Modelling Alternatives for Highland Soil Structural Degradation and Erodibility, Bui Plateau, Cameroon

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ABSTRACT

Highland triggers of soil physical degradation through the fragilisation of soil aggregates are primarily factors of soil biochemistry and anthropogenic mishandling of land resources. Soil degradation forms are challenging the sustenance of human systems on earth. This study probes into soil physical degradation and exposure to external stressors using 60 soil samples collected and analysed for soil aggregate stability, vulnerability and erodibility to determine soil structural stability/resilient capacity. The soils were found to be stable in structure, but highly vulnerable to stress and erodible. Coarse-granitic sandy soils just as the less evolved erosion soils of the eastern slopes of the plateau were proven to be most erodible and vulnerable to physical degradation. Soil Structural Stability Index (ISS) was very low ($\leq 4.3\%$: severe physical degradation) for disturbed soils under grazing with similar tendencies on cultivated humid volcanic soils. High erosion vulnerability/erodibility soils are indicative of low organic matter and organic carbon content issuant of heavy and uncontrolled grazing, annual biomass burning and long-term cropping without soil improvement schemes which calls for guided land use practices over the Bui Plateau.

Keywords: Soil degradation, soil erosion, soil erodibility, Soil organic Carbon, Bui Plateau.

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I. INTRODUCTION

Soils are fundamental to life on Earth but human pressures on soil resources are reaching critical limits [1]. Careful soil management is one essential element of sustainable agriculture and also provides a valuable lever for climate regulation and a pathway for safeguarding ecosystem services and biodiversity [2]. Physical land degradation involves the displacement and/or repositioning of soil particles without altering their chemical composition [3]. Soil degradation is a temporary or permanent lowering of the productive capacity of soil caused by overgrazing, deforestation, inappropriate agricultural practices, over exploitation of fuel wood leading to desertification and other man-induced activities [4]. Degradation as such is portrayed by physical, chemical, and biological soil depletion mechanisms. Outstanding physical processes are the decline in soil structure, crusting, compaction, erosion, desertification, environmental pollution, and unsustainable use of natural resources [5]. Major chemical processes are acidification and leaching, salinization, reduction in CEC and loss of fertility, biological processes on the other hand include reduction in total and biomass carbon, as well as the decline in soil biodiversity [5]. Erosion-induced soil degradation is initiated as a result of a decline in soil structure (compaction, crusting and loss of rooting depth and

plant available water) as well as a decline in soil organic carbon and fertility [6].

While the global food production is increasing, agrarian land is degrading rapidly, jeopardizing future prospects [7]. Soil erosion, chemical deterioration and physical degradation are parts amongst various types of soil degradation [8] that affect water infiltration into the soil by (i) reducing vegetation cover (ii) exposing less permeable soil layers through erosion, and (iii) rupturing soil structure including through the loss of soil organic matter [9]. Soil degradation is a rising menace to food security, as it forces farmers to use more inputs, and may eventually lead to soil abandonment [10]. Yield reduction due to past soil erosion may range from 2 to 40%, with a mean loss of 8.2% for Africa [11].

The health of soils is gaining needed attention, most notably in its inclusion into the Sustainable Development Goals (under target 15.3: Land Degradation Neutrality) as well as the other global targets set under the United Nations Convention to Combat Desertification [7]. The stability of aggregates in the surface soil is crucial to the processes of soil erosion and runoff generation in agricultural lands [12]. Soil erosion risk has been widely assessed based on rainfall-runoff erosivity, soil erodibility, and erodability (terrain characteristics) using the Universal Soil Loss Equation and its family of models. Soil erodibility is a key parameter in

erosion prediction and is important for conservation planning in the wake of arising need for protecting the limited land resources [13].

Assessment of soil exposure to external stressors and ensuing degradation is of prime importance to the implementation of Sustainable Land Management (SLM) strategies. Some significant number of studies on land degradation on the Western Highlands of Cameroon have variably been limited to diagnosis of the cause-effect analysis of watershed-forest degradation as provoked by man [14]-[17] and soil erosion [18]. Fewer studies investigated soil erodibility and structural stability as a proxy-indicator of soil physical degradation in the Western Highlands like the works of [19] over the Southern Bamileke Plateau and [20] for cultivated soils of Foubot. Studies on soil erodibility of permanently grazed Bamenda Highlands are lacking with only [21] for the Santa toposequence. The Bui Plateau is a knowledge void area about the status of soils yet ripe with soil degradation processes over time and space even in the most inaccessible areas. This study seeks to understand, using techniques of Geographical Information Systems, the physical degradation processes occurring at watershed scale and across pastoral systems of the Southern Bui Plateau, Western Highlands of Cameroon.

II. THE STUDY AREA

The Bui Plateau within the Bamenda Highlands presents a topographic variation with heights ranging from about 700 m above sea level (asl) around the Wasi-Ber and Mbaw Plains to 3011 m (asl) culminating at Mount Oku. The Plateau lies along the Cameroon Volcanic Line (CVL) and the Western Cameroon Highlands in its north western extension (Bamenda Highlands). To the northeastern direction, the plateau extends to the Nkambe High Plateau, to the northwest it extends to the Konene-Lassin Low Plateau, to the west it forms a continuity with the Oku-Kom Highlands, to the south west, it terminates into the Ndop and Wasi-Ber Plains of the Upper Nun Valley, to the south, the plateau forms a tongue-like elevated extension culminating at Mount Mbam (2000 m asl) and to the southeast it topples to the Mbaw Plain that extends to the Tikar and Mbam Plains (Fig. 1).

In its spatial delimitation, the South Bui Plateau cuts across the central limits of the plateau to western and eastern limits with the Kom Highlands and Mbaw Plains respectively and its southern extension or southern tongue; the Mount Mbam. [22], based on the Köppen's 1936 climatic classification, it is established that the Bui Plateau corresponds to the 'Aw' climate type, with two seasons (dry and wet). The dry season lasts for four to five months (November to March) while the wet season lasts for eight months (March/April to October). The climate together with the soils, dominantly iron and aluminum-rich has given rise to savanna grassland in majority interspersed with dotted montane shrubs and forest refugia. Important montane forest remnant can be found on Mount Oku and Mount Mbam showing characteristics of long-term anthropogenic degradation. The maintained grasslands are also a relic of long-term colonization of the hillslopes of the South Bui

Plateau by cattle herders. This is due to the adjacency of the Wasi-Ber, Ndop and Mbaw Plains to the southern extension of the plateau used as dry season transhumant grazing zones. Land degradation (soil and vegetation) is very visible in the two main localities of Lip in Jakiri and Mbiame local council areas. Administratively, the South Bui Plateau covers four municipalities (Lower Mbiame and Kumbo, Oku and Jakiri).

Fig. 1. Map of the Southern Bui Plateau in the Western Highlands of Cameroon.

According to [23], the study area comprises of volcanic soils (humid soils of high lava plateau and soils on low lava basalts), granitic coarse-sandy and fine-textured soils.

III. MATERIALS AND METHODS

FAO [24] established practical guidelines for field soil sampling. It recommended that within a stratum, the sampling locations where soil cores are taken should be determined randomly to avoid bias. However, certain areas shall be excluded in grazed lands, such as patches with animal excreta, animal pathways, driveways to enter/leave fields, very near watering points [24]. Soil samples were randomly collected for the studied sites following land cover/use to take care of the possible variation of soil properties with land-surface spatial heterogeneity. Each soil sample was made up of four soil cores which were combined to form a composite sample for analysis. Compositing (or bulking) several soil cores or subsamples to make a composite sample was recommended to estimate SOC content in soils by [24]. Soil physicochemical variables

have been widely reported from 0–20 cm soil depth. IPCC recommended a depth of 0–30 cm if soil parameters like SOC were to be analyzed. A total of 60 soil samples were collected at 0–30 cm (0.3 m) soil depth for the study (Fig. 1). Collected soil samples were air dried for 5 days before grinding and sieving for use in laboratory analysis at the Laboratory of Soil Analysis and Chemistry of the Environment (LABASCE) of the Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon. 2-mm sieve was used to obtain soil separates or particle sizes (percent sand, silt, and clay). The organic carbon concentrations of soil samples were determined by applying the dichromate oxidation method proposed by [25]. A conversion factor of 1.724 was used to convert soil organic carbon (SOM) to organic matter (SOM) as recommended.

The GPS coordinates of each sampling location was collected to enable geostatistical soil analysis and spatial interpolation. For interpolating soil properties – which vary not only with distances but also with direction – a method which assigns weights to the values of sampled points based on distances as well as the direction would be preferable [26]. The inverse distance weighting (IDW) method estimates the values of an attribute at unsampled points using a linear combination of values of sampled points weighted by an inverse function of the distance from the point of interest to the sampled points [27] and so was used in the spatial modelling of soil attributes and degradation indices.

For the estimation of soil structural degradation and erodibility, aggregate stability measures the structural stability of soils [4], and/or the ability of soil aggregates to withstand breakdown to small fragments when quickly moistened [28]. Factors that influence aggregate stability are important in evaluating the ease with which soils erode by water and/or wind, the potential of soils to crust and/or seal, soil permeability, quasi-steady state infiltration rates and seedling emergence and in predicting the capacity of soils to sustain long-term crop production [4]. Apart from quantitative indices for soil erodibility to estimate soil erosion some other indices are also used by researchers to understand the proneness of soil to erosion [29]. The soil aggregate stability index (ISS) developed by [30] have been widely used to assess soil structural degradation. Soil erodibility which is a measure of soils susceptibility to erosion has been widely estimated using the Universal Soil Loss Equation of [31] and/or the Revised Universal Soil Loss equation by [32]. Besides this, other erodibility indices include Clay Ratio (CR) [33], [34], Modified Clay Ratio (MCR) [35] and Critical Level of Soil Organic Matter (CLOM) [30]. We used the ISS to assess soil structural degradation, the Erosion/Productivity Impact Calculator (EPIC) soil erodibility estimator [36] to estimate soil erodibility and Critical level of soil organic matter (CLOM) [30] to assess soil susceptibility to erosion over the Plateau.

For the soil Aggregate Stability Index (ISS), [37] developed a soil crusting index for measuring the risk of soil structural degradation linked to crusting. This is based on soil organic matter content and percent clay and silt as expressed in Equation 1.

$$ISS = \frac{OM(\%) \times 100}{Clay(\%) + Silt(\%)} \quad (1)$$

where ISS is the soil crusting index, OM is the percent organic matter. For numerous savannah soils of West Africa, [37] distinguished the following critical values of ISS: $ISS < 5\%$ indicates severe physical degradation; $5\% < ISS < 7\%$ implies high hazards of physical degradation; $7\% < ISS < 9$ implies low risk of physical degradation; $9 < ISS$ indicates no physical degradation and soils with adequate SOM to maintain stability. Pieri [30] later modified the ISS by using soil organic carbon as a substitute to measure soil risk to structural degradation and aggregate stability based on soil organic carbon content (Equation 2).

$$ISS = \frac{1.724 \times OC}{(L + A)} \times 100 \quad (3)$$

where OC is the soil organic carbon, L is the silt fraction, and A is the clay fraction. An $ISS > 9\%$ indicates stable structure with sufficient SOC to main structural stability, $7\% < ISS \leq 9\%$ indicates low risk of structural degradation, $5\% < ISS \leq 7\%$ indicates high risk of degradation, and $ISS \leq 5\%$ indicates structurally degraded soil.

For Soil Erodibility (K), the direct measurements of erodibility factor are both costly and time consuming and has been feasible only for a few major soil types [31]. The USLE-K factor estimate has become the most popular and well-accepted soil erodibility calculation method [38]. The K-value based on basic soil property variables can be expressed in mathematical terms [39], [31] based on a nomograph regarding particle size (percent silt), percent of organic matter, soil structure and profile permeability as in Equation 3.

$$K = [2.1 \times 10^{-4} (12 - SOM) M^{1.14} + 3.25(S_i - 2) + 2.5(p' - 3)] / 100 \quad (3)$$

where M represents a newly defined term, the product of the silt + very fine sand (0.002–0.1mm) and 0.1–2 mm sand fractions (%), S_i and P' are the soil structure and permeability class, respectively, and SOM, as mentioned above, is soil organic matter content (%) [38]. Only two soil properties are needed in EPIC to calculate the soil erodibility K-value: the soil organic carbon content and soil particle size distribution [36] cited in [38] as in equation 4.

$$K = (0.2 + 0.3e^{[-0.0256SAN(1-SIL/100)])} \times \left(\frac{SIL}{CLA + SIL} \right)^{0.3} \times \left[1 - \frac{0.25C}{C + e^{(3.72-2.95C)}} \right] \times \left[1 - \frac{0.7SN_1}{SN_1 + e^{(22.9SN_1-5.51)}} \right] \quad (4)$$

where SAN is the sand content (%), SIL is the silt content (%), CLA is the clay content (%), C' is the soil organic carbon content (%), and $SN_1 = 1 - SAN/100$ [38]. The K-factor ranges from 1 (very easily eroded) to 0.01 (very stable soil). The EPIC soil erodibility estimator has been widely used in R/ULSE modeling due to its less data requirements, straightforwardness and efficiency in prediction. In this study, the K-factor was estimated using the algorithm of EPIC as in Equation 4.

Critical level of organic matter (CLOM) is also an

indicator of erosion susceptibility [29]. Its estimation is based on [30], as in Equation 5.

$$CLOM = \frac{OM}{Clay(\%) + Silt(\%)} \tag{5}$$

If the value of CLOM is less than 5%, it is indicated that soil loses its structure and becomes highly susceptible to erosion. Soil is said to be moderately susceptible to erosion if the value lies between 5 and 7%. CLOM value more than 9% indicates that soil is stable and offer more resistance to erosion [30].

IV. RESULTS AND DISCUSSIONS

A. Soil Types, Attributes and Risk of Physical Degradation

The soils of the South Bui Plateau are dominantly sandy (>75%) across all land cover/uses. High sand content in soil increases soil fragility to erosion and soil loss as opposed to dominant silt and clay which bind soil aggregate into structure. The mean values for silt and clay across all land cover/uses were 13.09% and 11.28% respectively (Table 1, Fig. 2 and 3). The degree of soil fragility based on soil physical parameters of sand, silt and clay and soil biological structural variable (soil organic carbon) is evaluated through the soil erodibility K-factor and CLOM.

TABLE 1: MEAN VALUES OF SOIL PHYSICAL CHARACTERISTICS OF THE SOUTHERN BUI PLATEAU

Land cover/use	Texture	No	Sand (%)	Silt (%)	Clay (%)	Organic Carbon (%)	Organic matter (%)
Eucalyptus forest	Loamy sand	02	86	8.5	5.5	3.72	6.42
Farmland	Sandy loam	36	76.9	12.3	10.8	4.18	7.20
Grazing land	Sandy loam	14	68.7	15.7	15.6	3.62	6.24
Degraded grazing land	Loamy sand	01	80.0	17.0	3.0	0.50	0.86
Abandoned farmland	Loamy sand	01	81.5	12.5	6.0	5.76	9.92
Improved grazing land	Loamy sand	01	84.5	11.99	3.5	5.10	8.80
Natural forest	Sandy loam	04	77.5	12.25	10.25	4.86	8.38
Catchment land	Loamy sand	01	79.5	16.0	4.5	3.60	6.21
Mean	Sandy loam	60	75.61	13.09	11.28	4.05	6.98

Source: Fieldwork (2020).

Fig. 2. Spatial variation of percent clay and sand over the southern Bui Plateau.

Fig. 3. Spatial variation of SOC and percent silts over the Southern Bui Plateau.

SOC content of the soils are general low. The mean SOC (%) across all land cover/uses was just 4.05%. low SOC content is an indicator of poor soil health and degraded soils with less nutrient pool. The south-eastern slopes are associated with low SOC (0.20-1.49%).

B. Land Use Practices and Soil Physical Degradation Processes

It is reported that the soils have near stable structures across the study area based on ISS. This explains a less likelihood of soil degradation by crusting, sealing and compaction. Whilst in majority the ISS index shows a near stable and resilient soil structure for some parts of the plateau, landscapes undergoing anthropisation and human misuse shows the weakening of soil resilience capacity and high risk of structural degradation as noted in [40]. This has been visible on poorly managed degraded grazing fields (ISS = $4.3\% \leq 5\%$ (severe physical degradation) currently undergoing soil compaction, nutrient depletion, soil biodiversity loss and tonnes of soil loss following heavy storm events and increase runoff (Table 2).

An ISS of 4.3% indicates a severe risk of physical degradation linked to destruction of soil structure by overgrazing and misuse of land. This involves mostly coarse-sandy granitic soils in the eastern section of the plateau (Fig. 4).

Other land use practices now said to be threatening soil aggregate stability (Plate 1.) and weakening of soils resistive capacity are farming and grazing (ISS = 23% and 19.9% respectively) as compared to (ISS = 53.62% and 57.14% for abandoned farmlands and managed grazing lands (ranch) respectively). This explains loss of soil vital elements like SOC and SOM responsible for structural stability by over-cultivation, nutrient mining, and uncontrolled grazing (mostly associated with biomass burning and transhumant seasonality). A reduction in soil aggregate stability implies an increase in soil degradation [4]. The high values of ISS

for abandoned farmlands and managed grazing lands are feedback signals for the need of SOC and SOM management and improvement to maintain healthy soils and landscapes.

Maximum SOC and SOM levels were reported from the two aforementioned land uses (5.76% and 5.10% of SOC; 9.92% and 8.80% of SOM). This forms the bases for sustainable land management practices that aimed at improving SOC and SOM content of the soils to ensure healthy soils.

Fig. 4. Soil stability index and soil structural degradation vulnerability.

TABLE 2: SOIL BIO-PHYSICAL PARAMETERS AND SOIL STRESS INDICES ACROSS LAND COVER/USES

Land cover/use	Sand (%)	Silt (%)	Clay (%)	SOC (%)	SOM (%)	ISS	CLOM	K
Eucalyptus forest	86	8.5	5.5	3.72	6.42	45.85	0.46	0.3
Farmland	76.9	12.3	10.8	4.18	7.2	23	0.31	1.86
Stable grazing land	68.7	15.7	15.6	3.62	6.24	19.9	0.19	0.34
Degraded grazing land	80	17	3	0.5	0.86	4.3	0.04	0.47
Abandoned farmland	81.5	12.5	6	5.76	9.92	53.62	0.54	0.36
Improved grazing land	84.5	11.99	3.5	5.1	8.8	57.14	0.56	0.34
Natural forest	77.5	12.25	10.25	4.86	8.38	36.83	0.36	0.37
Catchment area	79.5	16	4.5	3.6	6.21	30.29	0.3	0.42
Mean	75.61	13.09	11.28	4.05	6.98	33.86	0.35	0.56

TABLE 3: SOIL PHYSICAL DEGRADATION BIOPHYSICAL DETERMINANTS AND DEGRADATION MATRIX

	Sand (%)	Silt (%)	Clay (%)	SOC (%)	SOM (%)	ISS	CLOM	K
Sand (%)	1							
Silt (%)	-0.54	1						
Clay (%)	-0.86**	0.04	1					
SOC (%)	0.11	-0.56	0.20	1*				
SOM (%)	0.11	-0.56	0.20	0.99**	1			
ISS	0.56	-0.71*	-0.24	0.84**	0.84**	1		
CLOM	0.55	-0.75*	-0.20	0.87**	0.86**	0.96**	1	
K	-0.19	-0.06	0.26	0.00	-0.00	-0.31	-0.15	1

**Significant at 0.01 level (2-tailed) *significant at 0.05 level (2-tailed).

Landslides along the Lip-Mbokam road

Indicators of over grazing on the Lip-Mbam Highlands

Plate 1. Process-response analysis of physical degradation over the Plateau.

C. Bui Plateau Soil Traits, Aggregate Stability and Degradation Indices

Several factors have been reported to determine soil aggregate stability and hence soil structural degradation. Amongst the main soil biophysical and chemical components have been soil separates (texture), SOC and SOM. Based on a single factor analysis, SOM or SOC can be used as an indicator of soil health and degradation (Table 3).

Sand is negatively correlated with clay ($r = -0.86$, $p = 0.003 < 0.01$). Silt is negatively correlated with CLOM and ISS ($r = -0.75$, $p = 0.019 < 0.05$) and ($r = -0.71$, $p = 0.033 < 0.05$). Organic carbon is positively correlated with SOM, ISS and CLOM ($r = 0.99$, $p = 0.000 < 0.01$, $r = 0.87$, $p = 0.005 < 0.01$ and $r = 0.84$, $p = 0.003 < 0.01$). SOM derived from SOC is normally correlated to it ($r = 1$), but also positively correlated with CLOM ($r = 0.86$, $p = 0.003 < 0.01$) and to ISS ($r = 0.84$, $p = 0.005 < 0.01$). The ISS and CLOM were positively related ($r = 0.96$, $p = 0.000 < 0.01$).

None of the soil parameters were strongly correlated with K (soil erodibility). There is weak negative correlation between K and ISS ($r = -0.31$), and between K and percent clay ($r = 0.26$). Acceptable levels of clay in the soil helps to bind soil particles into peds thereby reducing soil erodibility. The weak correlation of K with the selected soil physicochemical properties therefore revealed that ISS and CLOM are good predictors of soil structural stability and/or

degradation and hence soil erosion susceptibility assessment. This explains the importance of SOC and SOM as the main parameters responsible for maintaining soil health and aggregate stability to reduce the risk of soil physical degradation. The SOM plays vital role in binding soil particles into aggregates of stable structure. The low level of SOC and SOM partly linked to unsustainable land use practices like biomass burning, overgrazing and over-cultivation explains the weakening of the soil's resilient capacity to external stressors and the increase susceptibility to water erosion. In this respect, SOM explains tolerant limits for ISS and an early warning for sustainable SOM management to improve soil health and resilience. SOM is very beneficial for protecting soil from structural degradation.

D. Soil Erodibility and Soil Erosion Susceptibility

Soil erodibility a measure of the soil's proneness to water erosion hazards was assessed based on EPIC and the susceptibility of soil to this physical stressors assessed using percent critical organic matter (CLOM). The general soil texture (sandy loam) over the plateau is a factor explaining the high erodibility of the soils due to its very high sand content ($\geq 70\%$) making soil structure vulnerability to external stress. Topography and soil formation traits combine to increase this soil erosion risk (Fig. 5).

Based on CLOM, coarse-granitic sandy soils, humid volcanic soils and less evolved erosion soils at higher

elevations are the most likely prone to erosion. This covers approximately 92.51% of the study area (Table 4); either 12578.6 km². This includes very highly susceptible areas (36.30% or 4936.04 Km²) and extremely susceptible areas (56.21% or 7642.56 Km²).

TABLE 4: SOIL EROSION SUSCEPTIBILITY CLASSES AND AFFECTED AREAS

Susceptible Classes	Area (km ²)	Percentage
Nearly stable to susceptible	14.52	0.11
Moderately susceptible	26.01	0.19
Highly susceptible	976.93	7.19
Very highly susceptible	4936.04	36.30
Extremely susceptible	7642.56	56.21
Total	13596.06	100

Fig. 5. Critical organic matter and soil susceptibility to erosion hazards.

The different soil types depending on SOM and SOC content shows varying erodibility. Over three quarters of the Bui plateau is subject to high and extreme erodibility as well as erosion vulnerability (Fig. 6.).

Less evolved erosion soils covering the Mbam Mountain range are the most erodible ($K = +1$). This is followed by coarse-granitic sandy soils ($K = 0.98-1$). Areas with slightly low soil erodibility are most covered by humid volcanic soils with high concentration of organic matter and stables soil structure. Controlling grazing over the south-eastern section of the plateau will be a great relief to the soil erosion threat. Less evolved erosion soils of the Mbam Mountains and coarse-granitic sandy soils of the Mbokam-Mbiame Range are highly erodible because of the high sand content and less organic matter to bind soil particles to form peds. The fragility of these soils and exposure to water erosion has been accelerated by heavy and uncontrolled grazing, associated with yearly biomass burning and vegetation depletion. Fire is said to increase event soil loss due to its increase soil bareness and runoff speed over land.

Fig. 6. Soil erodibility ($t\ ha^{-1}\ h\ ha^{-1}\ MJ^{-1}\ mm$) over the Southern Bui Plateau.

Soil aggregate stability is influenced by a number of factors including soil texture, clay mineralogy [28], SOM level, type and content of cations, contents of Fe-Al oxyhydroxides and $CaCO_3$, with multiple interactions among these properties capable of modifying their individual influence [41]. The two most important are SOM [12], especially in low-sodium soils [42], [43] and Fe-Al oxides mainly in tropical and lateritic soils [44], [45]. In view of its role in soil aggregation and erosion control, in availability of plant nutrients and in ameliorating other forms of soil degradation than erosion, SOM has proven to be an important indicator of soil degradation [46]. After particle size distribution of soils, SOM ranks next as an indicator of soil erodibility [47], the proneness of soil to erosion. The Universal Soil Loss Equation (USLE) and other erosion prediction models developed from it show the importance of SOM in soil erosion prediction. The severity of soil erosion by water is intricately linked to SOM concentration [48], and so could be estimated from SOM by calibration involving matching possible range of SOM values with established erosion severity classes [46]. Whilst SOM remains a candidate without substitute as long as a one-parameter indicator of soil degradation is needed, narrowing down to the use of its labile and microbial components could be more appropriate, since early detection is important in the control and management of soil degradation.

V. CONCLUSIONS

SOM and SOC has proven vital for soil aggregate stability and soil health. Maintaining important levels of SOM and SOC are primordial for maintaining stable and healthy soils. SOM and SOC are intrinsically linked to SDG 1, 2, 8, 13 and 15. Maintaining acceptable levels of SOC is also important for enhancing carbon sequestration and climate change mitigation as pathways towards achieving

SDG 13. For the soil as a resource-base to humankind fully contributes to the achievement of sustainable development goals, acceptable SOC and SOM levels are needed to be maintained through sustainable land management strategies that reverse degrading soils and maintain fertility and soil carbon sink capacity. The principles of sustainable land management practices laid down by SDG 15.3 are aimed at reversing land degradation and thriving for a land degradation neutral world by 2030. Sustainable grazing, limiting transhumance and grassland burning are amongst the recommended strategies to reverse continuous degradation of the degrading areas and improvement upon the quality of non-degraded but vulnerable lands over the plateau.

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