Microtopographic Erosion Features as Indicator of Erosion Hazard for Conservation Advice

***Lok Bahadur Kunwar*[1], *Eelko Bergsma*[2] and *Dhruba Pikha Shrestha*[2]**

[1] Soil Science Division, Nepal Agriculture Research Council, Lalitpur, Nepal
[2] International Institute for Geo-information Science and Earth Observation (ITC), Enschede, The Netherlands
[2] Home mail address: Haydnlaan 2, 7522HE Enschede, the Netherlands.
E-mail: bergsma@itc.nl

Abstract: Field observation of soil microtopography could distinguish seven types of features related to erosion. The features are: resisting clods, eroding clods, flow surfaces, prerills, rills, depressions and basal vegetal cover. In each of fifty tape intervals of 25 cm along the contour, the dominant feature is recorded.

The feature record as a whole can be used to characterise the intensity of the erosion at the end of a rainy period. Thus different cropping systems can be compared for the erosion which they produce. A selection of the cultivation system that reduces erosion most effectively can be made in this way. Care should be taken that other erosion conditions are sufficiently similar, such as relief and rainfall.

The method of recording soil surface features of microtopography is simple to learn, fast in operation, and cheap in execution. The feature recording can be done on whatever important types of land use exist in an area, such as annual and perennial crops, grassland, forest, orchard or plantation.

Keywords: erosion hazard, soil conservation, microtopographic erosion features

1 Erosion hazard and soil conservation advice

For rural extention about soil conservation systems and practices, the erosion hazard needs to be known to make good recommendations. Measurement of soil loss is costly and data are rare. Prediction models are insufficiently calibrated in most areas.

Without the need to determine soil loss in t/(ha・y), a method has been developed that can be used to compare cropping systems, land use practices and conservation systems for their resistance to erosion (Bergsma 1992, 1997, 1999; Bergsma & Kwaad 1992).

2 Method of evaluating the erosion hazard by microtopographic erosion features

To characterise the erosion hazard, the accumulated effect of erosion is observed as expressed by microtopographic erosion features formed over a previous rainy period. These specific features are used instead of the 'random' roughness' of the eroded soil surface. The microtopographic features used for evaluating the erosion hazard are seven types (Table 1).

In a field to be studied a measuring tape (of for instance 2.5 m long) is stretched along the contour, so that surface flow features will be met across the tape. The tape has alternately coloured intervals of 25 cm. For each interval the dominant of the seven microtopographic features along the tape is determined. The record covers 50 intervals, following the same contour line. Thus each tape interval represents 2 % of the area. Two repetitions of the feature record are made, in the contour direction, at one or two meters above or below the first observation line. The recording of the microtopographic erosion features has an accuracy of 4 % in a feature percentage that is obtained from observation of 50 tape intervals.

Table 1 Microtopographic erosion features used for the evaluation of rain erosion hazard

Type	General description	Characteristics
Resistant or recently made clods	Original forms that generally were created by tillage and either resist degradation or have been newly formed.	* sharp edges * overhanging sides * former soil surface may be present on a side ...of the clod * rocks and stones are included under this ...heading
Eroded clods	formed by splash and disaggregation (wetting, drying, etc.), not by flow	* dominantly convex surface * micro-pedestals of coarse sand, gravel and ...vegetal matter may be present on the upper ...clod surface * are situated above the areas of flow
Flow surfaces	formed by shallow unconcentrated flow	* developed on deposits that smoothed the pre- ...existing micro-relief, or on parts that have ...been smoothed by erosion * often have parallel linear flow patterns of ...lag sediment
Prerills	Shallow micro-channels of concentrations of flow, up to about 3 cm—5 cm deep.	* shallow channel, slightly concave ...cross-section * may have small scarps at the sides * mostly discontinuous, not integrated in the ...micro-drainage system of the field.
Rills	Micro-channels, incised deeper than the prerills of 3 cm—5 cm depth	* formed by incision into the soil, or formed ...originally by collaps of seepage tunnels * may reach the ploughpan or B-horizon * in case of a resistant subsoil have a distinct ...rill-bottom and U-shaped cross section * clear lateral micro-scarps occur at the sides ...when flow was recent * function mostly as part of the micro-drainage ...system of the field * occur often below a knickpoint in the ...gradient of flow
Depressions	Areas without immediate drainage outlet, where ponding occurs and material can accumulate. Tillage as in land preparation leads to small depressions. Eventually these areas may be filled by deposits, or be removed by incision and headward erosion of micro-channel flow.	* no immediate outlet * site for surface ponding and in-field ...deposition of eroded material.
Vegetative matter	Basal cover of living or dead residue, close to the surface and resistant against wash.	* low folial and other vegetal matter.that ...cannot be removed easily, either because of ...intensive plant rooting, partly ploughed-in ...residues or otherwise stable in position.

The percentage distribution of the seven features is determined. An indicator of erosion intensity is calculated as the percentage flow area + two times the percentage prerill and rill area. This indicator showed correlation with soil loss in previous research cases (Bergsma 1997, 1999) (Table 2).

Table 2 Correlation between erosion intensity derived from surface features and measured soil loss

Location and date	Number of treatments ×replications of erosion plots	Spearman rank correlation coefficient		
		all individual plots	number of plots excluded †	plots grouped per treatment
Chiang Dao, Northern Thailand August 1994	5×4 and 2×1	0.39 (93%)	3: 0.76*** 4: 0.79***	0.85* (98%)
Doi Thung, Thailand, July 1997	5×4 and 3×1 only 8 studied	0.55 (<<95%)	1: 0.93** 4: -	- 0.94**

*** = significance level of 0.001 ( ) = statistical probability
** = significance level of 0.01 † = for reasons of faulty plot management, deposition within- plot, and two 1997 derived but unlikely extreme erosion intensities.
* = significance level of 0.05

Exceptions in this correlation revealed errors in erosion intensity determination as well as errors in soil loss measurement, a mutual check of both is the result.

The method of recording soil surface features of microtopography is simple to learn, fast in operation, and cheap in execution. In one case, 24 plots located close together, could be studied in one morning. The feature recording can be done on whatever important types of land use exist in an area, such as annual and perennial crops, grassland, forest, orchard or plantation (Turkelboom 1999, p. 87—90, de Bie 2000, p. 143—164).

When applying the method for comparison care has to be taken that other erosion hazard factors than the one investigated are sufficiently similar, such as relief and rainfall. But the method of recording the microtopographic erosion features can be readily applied for a new comparison in a region where erosion conditions are different from the first area of investigation.

3 Erosion hazard study of sites near Kathmandu, Nepal

Erosion hazard has been evaluated on 12 sites that represent main physiographic landscape units in the Likhu Khola watershed (Kunwar 1995), located 50 km. north-west of Katmandu, Nepal, in steep and eroding terrain in the Middle Mountain Region (Shrestha 2000) (Table 3).

Table 3 Environmental characteristics of the 12 observation sites (Shrestha 1997, 2000)

Site	Location	Elevation a.s.l.	Steepness of site	Aspect	Land use/ management	Soil name
1	Geragaon	800 m	10%	North	Maize-millet/mustard 3-4 times contour ploughing 2 times hoing and weeding	Fine loamy, acidic, thermic, deep to very deep, Ultic Haplustalf
2	Mahadev Khola	750 m	35%	South	Degraded sal forest (Shorea sp.)	Fine loamy, acidic, thermic, very deep, Ultic Paleustalf

Continue

Site	Location	Elevation a.s.l.	Steepness of site	Aspect	Land use/ management	Soil name
3	Baseri	780 m	16%	South	Maize-millet/mustard 3—4 times contour ploughing, 2 times hoing and weeding	Coarse loamy, thermic, shallow, Typic Ustochrept
4	Rachandanda	910 m	10%	North	Maize-millet/mustard 3—4 times contour ploughing 2 times hoing and weeding	Coarse loamy, thermic, deep, Ultic Haplustalf; red colour
5	Furkesalla	770 m	35%	South	Dense sal forest (Shorea sp.).	Coarse loamy, thermic, shallow, Lithic Ustochrept
6	Furkesalla	960 m	20%	South	Maize-millet/mustard 3—4 times contour ploughing 2 times hoing and weeding	Fine loamy, non acidic, thermic, moderately deep, Typic Ustochrept
7	Geragaon, office building	790 m	20%	North	Degraded sal forest (Shorea sp.).	Fine loamy, acidic, thermic moderately deep, Typic Haplustult
8	Budisera	770 m	35%	North	Dense sal forest (Shorea sp.)	Coarse loamy, acidic, thermic, moderately deep, Typic Haplustult.
9	Kothwok	1 150 m	20%	North	Maize-millet/mustard 3—4 times contour ploughing 2 times hoing and weeding	Coarse loamy, thermic, shallow, Typic Ustochrept
10	Jaisigaon	1 150 m	20%	South	Maize-millet/mustard 3—4 times contour ploughing 2 times hoing and weeding	Coarse loamy, thermic, very shallow, Typic Ustochrept
11	Chanpaboat	1 270 m	20%	North	Maize-millet/mustard 3—4 times contour ploughing 2 times hoing and weeding	Coarse loamy, thermic, deep, Dystric Ustochrept
12	Gurunggaon	1 600 m	20%	North	Maize-millet/mustard 3—4 times contour ploughing 2 times hoing and weeding	not sampled

4 Results and discussion

The microtopographic erosion features were recorded after each rainshower in the period of May 31 — June 16, 1994. For determining the comparative rain erosion hazard of the sites, a ranking of the indicator of erosion intensity has been made for the last observation date (Table 4).

Some Sal forest sites have a degraded open stand. All sites have either a north (N) or a south (S) exposition. Most sites have a topsoil texture of sandy loam (SL), some sites have a loam(L) or sandy clayloam(SCL) topsoil texture.

The sites of degraded Sal forest have the lowest erosion hazard. There is more sunlight on the soil surface and this allowes a more dense basal plant cover.

Table 4 Order of the sites from high to low erosion intensity, observed on 16-6-94

Site	Percentages of microtopographic features							Erosion intensity indicator and rank		Land use	Slope expo-sition	Top-soil tex-ture
	resistant clods	eroding parts	flow paths	pre-rills	rills	depre-ssions	basal cover					
1	-	18	42	4	34	2	-	118	12	maize	N	SL
10	-	28	32	-	40	-	-	112	11	maize	S	SL
6	-	24	47	-	30	-	-	107	10	maize	S	SCL
4	-	22	50	-	28	-	-	106	9	maize	N	L
11	-	30	34	-	34	2	-	102	8	maize	N	SL
5	-	24	54	16	6	-	-	98	7	Sal forest	S	-
3	-	34	38	-	28	-	-	94	6	maize	N	SL
9	-	22	50	-	22	6	-	94	5	maize	N	SL
12	-	32	36	-	28	4	-	92	4	maize	N	-
8	-	22	65	4	-	-	9	73	3	Sal forest	N	SL
7	-	13	57	2	1	-	27	63	2	degraded	N	SL
2	-	9	41	4	6	-	40	61	1	degraded	S	L

There appears a tendency that on southernly exposed slopes the erosion is stronger. This is confirmed by the research of Shrestha (2000).

Site 5 has an exceptionally high amount of flow area.. It is the only soil profile that has a lithic contact within 50 cm. It has limited incision and increased overland flow.

The organic matter content shows a negative correlation with the observed erosion intensity (Spearman rank correlation coefficient R= 0.61*). The crusting index (FAO 1983) shows a positive rank correlation with the erosion intensity (0.48*); it indicates that crusting of the sandy loam soils was important for the erosion development. Excluding the only site with a topsoil texture of sandy clayloam, the rank correlation becomes 0.71**.

5 Conclusions

(1) Soil erosion hazard on the maize-millet sites was various, partly due to different soil surface texture of the sites. Under dense Sal forest the hazard was lower; crown canopy, a seasonal litter layer and a good permeability limit the erosion.. The erosion hazard is lowest on sites with degraded Sal forest; these sites have a substantial basal plant cover.

(2) The organic matter content shows a negative correlation with the observed erosion intensity.

(3) The erosion intensity derived from microtopographic features had correlation with the Crusting index. This indicates that crusting of the sandy loam soils was important for the erosion development.

References

Bergsma E. 1992
Features of soil surface micro-topography for erosion hazard evaluation, p.15-26 in: Hurni H. & Kebede Tato eds. 1992, Erosion, conservation and small-scale farming, selection of papers presented at the 6th International Soil Conservation Organisation(ISCO) conference, Ethiopia and Kenya, 1989.

Bergsma E. 1997
Rain erosion hazard evaluation by soil surface micro-topographic features - A case of the soil loss plots at Chiang Dao experiment station, northern Thailand, in “Land Husbandry – the International Journal of Soil and Water Conservation” vol **2**, 1:45-58.

Bergsma E. & F.J.P.M.Kwaad 1992
Rain erosion hazard evaluated from soil surface features as well as from soil loss, p.25-35 in: People protecting their land. Proceedings 7th Conference, International Soil Conservation Organisation

(ISCO) conference, under the auspices of the Department of Conservation and Land Management, Sydney, Australia, 1992.

Bergsma E. 1999

Erosion intensity evaluated from micro-topographic soil erosion features, and its correlation with conservation practices, presence of fertiliser, and the erosion development between contour hedges; data of Doi Thung, northern Thailand. To be published in the Proceedings of the Tenth International Soil Conservation Organisation (ISCO) Conference, Purdue, 1999.

de Bie C.A.J.M. 2000

Comparative performane analysis of agro-ecosystems. Doctoral Thesis, Wageningen University, the Netherlands.Chapter 11: Soil erosion indicators for maize-based agro-ecosystems in Kenya.

FAO 1983

Guidelines: Land Evaluation for rainfed agriculture. FAO Soils Bulletin 52. Rome.

Kunwar L.B. 1995

Study of the relationship between land use and soil erosion hazard, using simple erosion field tests, surface microtopographic features and remote sensing data; a case study in the Likhu Khola watershed, Nepal. MSc Thesis, Soil S Cience Division, International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede, the Netherlands.Shrestha, D. P., 1997.

Assessment of soil erosion in the Nepalese Himalaya: A case study in Likhu Khola valley, Middle Mountain Region. Land Husbandry, **2**,(1): 59-80.

Shrestha, D. P., 2000.

Aspects of erosion and sedimentation in the Nepalese Himalaya.Doctoral thesis, Ghent University, Ghent, Belgium, p. 265.