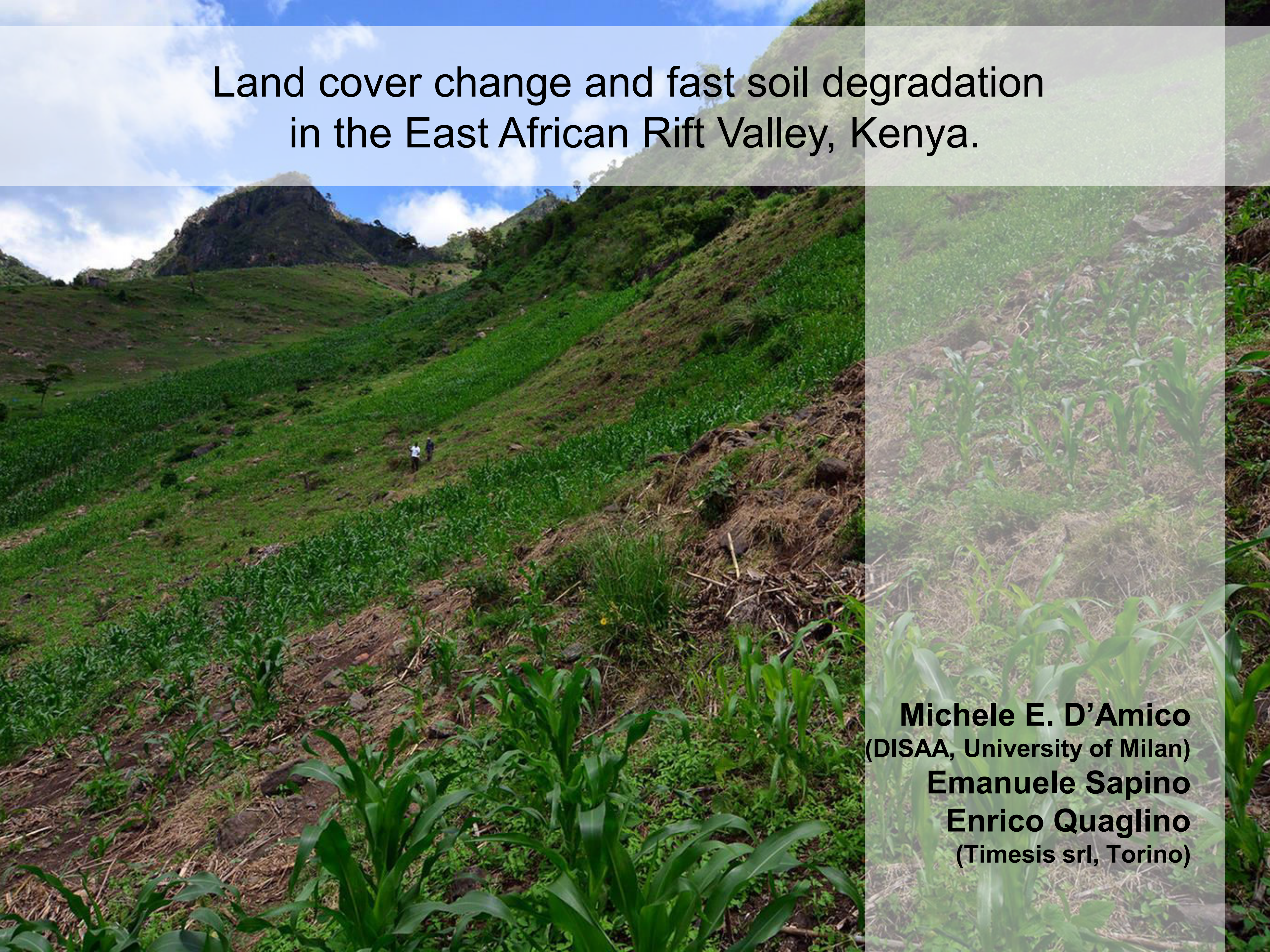
Land cover change and fast soil degradation in the East African Rift Valley, Kenya.



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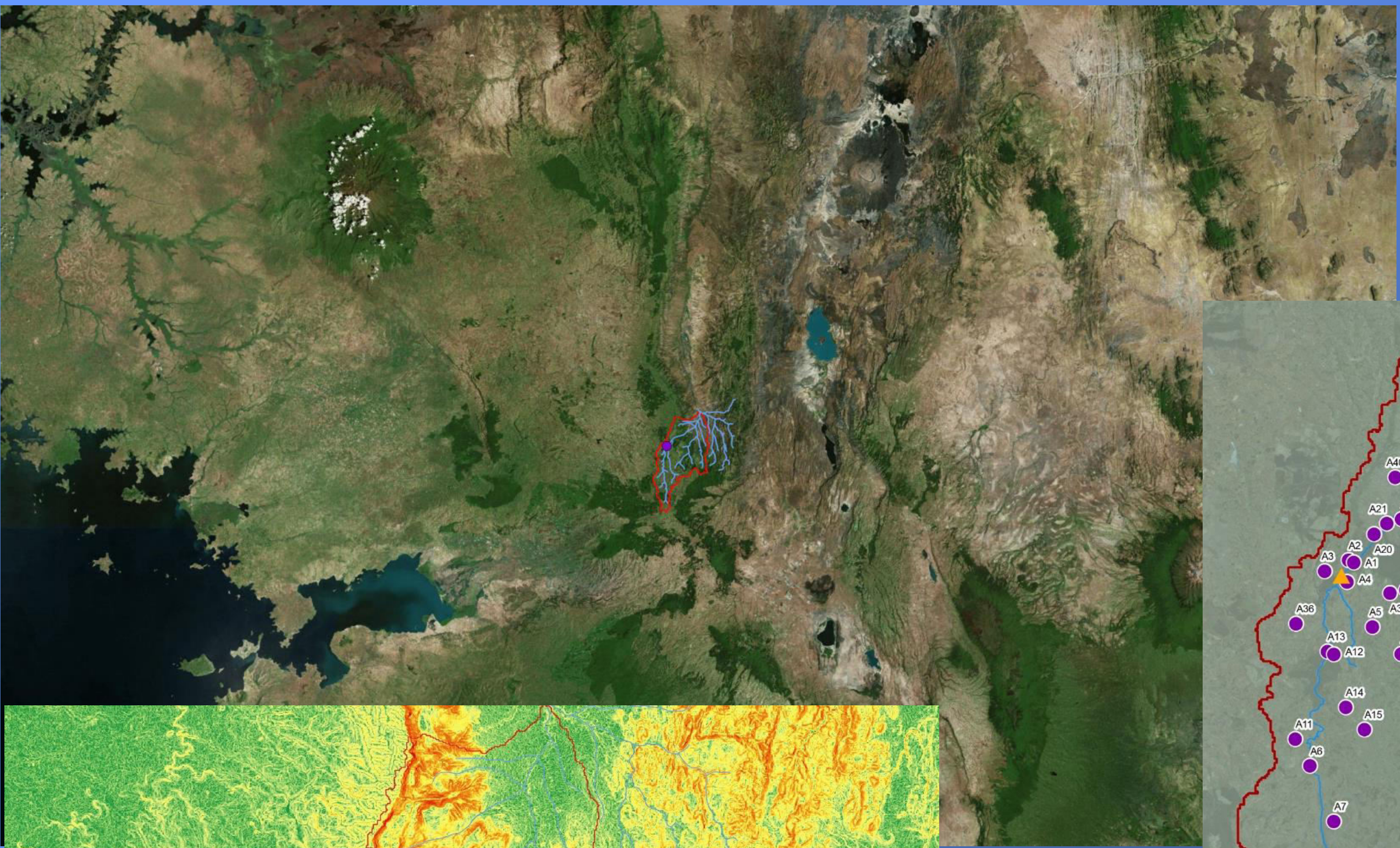
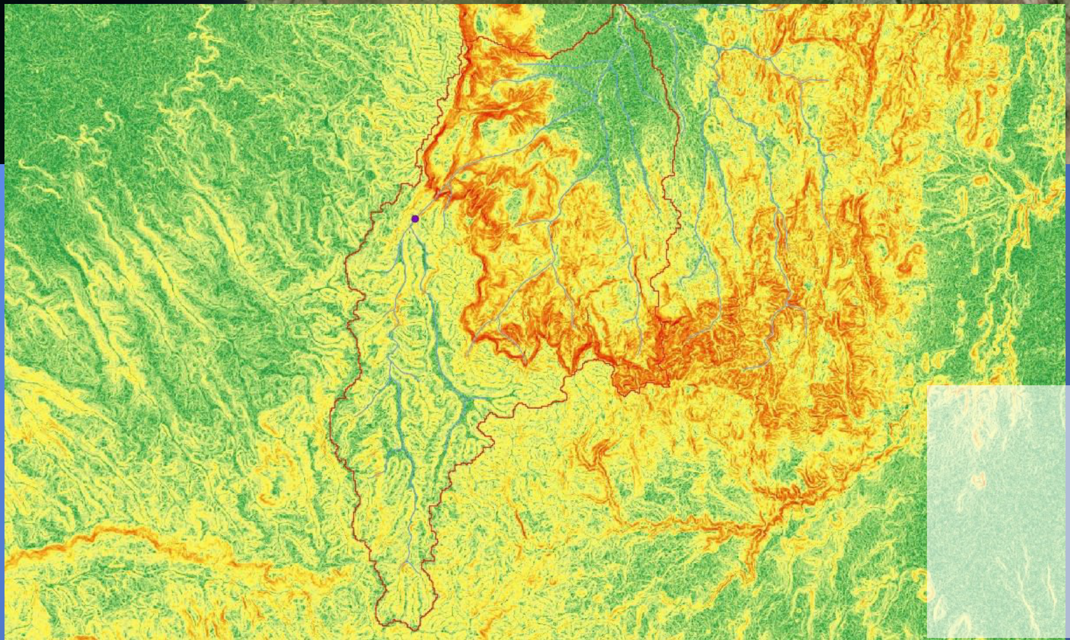
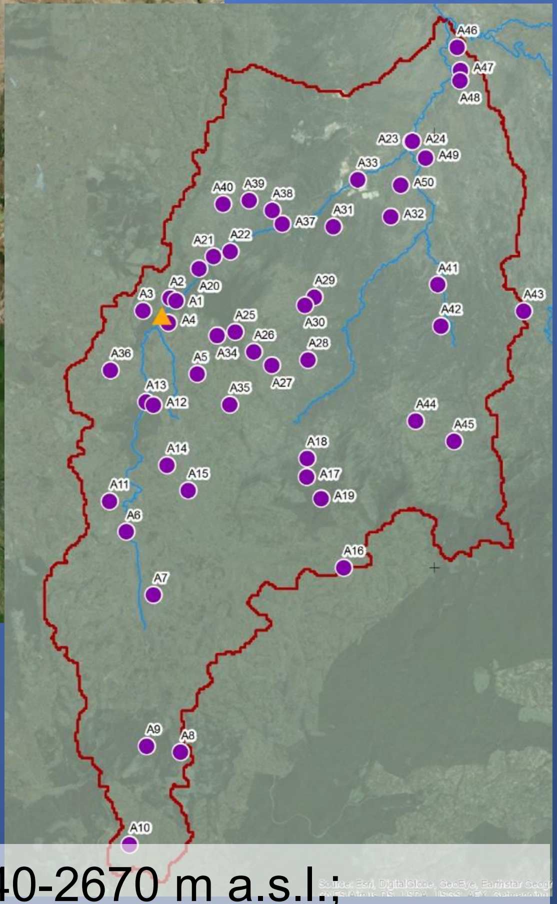
Study area

Kimwarer basin / Elgeyo-Marakwet district, Eastern branch of the Rift valley, Kenya.



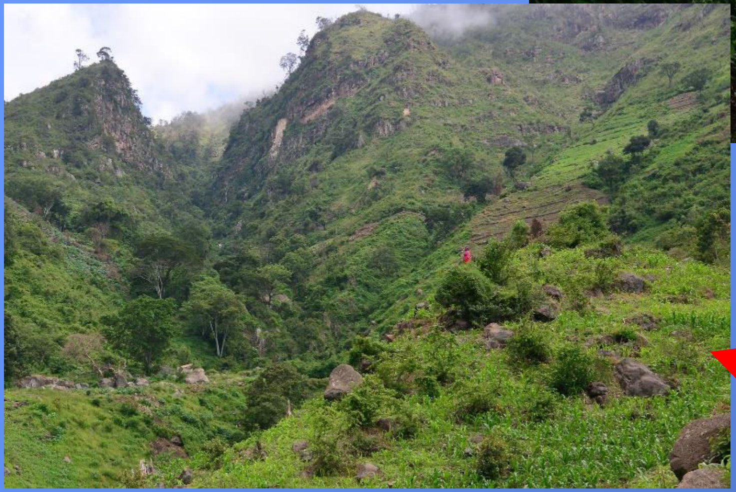




Alt: ca. 1140-2670 m a.s.l.;

MAP: ca. 1200-2500 mm

50 soil sampling sites



Rainforest and pastures on the high plateau

Rainforest on the high escarpment

Deforested steep slopes on the mid-escarpment

Crops and deciduos acacias on the low escarpment

Desertification on the Kerio Valley floor

The Kerio Valley floor includes floodplains and low-steepness alluvial fans; the potential Acacia savannah has been mostly substituted by corn crops, later abandoned because of extreme soil erosion, resulting in a semi-desert habitat

15 soil types, the most common are:

Ferralsols on the high plateau

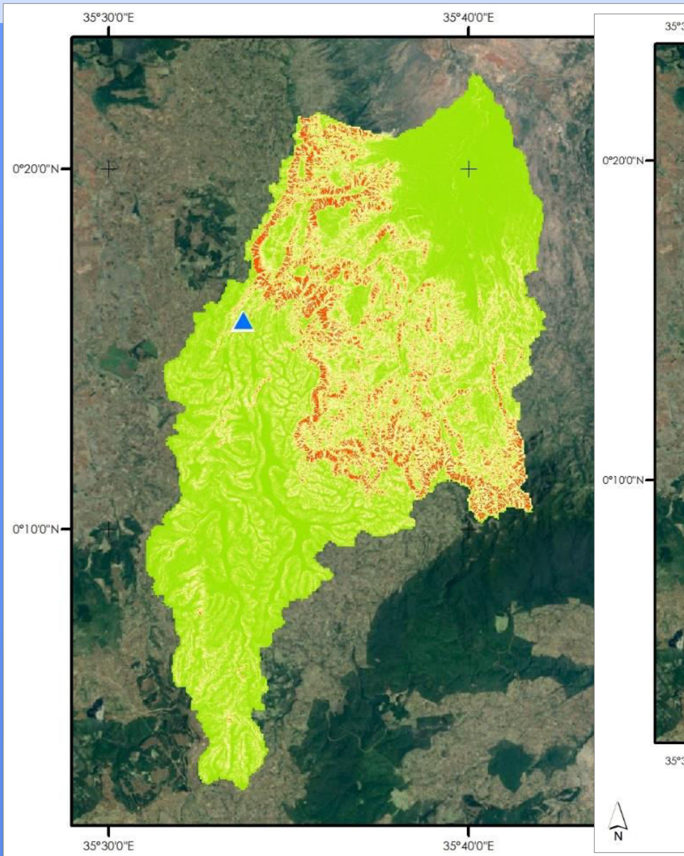
Umbrisols under montane rainforest on the high escarpment

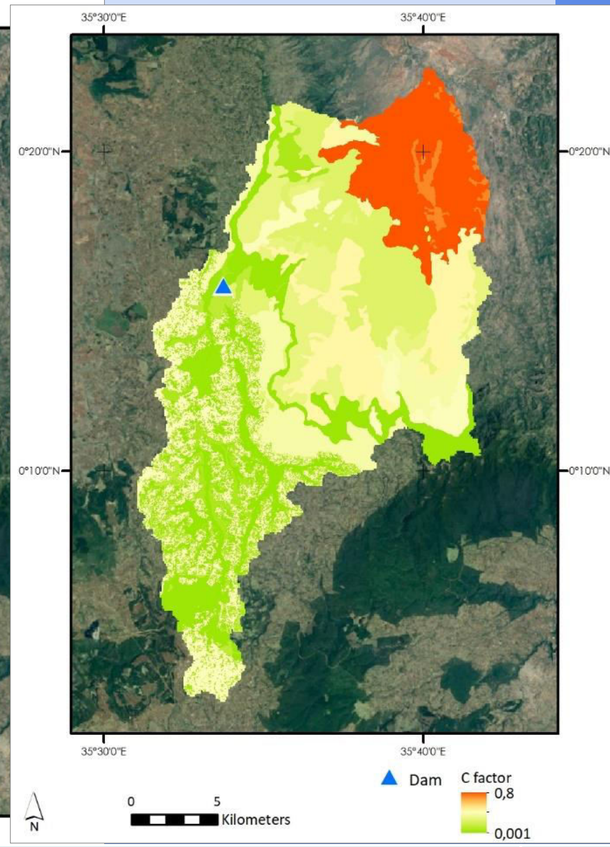
Phaeozems and Vertisols on recently deforested steep slopes on the mid-escarpment

Kastanozems on the low escarpment

Eroded Vertisols and lateritic crusts with Leptosols on the Kerio Valley floor

RUSLE factors





A = R*K*LS*C*P

A = estimate of soil loss (t ha^{-1} y^{-1});

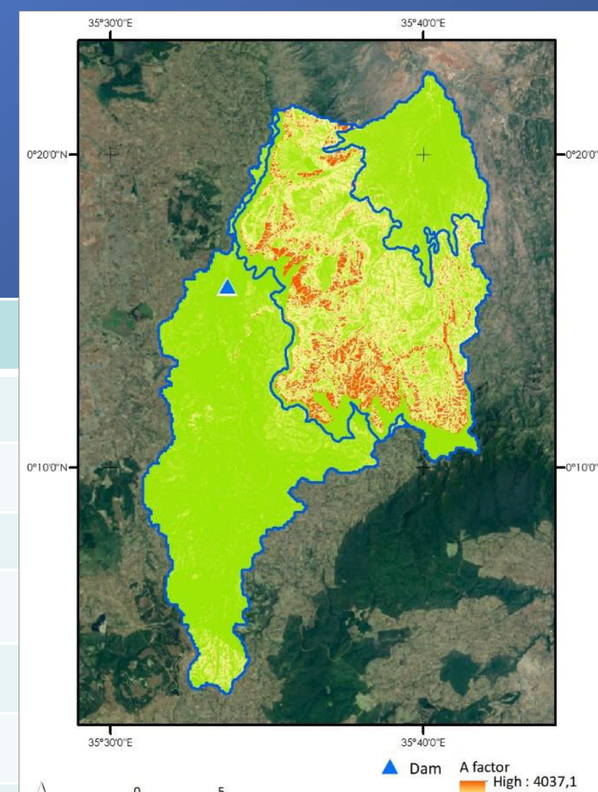
R = rainfall erosivity (MJ mm h^{-1} ha^{-1} y^{-1});

K = soil erodibility (t ha h ha^{-1} MJ^{-1} mm^{-1}), which depends on soil organic matter and texture;

LS = topographic, Slope-Length factor (adimensional);

C = soil cover factor (estimated, adimensional);

P = soil protection/management factor



Equation number	Original location data	Equation	Author
1	Inland Kenya, <1250 m a.s.l.	$R = 17.02 * (0.029 * (11.36 * P - 701) - 26)$	Moore (1979)
2	Inland Kenya, >1250 m a.s.l.	$R = 17.02 * (0.029 * (3.96 * P + 3122) - 26)$	Moore (1979)
3	Ugandan Plateau	$R = 17.02 * (0.029 * (16.58 * P - 6963) - 26)$	Moore (1979)
4	East Africa	$R = 117.6 * 1.00105^{Pa}$ (P < 2000mm) $R = 0.5 * P$ (P > 2000mm)	Kassam et al (1992)
5*	Africa	MFI=1/P*Σpi^2 R=50.7*MFI-1405	Vrieling et al. (2010)
6	Africa	FI=pi^2/P	Vrieling et al. (2010)

Kerio Valley soils almost completely eroded in the last decades (comparing with the study performed in 1996), their potential erodibility is intermediate; the crucial factor involved in the extreme soil loss are probably related with land cover.

$$K = (0.00021 * M^{1.14} * (12 - OM) + 3.25 (STR - 2) + 2.5 (PER - 3)) / (7.59 * 100)$$

where:

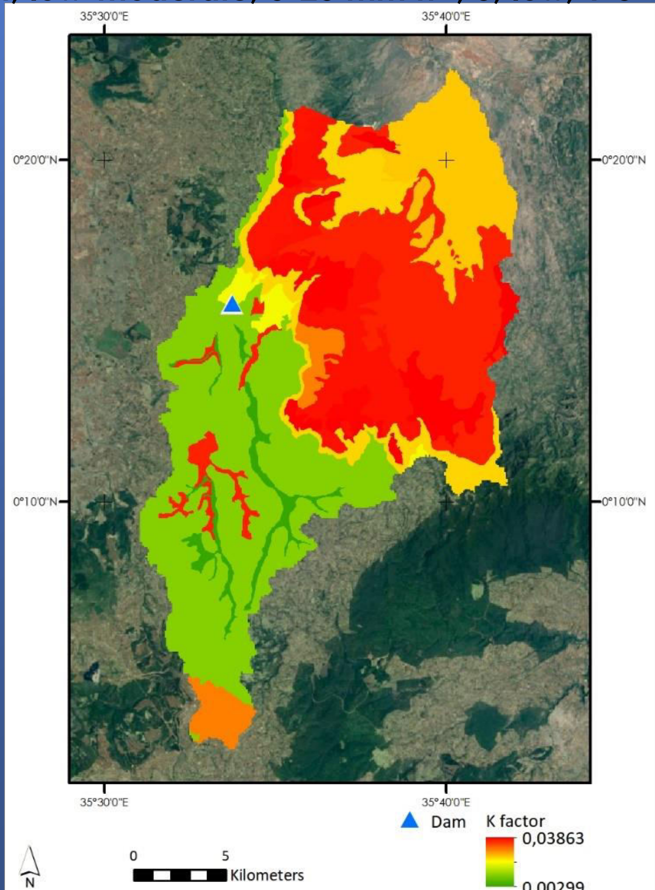
M = (silt % + very fine sand %) x (100 - clay%);

OM = organic C% * 1.72, percent organic matter;

STR = structure code based on shape and dimension of aggregates in the topsoil: (1) very fine, <1 mm; (2) fine granular or blocky, 1-2 mm; (3) medium granular or blocky, 2-5 mm and coarse granular, 5-10 mm; (4) very coarse granular, columnar, coarse blocky or platy, or massive, >10 mm);

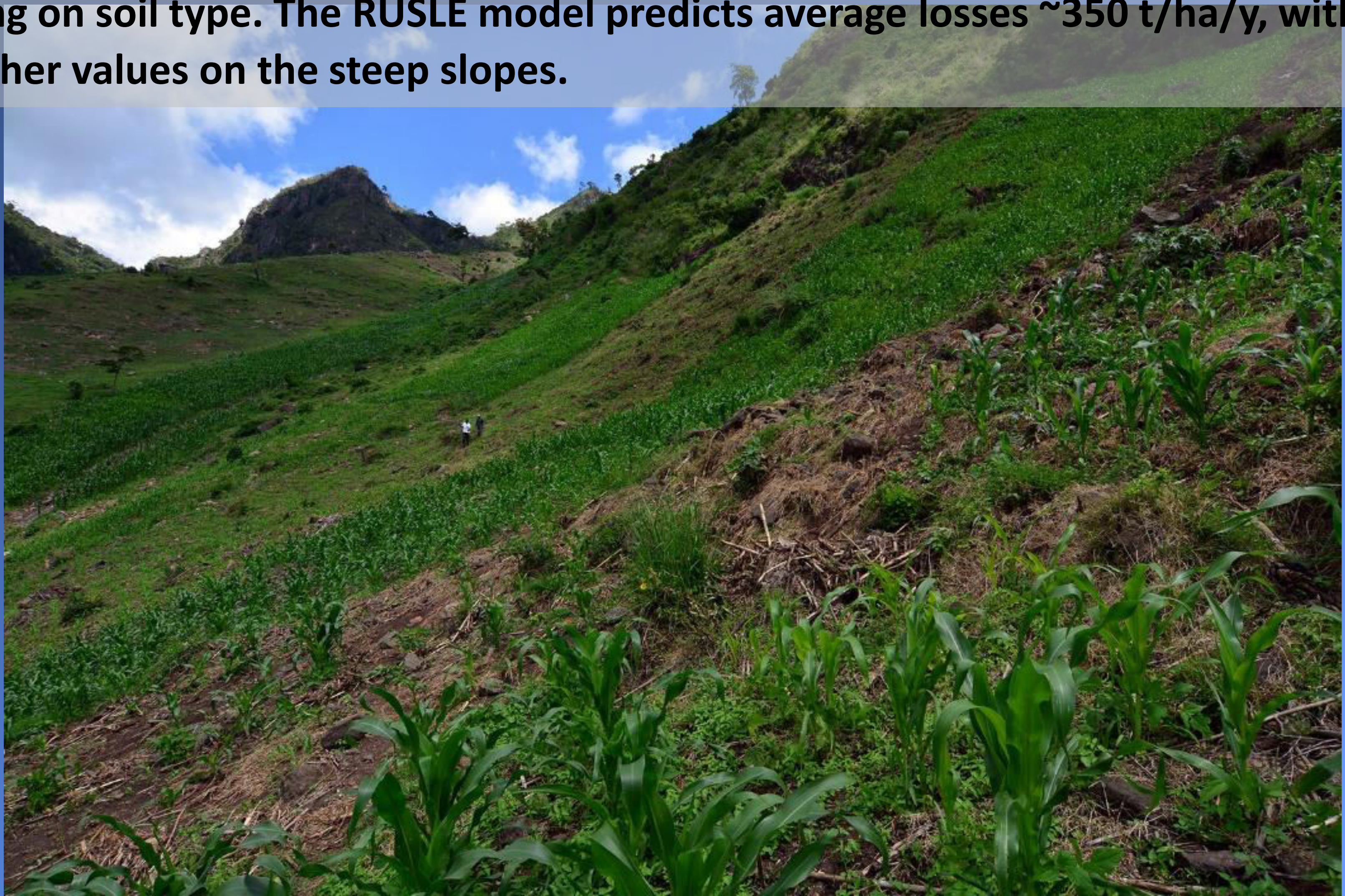
PER = the profile permeability class: 1 – high, >130 mm h^{-1}; 2 high-moderate, 60-130 mm h^{-1}; 3, moderate, 20-60 mm h^{-1}; 4, low-moderate, 5-20 mm h^{-1}; 5, low, 1-5 mm h^{-1}; very low, <1 mm h^{-1}.

Soil classification	M factor	clay	Organic matter %	K factor ($MJ^{-1} m\ m^{-1}$)
Skeletic Leptic Cambisol	3661.7	16.6	3.6	0.0386
Arenic Skeletic Fluvisol	4628	11.0	1.37	0.0434
Haplic Ferralsol	1893.78	48.43	10.22	0.0111
Haplic Lixisol / Acrisol	2676.13	43.00	3.75	0.0298
Mollic Gleysol	5667.48	9.00	17.56	0.0030
Calcic Skeletic Kastanozem (colluvic)	3037.42	36.5	4.46	0.0337
Skeletic Leptosol*	3280.64	26.87	3.42	0.0359
Rhodic Leptic Skeletic Luvisol (cutanic)	2459.57	42.00	6.91	0.0201
Leptic Nudiargic Rhodic Luvisol (ferric)	2825.06	42.00	4.69	0.0245
Vertic Skeletic Phaeozem (colluvic)	4452.96	25	5.69	0.0371
Skeletic Cambic Phaeozem	3729.54	26.75	3.24	0.0376
Haplic Plinthosol (Leptic)	2490.72	39.5	3.68	0.0325
Haplic Regosol	2953.72	22	2.34	0.0369
Cambic Umbrisol	3340.80	36.00	7.16	0.0238
Calcic Vertisol	1327.04	56.00	0.91	0.0253



Land-use change in the Kerio Valley floo happened during the ‘80s, when local people moved from pastoralism to agriculture; original Acacia savannah was disrupted by ploughing to permit cropping. Soil maps performed during that period describe soils as Ferralsols, with rooting depth limitations by lateritic crusts below 1-2 m. At present, the lateritic crust outcrops over large surfaces, and 2-5 m deep, 10-20 m large gullies cover >50% of the surface. The cultivations are thus being abandoned. The soil loss might be estimated conservatively ~100 t/ha/y; this is an extremely high value considering the almost flat surface. The average soil loss calculated by an adapted RUSLE method is 51 t/ha/y; there is an important underestimation by the model.

On the slopes of the escarpment, deforestation happened mostly after 2010, as visible from aerial photos. Umbrisols with thick A horizons are dominant under natural vegetation, but are not observed in deforested areas, evidencing a fast loss of the 30-50 cm A horizon (>320 t/ha/y). Deeper, less resistant horizons are exposed, and rills, gullies and mudflows develop after most rainstorms, with variations depending on soil type. The RUSLE model predicts average losses ~350 t/ha/y, with much higher values on the steep slopes.



The rainfall erosivity-R factor is high in tropical areas, and a preservation of a vegetation cover is necessary to impede a complete soil loss in just a few years. It is also extremely important to preserve the surface, organic-matter rich soil horizons, influencing soil erodibility-K factor