DR (19.6), which was found to be unstable, followed by Sechu-Zubza (15.4), unstable. The lowest was recorded in Kiruphema (12.4), which was fairly stable. In the sub-surface soils, the dispersion ratio recorded to be fairly stable, where, the highest DR was recorded in Peducha village (19.1), which was unstable, followed by Mezoma (15.2), unstable and Dzulekema (14.8), fairly stable. The lowest was observed in Kiruphema (12.6), which was fairly stable.

Dispersion ratio showed positively correlated with Erosion Index (r= 0.35), and a negative correlation with silt and clay (r= -0.41) (r=-0.58), respectively (Table 3). The negative correlation of dispersion ratio with clay indicated that soil erodibility reduced as clay concentration rose. Similar results have been reported by Rasheed (2016); Sharma and Kumar (2010); Kumar and Singh (2007); Jeloudar *et al.* (2018). DR also showed significant positive correlation with sand (r= 0.63*) (Table 3). The presence of more sand increased the soil's erodibility as it raised the dispersion ratio, according to the positive correlation between dispersion ratio and sand. As comparison to cultivated soil, forest soil had a lower dispersion ratio (Khera and Kahlon 2005). Ajibola *et al.* (2018) also reported lowest soil erodibility indices in forest land uses as compared to other land uses.

C. Erosion index (EI)

The Erosion index of the surface soils of different villages varied from 8.4 to 12.6, 8.5 to 12.2 and 9.6 to 12.2 with a mean value of 9.88, 10.36 and 10.65 under terrace, *jhum*, and forest land use, respectively. The EI of sub-surface soils varied from 8.3 to 11.9, 9.1 to 12.1 and 9.3 to 12.5 with a mean value of 9.85, 10.4 and 10.61 under terrace, *jhum*, and forest land use respectively (Table 2). The surface soil under terrace land use of Peducha village (12.6) was found to be most erodible of all land uses, and the least erodible was recorded in the sub-surface soil under terrace land use of Mezoma village (8.3). Erosion index values of 0 to 5, 6 to 10, 11 to 15, 16 to 20, and >20 was classified as very low, low, medium, high, and very high, respectively.

Out of 48 soils, 36 soils were found to be low and 12 samples, medium. Irrespective of land use on the basis of average values, the EI of surface soils was reported to be most erodible in Peducha village with a mean value of 12.2, which was categorized as medium, followed by Kiruphema (10.7), Sechuma (10.5), Khonoma and Khono-Basa (10.1), categorized as medium respectively. The Erosion index was least recorded in Dzulekema village with 9.3, categorized as low. In sub-surface soils, the land use with the most erodible was recorded in Peducha village with 12.0, categorized as medium, which was followed by Sechuma and Kiruphema (10.7), also categorized as medium respectively. The least erodible was recorded in Mezoma with 9.3, under the category low. However, considering 2.8 as the threshold value of EI, all the soils are subjected to erodible class and need conservation measures (Fig. 2). The correlation coefficient data revealed that Erosion index showed positive correlation with Dispersion ratio (r= 0.35) and sand (r= 0.28) and showed negative correlation with silt (r= -0.19) and clay (r= -0.36), respectively (Table 3). Mehta *et al.* (2005); Agnihotri *et al*. (2007); Kumar *et al*. (2017) also observed the similar findings. The erosion index increased as dispersion ratio increased, showing that these soils were more susceptible to water erosion.

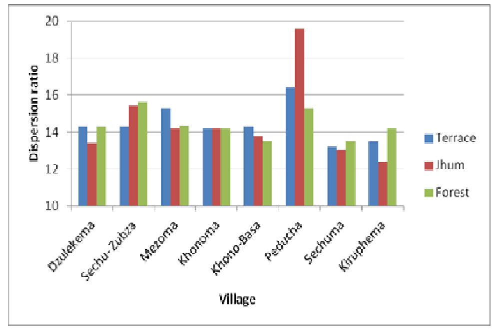

Fig. 1. Dispersion ratio (DR) of soils under different land uses in surface soils (0-15cm).

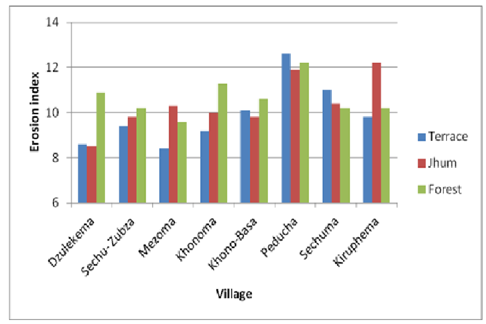

Fig. 2. Erosion index (EI) of soils under different land uses in surface soil (0-15 cm).

Table 1: Mechanical composition of soils under different land uses.

Land use & location	Sand (%)		Silt (%)		Clay (%)	
	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
Terrace						
Dzulekema	37.1	41.1	30.0	25.0	30.0	30.0
Sechu-Zubza	24.8	27.7	40.0	40.0	30.0	30.0
Mezoma	42.7	43.8	30.0	30.0	25.0	25.0
Khonoma	45.2	40.7	30.0	30.0	25.0	25.0
Khono-Basa	44.7	48.5	30.0	25.0	25.0	20.0
Sechuma	19.5	24.8	40.0	35.0	40.0	35.0
Kiruphema	28.4	29.8	35.0	35.0	30.0	30.0
Peducha	32.4	37.1	35.0	30.0	30.0	30.0
Mean	34.36	36.7	34.36	36.7	29.37	28.12
Jhum						
Dzulekema	34.5	36.7	25.0	30.0	30.0	25.0
Sechu-Zubza	32.6	34.7	35.0	35.0	30.0	25.0
Mezoma	32.2	35.8	35.0	30.0	30.0	30.0
Khonoma	38.8	34.5	30.0	35.0	25.0	30.0
Khono-Basa	31.3	35.8	35.0	35.0	30.0	25.0
Sechuma	36.7	38.7	30.0	25.0	30.0	30.0
Kiruphema	22.6	23.2	40.0	40.0	35.0	35.0
Peducha	38.5	35.3	30.0	30.0	30.0	30.0
Mean	33.43	34.35	32.5	32.5	30.0	28.75
Forest						
Dzulekema	27.2	25.7	30.0	30.0	35.0	40.0
Sechu-Zubza	36.3	38.0	30.0	30.0	30.0	25.0
Mezoma	33.4	42.4	35.0	30.0	30.0	25.0
Khonoma	38.8	42.4	30.0	30.0	25.0	25.0
Khono-Basa	33.4	42.0	30.0	30.0	30.0	25.0
Sechuma	32.3	36.6	30.0	35.0	30.0	25.0
Kiruphema	27.0	29.0	35.0	35.0	30.0	30.0
Peducha	37.8	42.0	30.0	30.0	30.0	25.0
Mean	32.29	37.28	31.25	31.25	30.0	27.5

Table 2: Dispersion ratio and erosion index of soils under different land uses.

Land use & location	Dispersion ratio		Erosion index	
	0-15cm	15-30cm	0-15cm	15-30cm
Terrace				
Dzulekema	14.3	14.5	8.6	8.5
Sechu-Zubza	14.3	12.8	9.4	9.5
Mezoma	15.3	14.8	8.4	8.3
Khonoma	14.2	14.0	9.2	9.4
Khono-Basa	14.3	14.5	10.1	9.8
Sechuma	13.2	13.1	11.0	11.9
Kiruphema	13.5	13.2	9.8	10.0
Peducha	16.4	16.0	12.6	11.4
Mean	14.4	14.1	9.88	9.85
Jhum				
Dzulekema	13.4	14.8	8.5	9.1
Sechu-Zubza	15.4	14.5	9.8	9.6
Mezoma	14.2	15.2	10.3	10.2
Khonoma	14.2	14.4	10.0	10.2
Khono-Basa	13.8	14.0	9.8	10.0
Sechuma	13.0	13.5	10.4	10.2
Kiruphema	12.4	12.6	12.2	11.8
Peducha	19.6	19.1	11.9	12.1
Mean	14.5	14.7	10.36	10.4
Forest				
Dzulekema	14.3	15.2	10.9	10.3
Sechu-Zubza	15.6	16.9	10.2	10.5
Mezoma	14.3	14.6	9.6	9.3
Khonoma	14.2	15.1	11.3	11.5
Khono-Basa	13.5	13.5	10.6	10.5
Sechuma	13.5	13.3	10.2	10.0
Kiruphema	14.2	14.3	10.2	10.3
Peducha	15.3	16.8	12.2	12.5
Mean	14.3	14.9	10.65	10.61

Table 3: Correlation coefficient among various soil properties of surface soil (0-15 cm).

	Sand	Silt	Clay	DR	EI
Sand	1				
Silt	-0.69*	1			
Clay	-0.56	0.82**	1		
DR	0.63*	-0.41	-0.58	1	
EI	0.28	-0.19	-0.36	0.35	1

** Significant at 1% level of probability (r >0.735); * Significant at 5% level of probability (r >0.602)

Table 4: Correlation coefficient among various soil properties of sub-surface soil (15-30 cm).

	Sand	Silt	Clay	DR	EI
Sand	1				
Silt	-0.65*	1			
Clay	-0.87**	0.78**	1		
DR	0.37	-0.34	-0.58	1	
EI	0.31	0.12	-0.26	0.42	1

** Significant at 1% level of probability (r >0.735); * Significant at 5% level of probability (r >0.602)

CONCLUSIONS

The soils in the research region, particularly Peducha village was highly sensitive to erosion. High erosion sensitivity will cause excessive transport on the soil surface, thus shall owing the depth of the soil and lowering land's yield. Regardless of the land use, all the soils were subjected to be erodible class considering 2.8 as the threshold value for erosion index and 15 as the threshold limit for Dispersion ratio. Therefore, it is crucial to exercise extreme caution while making any interventions in all the land uses. To reduce the impact of erosivity of rainfall, proper soil and water management strategy should be adopted to increase the vegetative cover and to improve the infiltration capacity of the soil. Hence, it is recommended that proper reclamation activities be made, such as fertilization in terraces, boosting the plant composition and density in *jhum,* and safeguarding forests from anthropogenic influence to prevent soil erosion.

FUTURE SCOPE

Considering the outcome of the investigation, various biological and mechanical measures of soil and water conservation may be employed in different land uses to find out the location specific effective measures to protect the soils from further degradation.

Author contributions: A.P., M.D. and S.R. wrote the main manuscripts. A.P., M.D., and J.B.B. did the data analysis and prepared all the figures. A.P., A.J. and H.N.K. analyzed all the samples for various soil properties.

Conflict of Interest. None.

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