Soil erosion risk in the Gatumba Mining Sector

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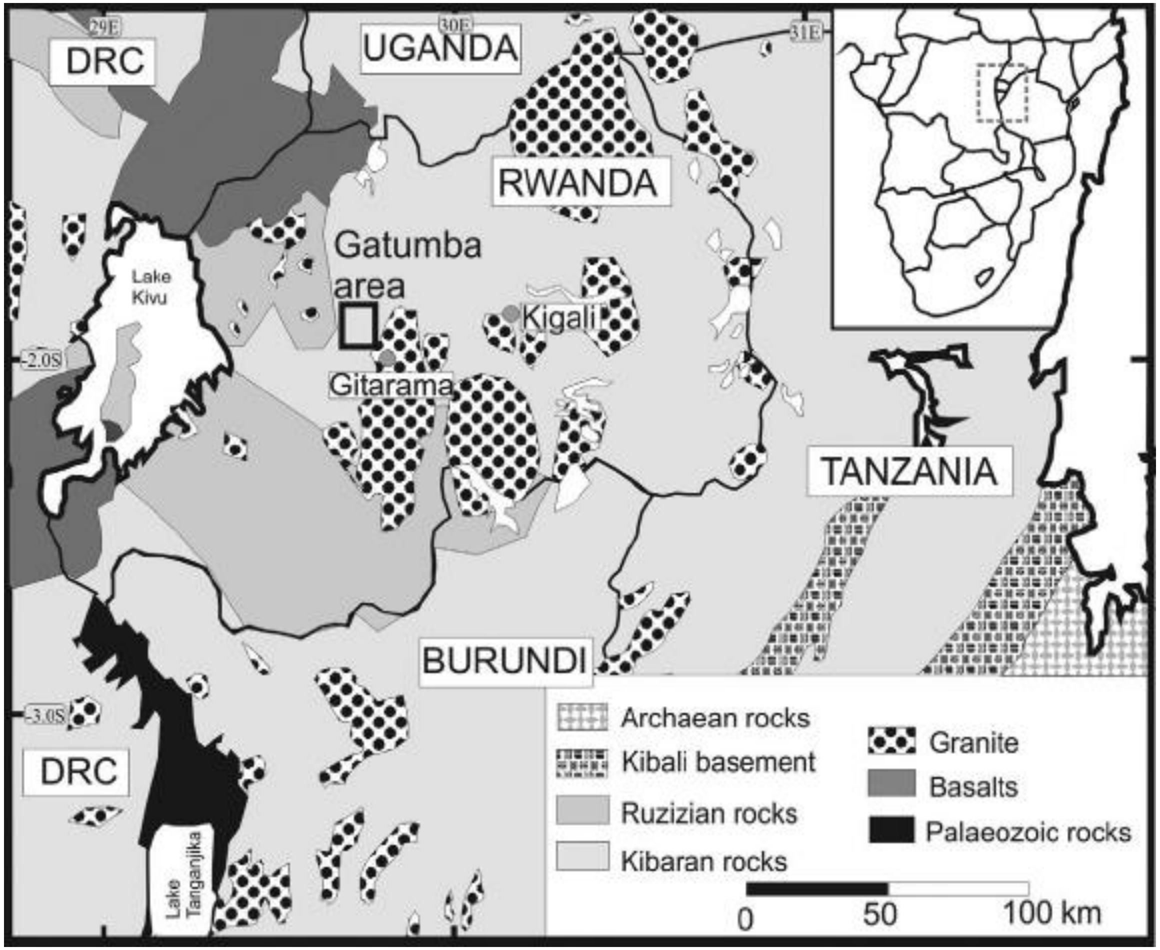
Outline

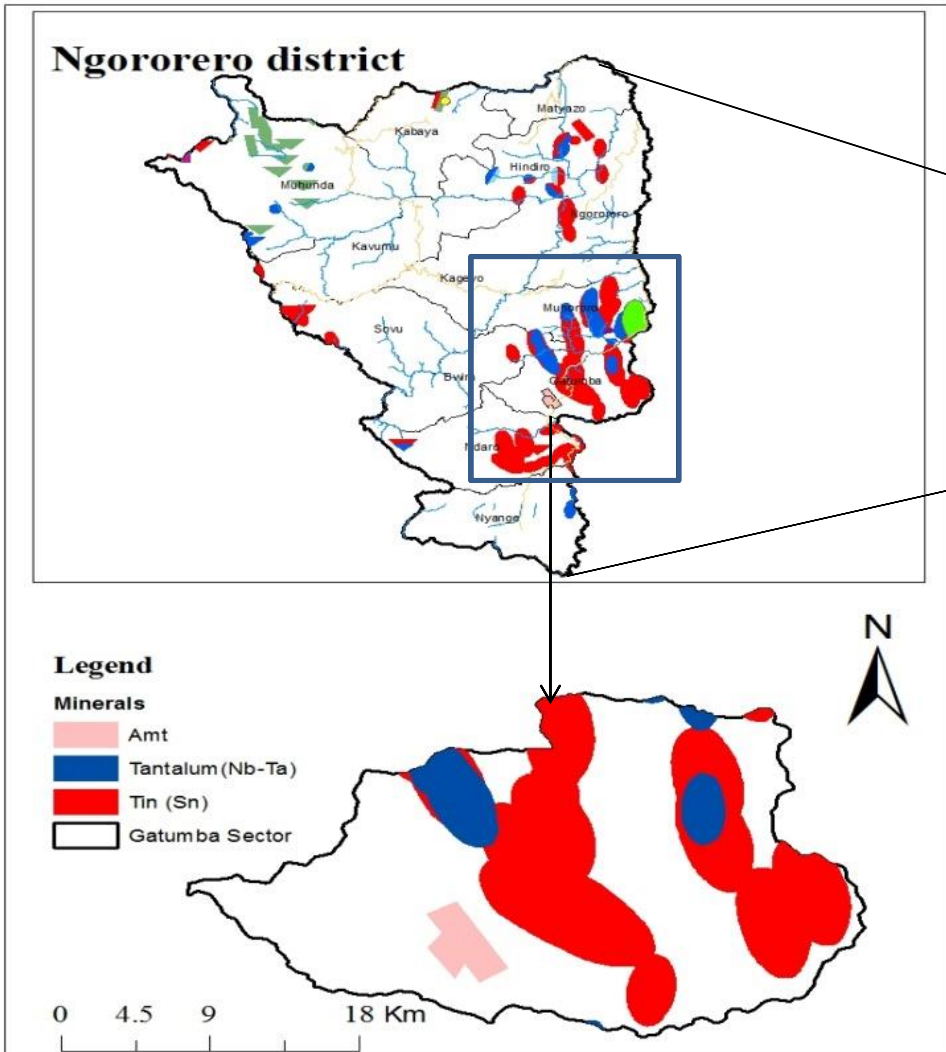
Study area

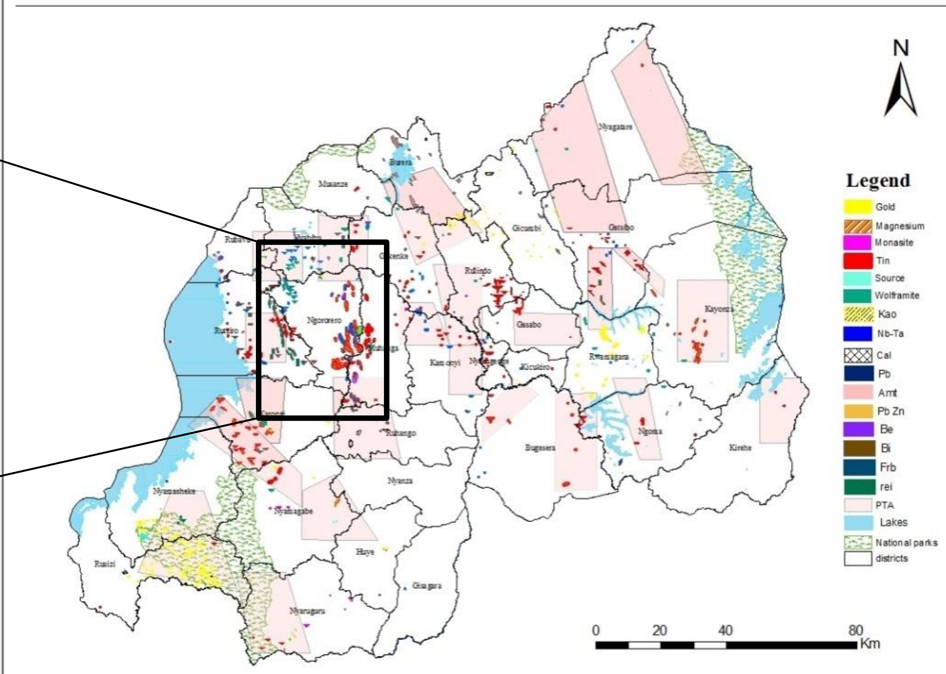
Gatumba area on the simplified geological map of Rwanda



Minerals

Cassiterite (tin ore), Niobo-tantalite (tantalum and niobium ore, locally called coltan), Wolframite (tungsten ore), Tourmaline, Beryl, Amblygonite, Spodumene, Apatite Li-phosphates.





Largest deposits of coltan and cassiterite in Gatumba

Types – Characteristics of ASM

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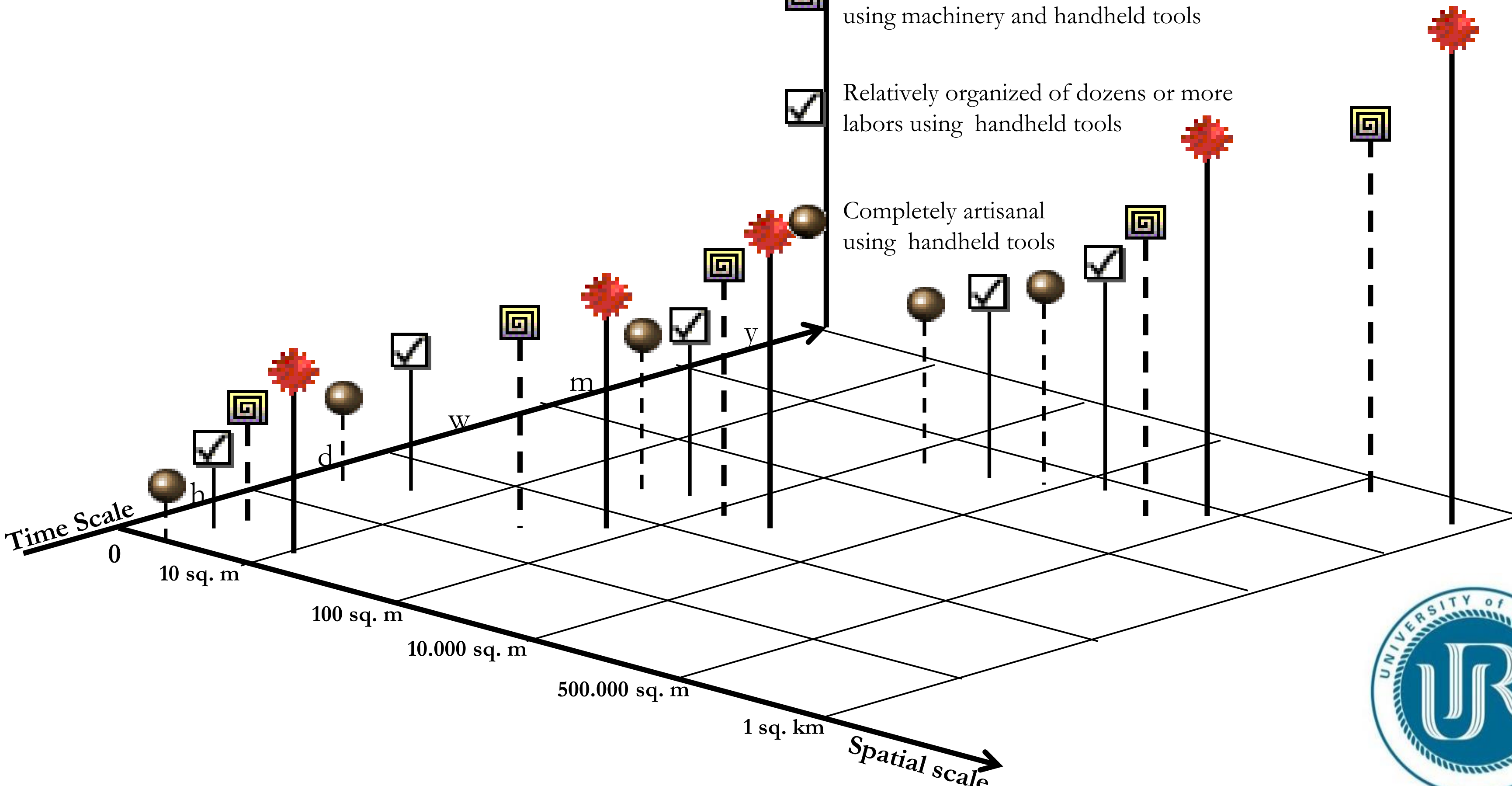
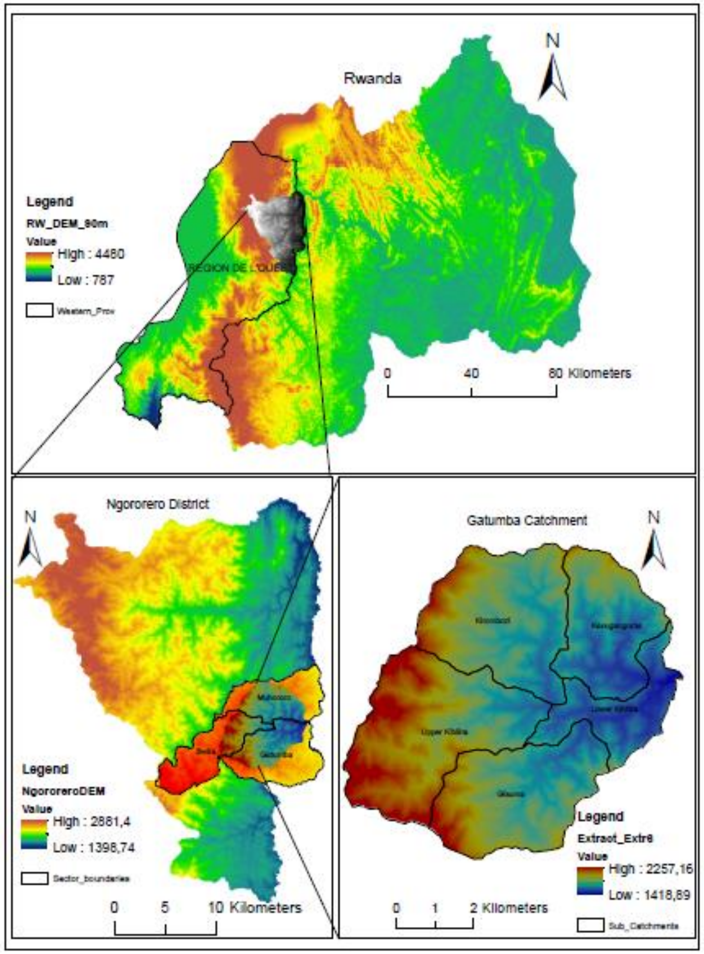
Techniques used in ASM by relating them to a relative time frame of mining operation and the extent of land that is involved or disturbed.

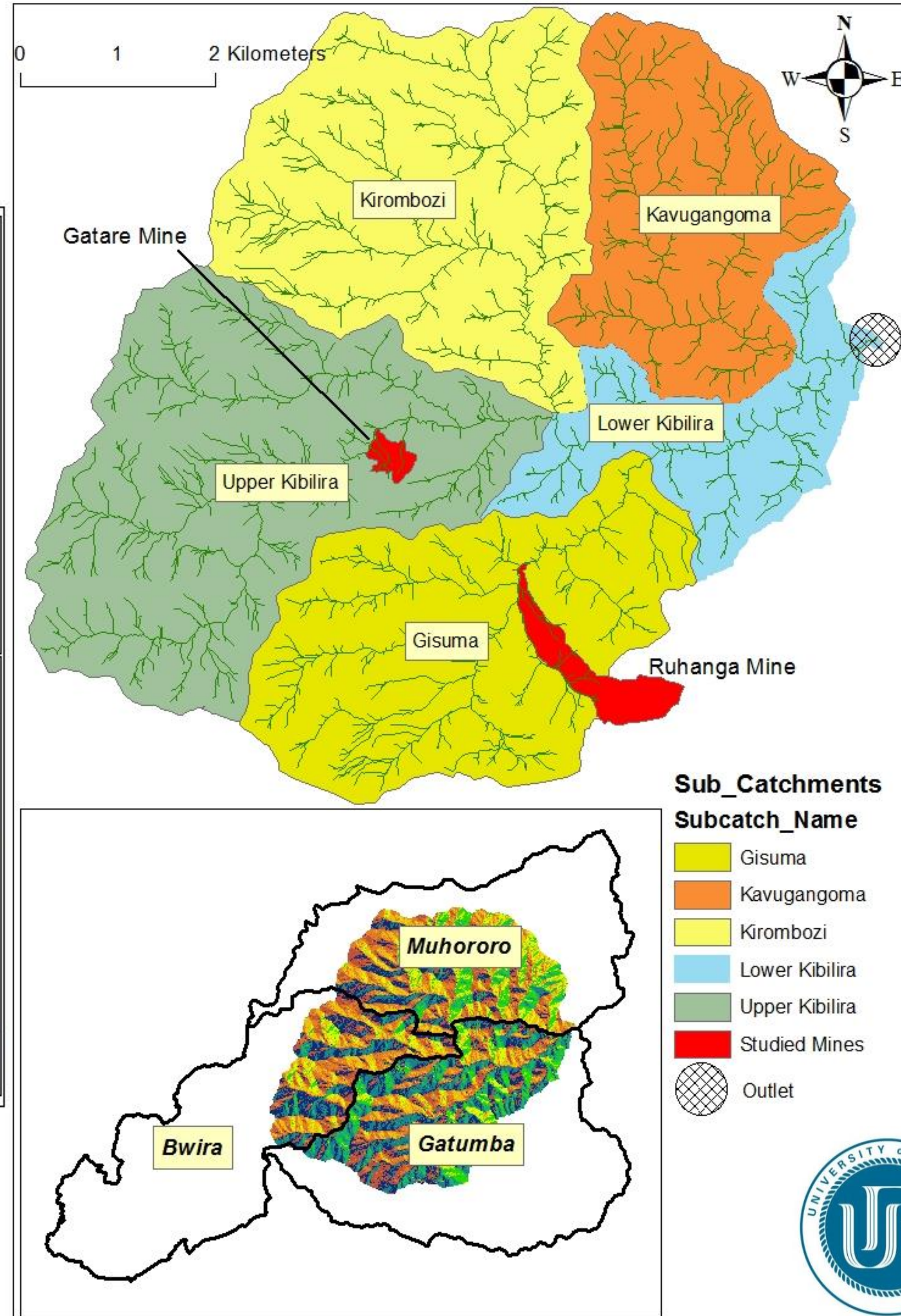


Coexistence/competition between mining and agriculture

Material and Methods

sub-catchments of the Gatumba watershed

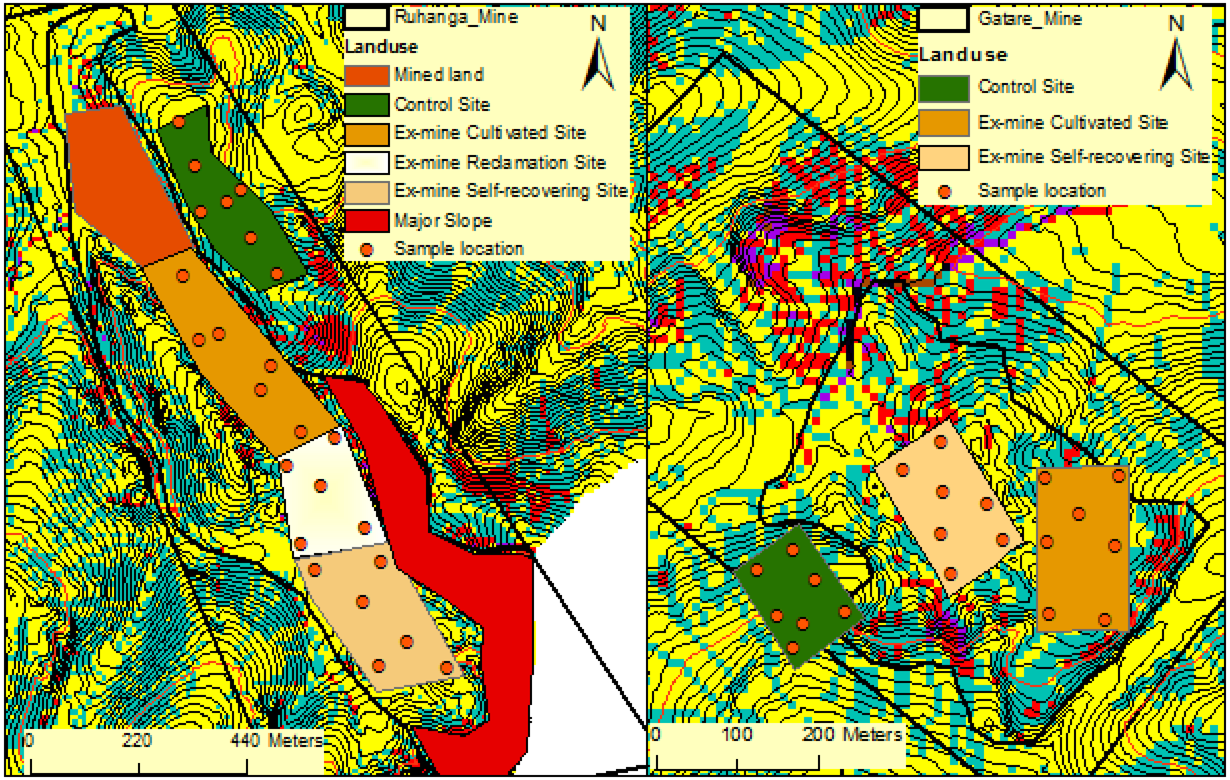




Analysed parameters & Methodologies

Parameters	Method
Soil texture	Hydrometer method (*Gee* and *Or* 2002)
Org Matter Content	UV spectrophotometer colorimetry after the standard wet chemistry technique (*Tiessen* and *Moir* 1993)
Aggregate stability	Wet sieving method (*Angers* and *Mehuys* 1993)
Interpolation Krigging	Climate data over 30 years -Thornthwait method and drought Indices (*Peguy*, 1970)
Slope analysis	DEM of the area (in GIS-based analysis)
Soil Erosion Risk Assessment	GIS - based RUSLE modeling using OM & P (support practice) scenarios (*Renard* 1997)

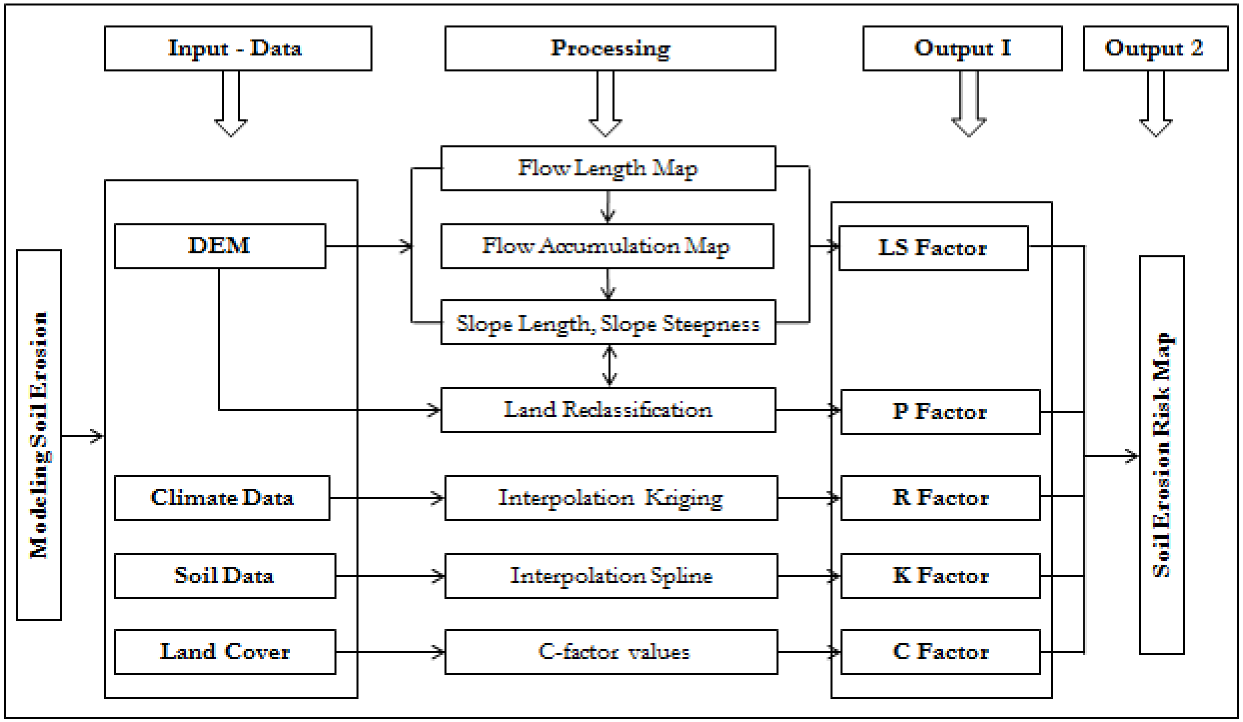
Sketch of land use **c**lasses and sampling sites in Ruhanga and Gatare Mines



Sketch of land use **c**lasses and sampling sites in Ruhanga and Gatare Mines

Soil erosion modelling: RUSLE

$$A = R \times K \times LS \times P \times C$$



Flowchart of soil erosion modelling

A (t ha^{-1} yr^{-1}): the computed spatial average of total soil loss per year,
R (MJ mm ha^{-1} hr^{-1} yr^{-1}): the rainfall erosivity,
K (t ha^{-1} per unit R): the soil erodibility factor,
LS the slope length and steepness factor (dimensionless),
P the erosion control - conservation practice factor (dimensionless),
C the land surface cover management factor (dimensionless).

Statistical outputs of soil texture, OM and SSA in topsoil layer and subsoil layer of mines (n: 44/44)

	Topsoil (0-30cm)					Subsoil (30-60cm)				
Sta. Param	Clay (%)	Silt (%)	Sand (%)	OM (%)	SSA (%)	Clay (%)	Silt (%)	Sand (%)	OM (%)	SSA (%)
Mean	31.94	21.03	47.03	1.77	8.11	34.94	19.58	45.48	1.46	7.95
Std. Dev	2.55	1.36	2.23	0.15	0.50	2.51	1.29	2.15	0.10	0.53
Median	36.00	19.00	44.00	1.62	9.22	38.00	18.00	42.00	1.47	8.10
Std. Error	14.66	7.79	12.83	0.86	2.86	14.40	7.41	12.34	0.55	3.07
Sample Variance	215.06	60.72	164.53	0.75	8.17	207.50	54.88	152.38	0.31	9.43
Kurtosis	-1.04	1.76	0.58	2.23	-0.34	-0.92	2.64	0.16	-0.83	-0.63
Skewnis	-0.52	1.25	0.92	1.16	-0.38	-0.55	1.47	0.86	0.20	0.01
Range	45.00	35.00	52.00	4.03	12.27	47.00	33.00	50.00	1.91	11.79
Minimum	6.00	9.00	30.00	0.57	0.7	8.00	11.00	28.00	0.64	1.84
Maximum	51.00	44.00	82.00	4.60	13.04	55.00	44.00	78.00	2.55	13.64
Confidence Level	5.20	2.76	4.55	0.31	1.01	5.11	2.63	4.38	0.20	1.09

Ex-mine cultivated site

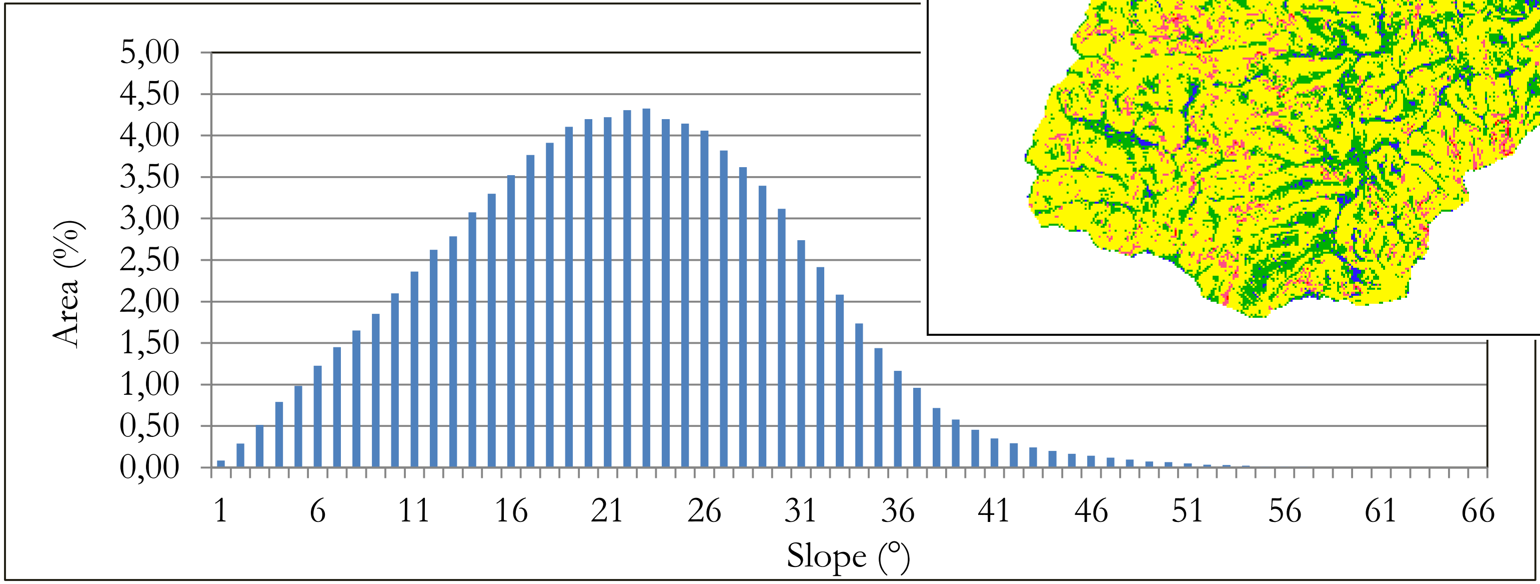
Ex-mine reclamation site

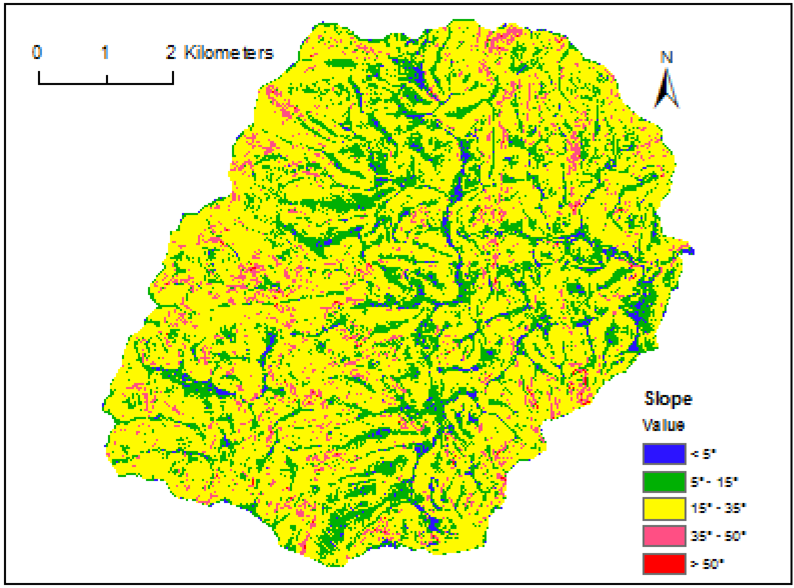
Ex-mine self-recovering site

Ongoing mining site

Results

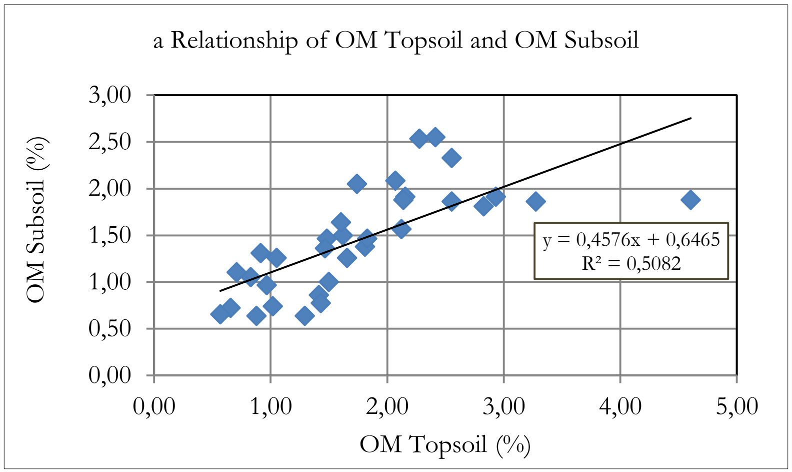
1. Slope Classes of the Gatumba watershed

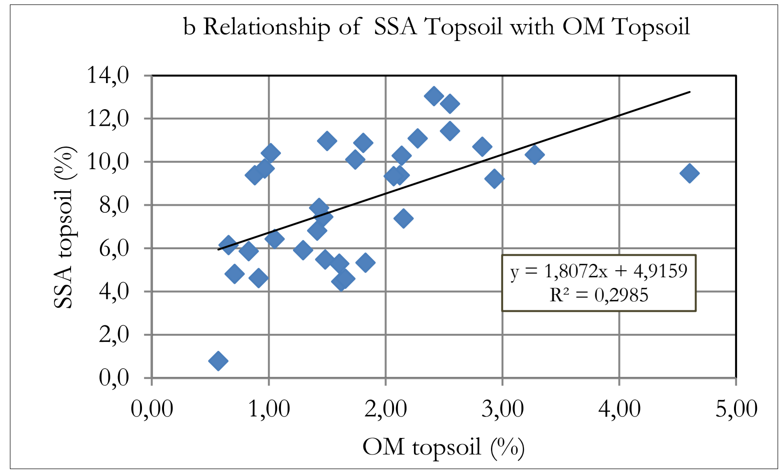


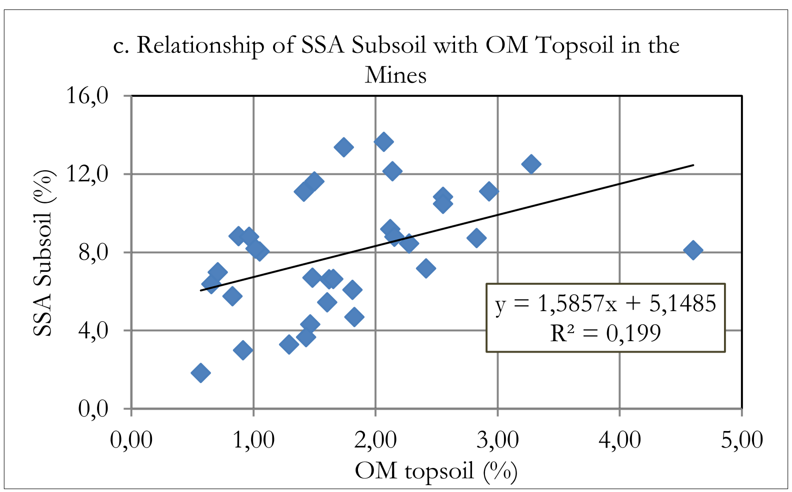


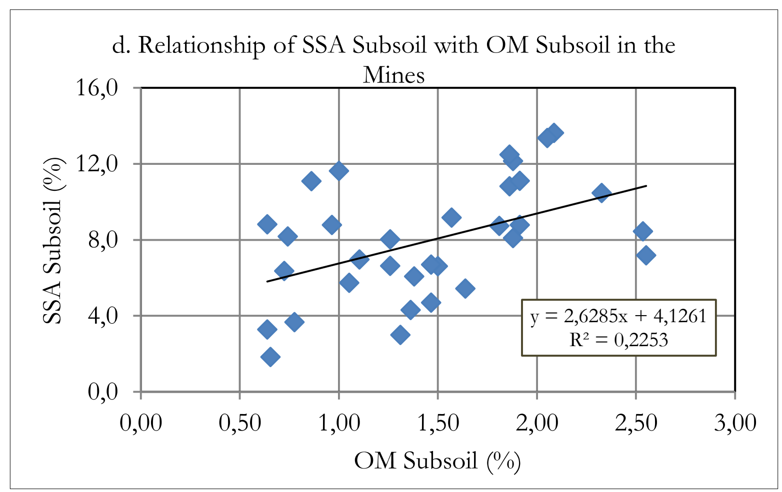
Slope Class (°)	Total Area (ha)	% Total Slope
0-15	1679.11	28.6
15 -35	4043.3	66.8
>35	272.95	4.6
Total	6004.9	100

Relationship of SSA with OM in the topsoil and subsoil layers

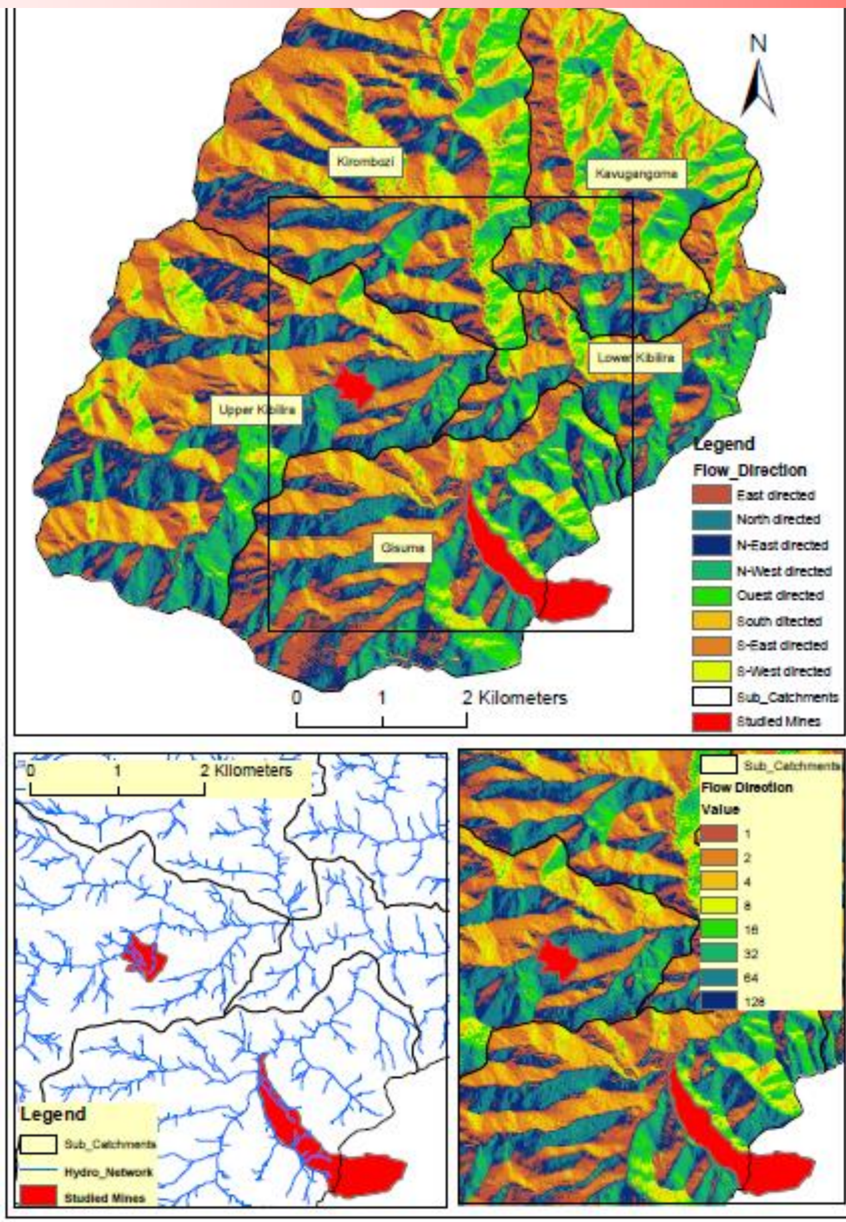




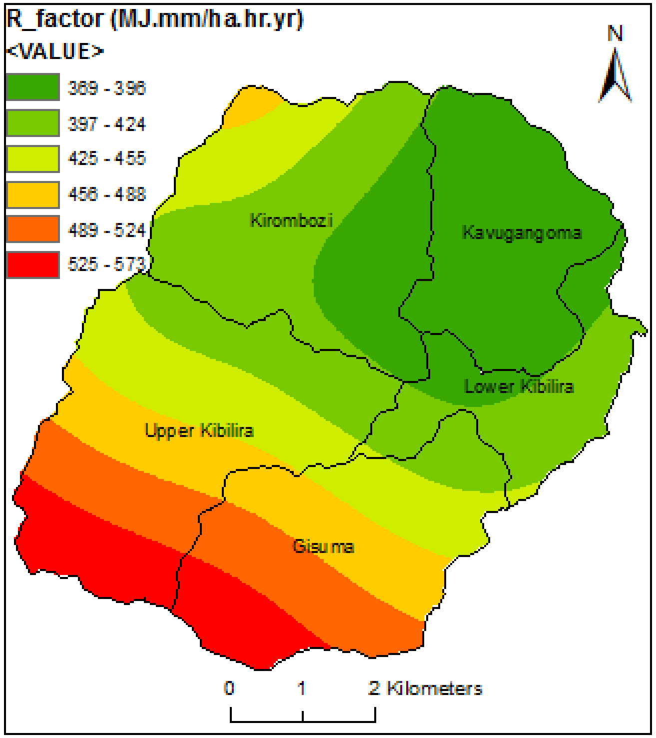




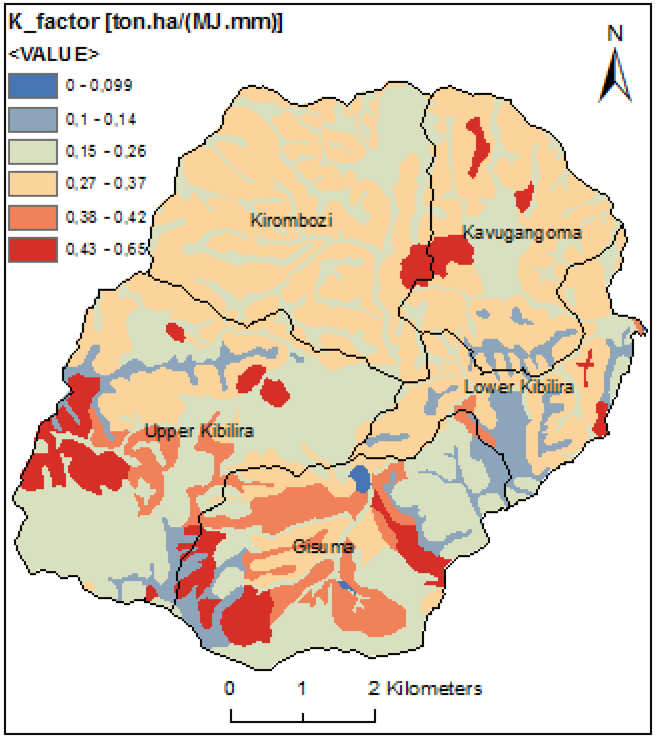
Flow direction



R Factor and K Factor

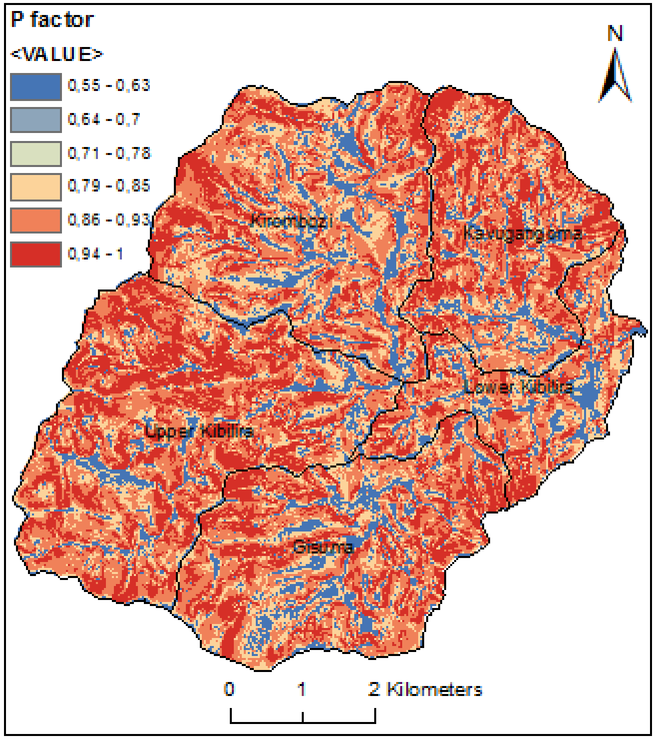


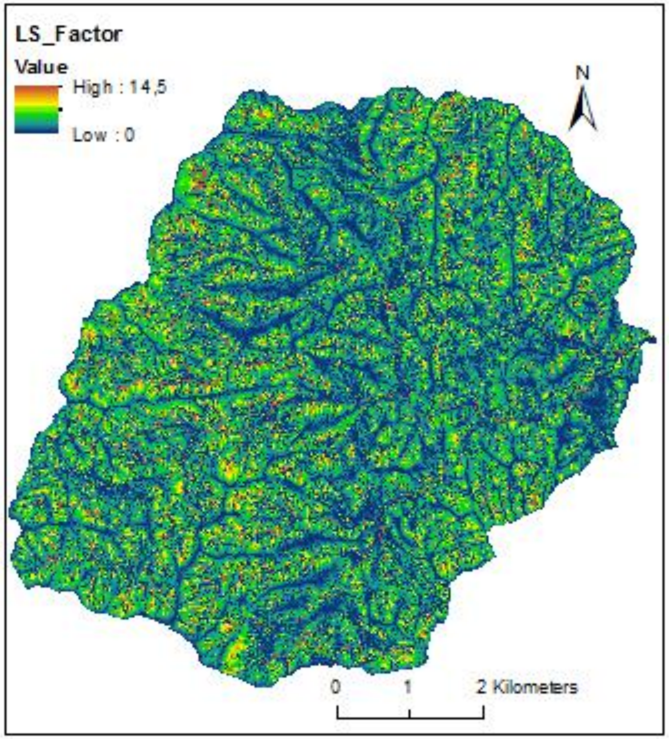
R factor Map of Gatumba watershed



K factor Map of Gatumba watershed

P Factor and LS Factor

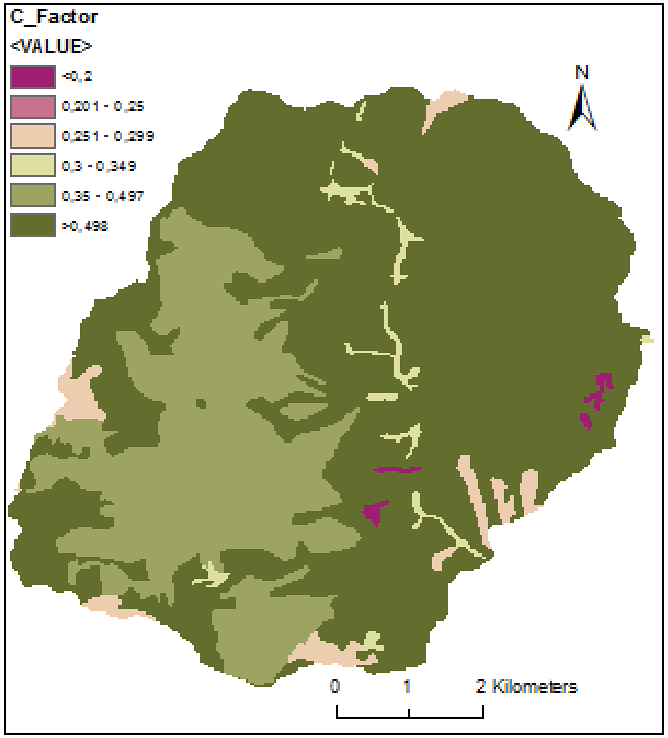


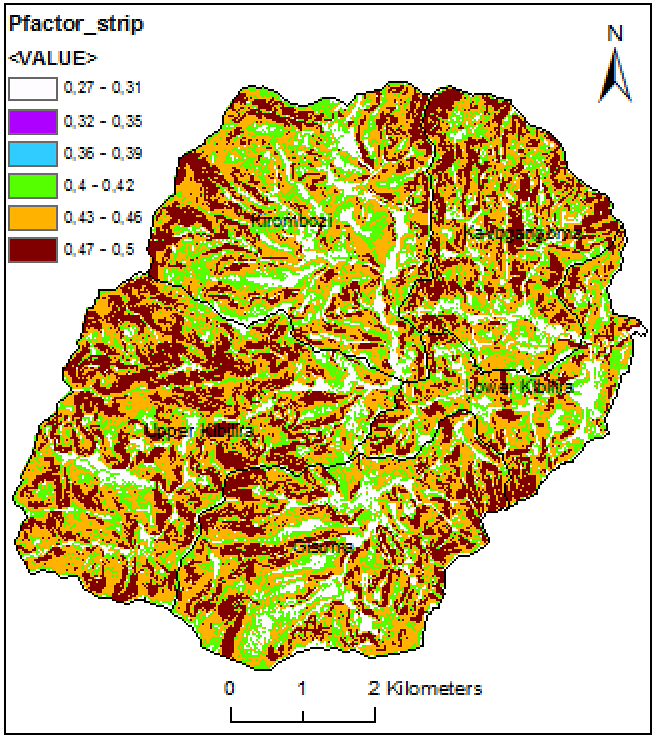


P factor Map with Strip cropping

LS factor Map

C Factor and P Factor_Strip

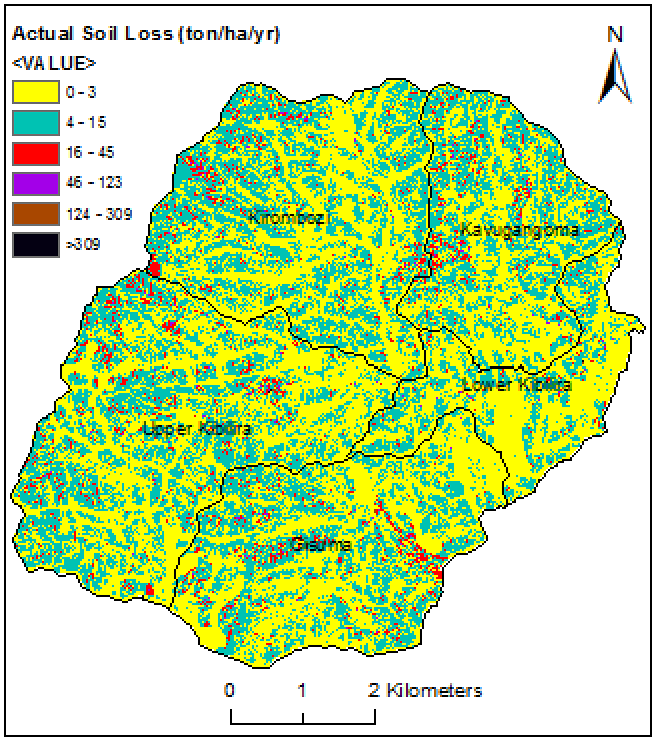




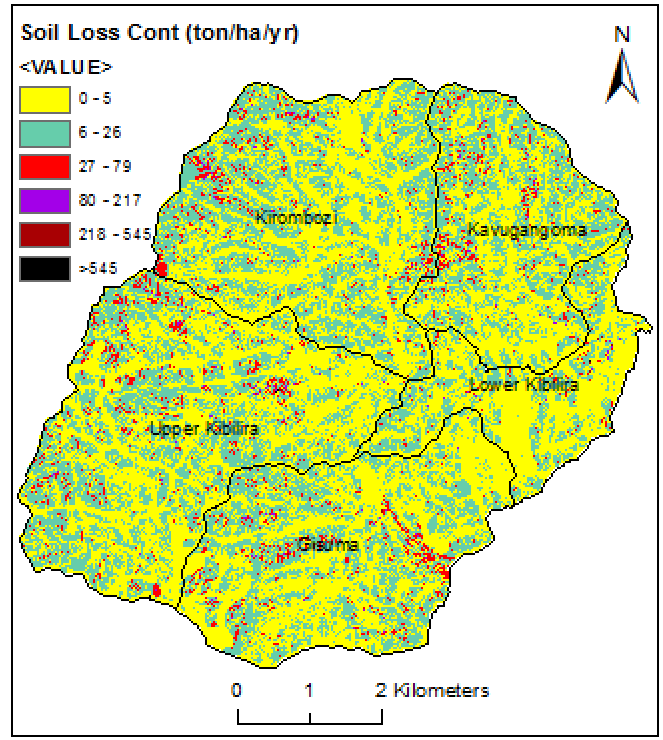
C factor distribution

P factor Map with strip practice

Actual Soil Loss & Soil loss with countours

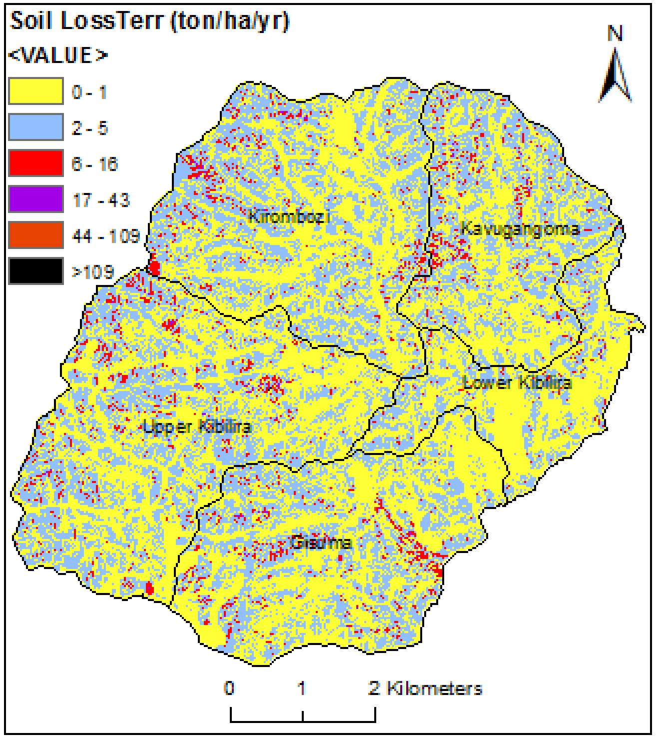


Actual spatial distribution of soil loss (t ha^{-1} yr^{-1})

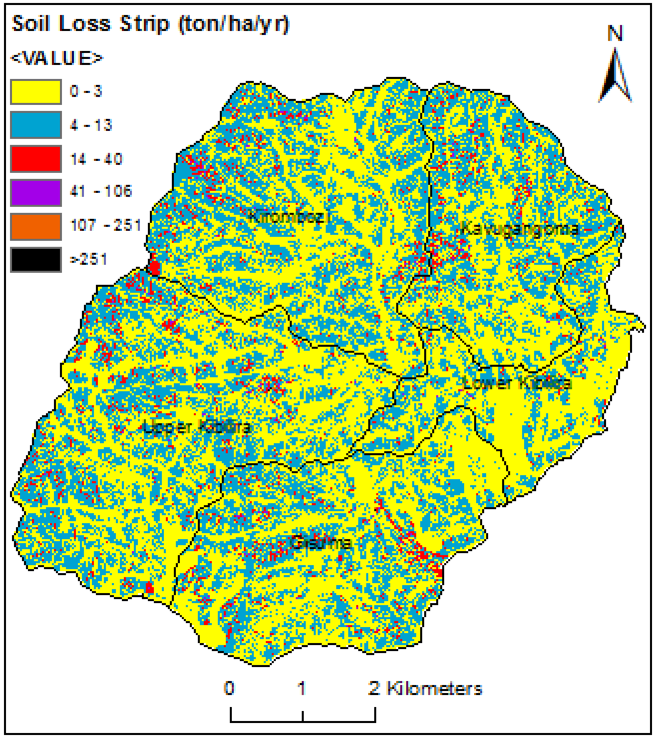


Spatial distribution of soil loss with contour support practice (t ha^{-1} yr^{-1})

Soil Loss Terraces & Soil loss with Strips



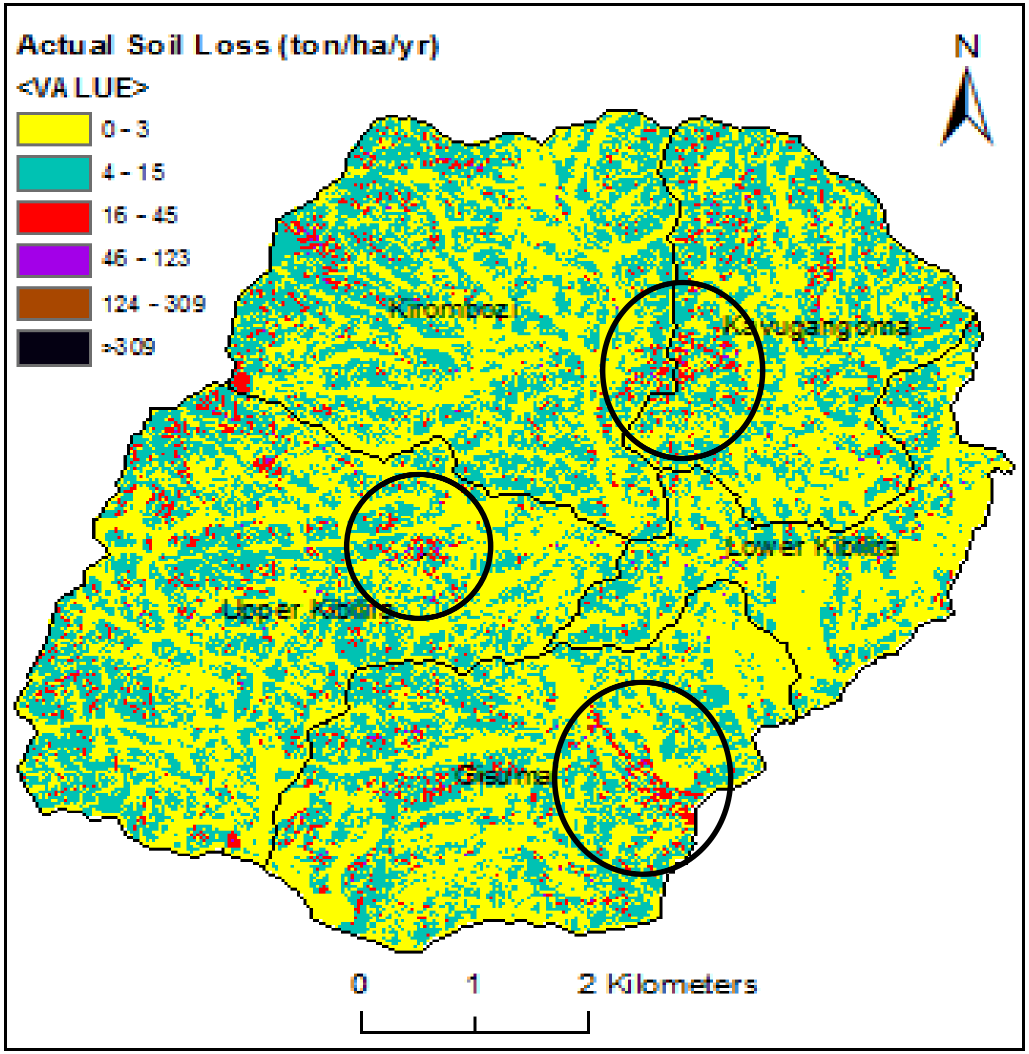
Soil erosion potential with terrace support practice (t ha^{-1} yr^{-1})



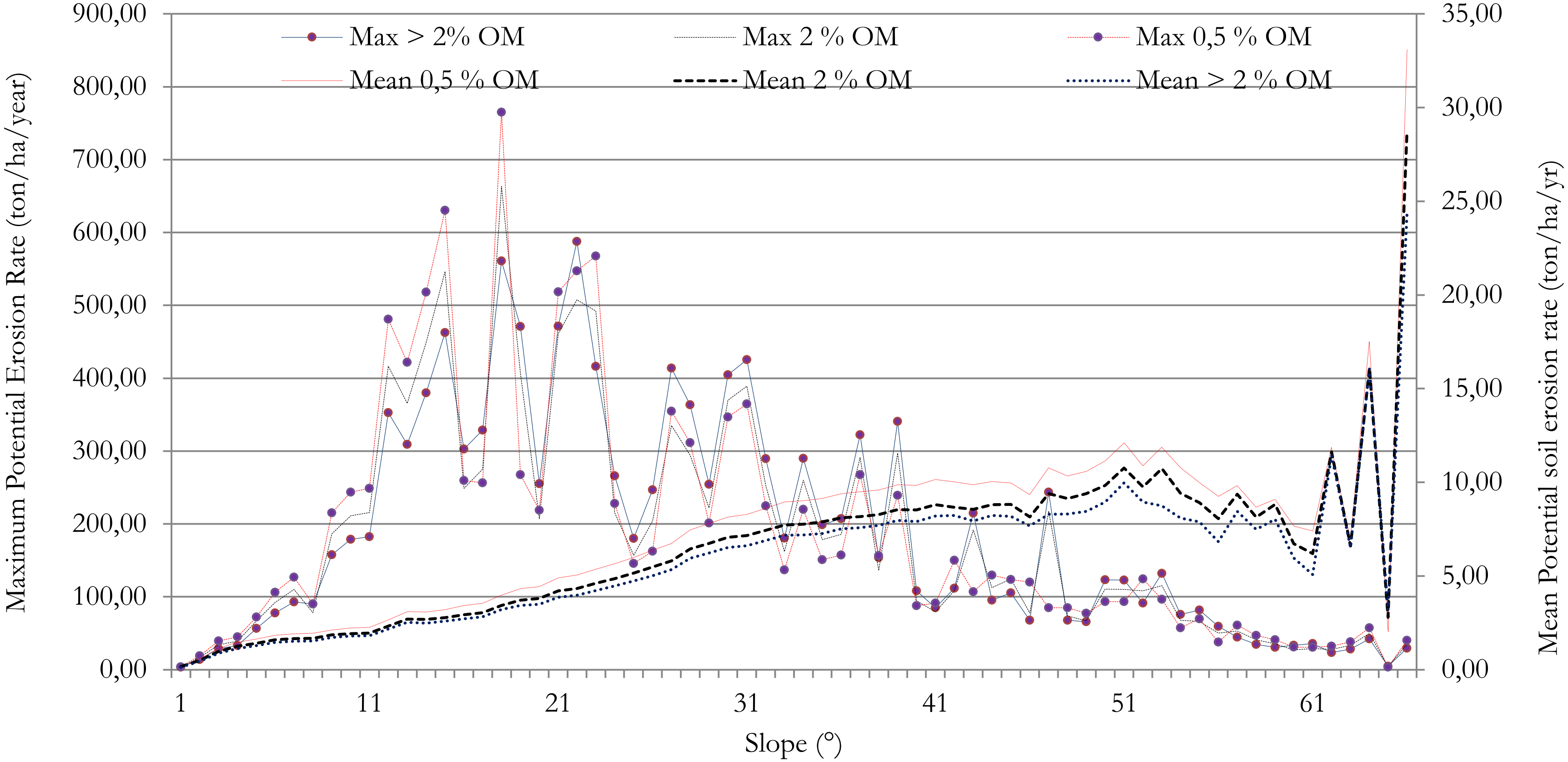
Soil erosion potential with strip support practice (t ha^{-1} yr^{-1})

7. Soil erosion risk assessment

6. Actual spatial distribution of soil loss (ton/ha/year)



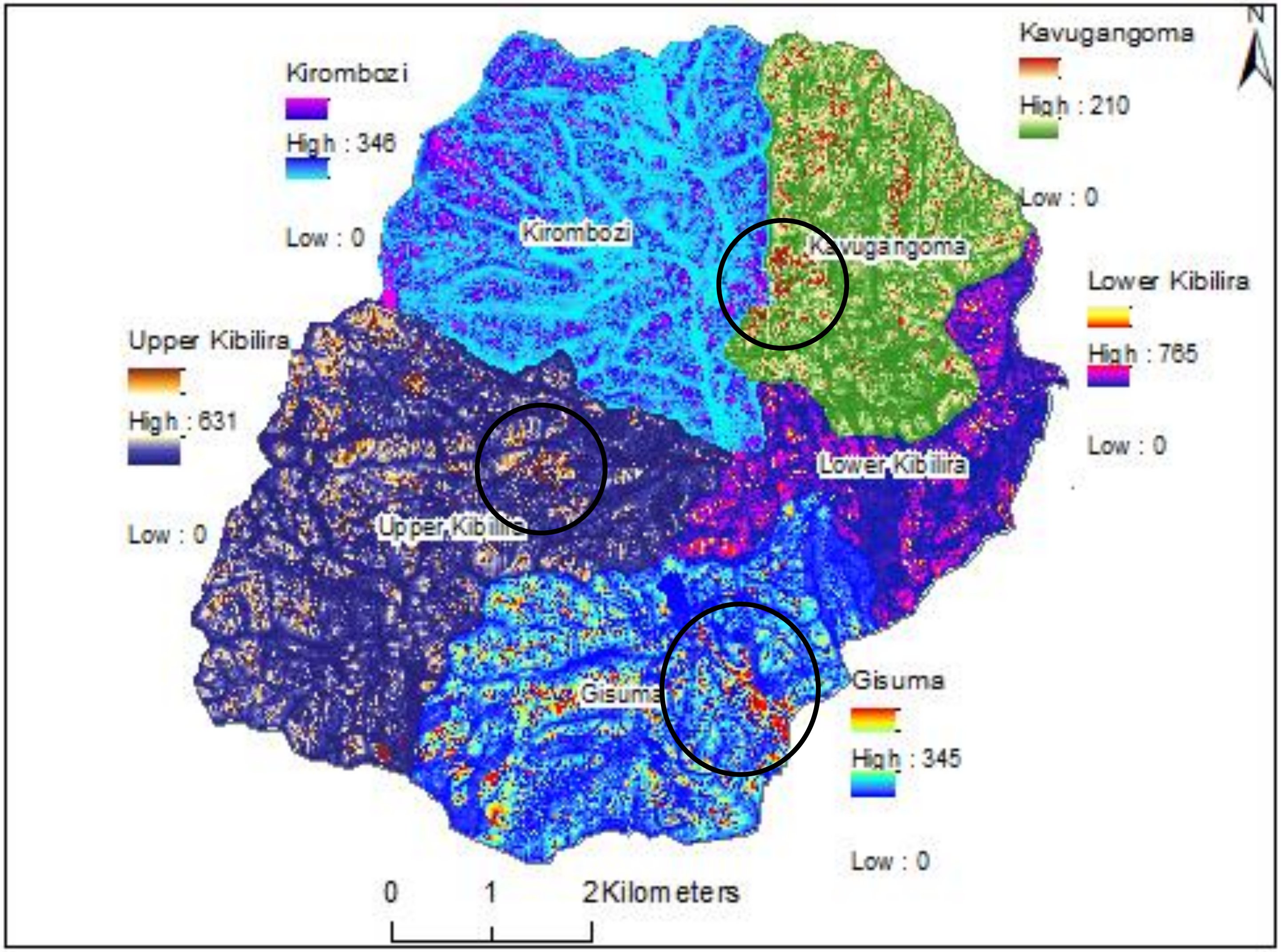
Actual spatial distribution of soil loss using OM scenarios (t. ha^{-1}. yr^{-1})



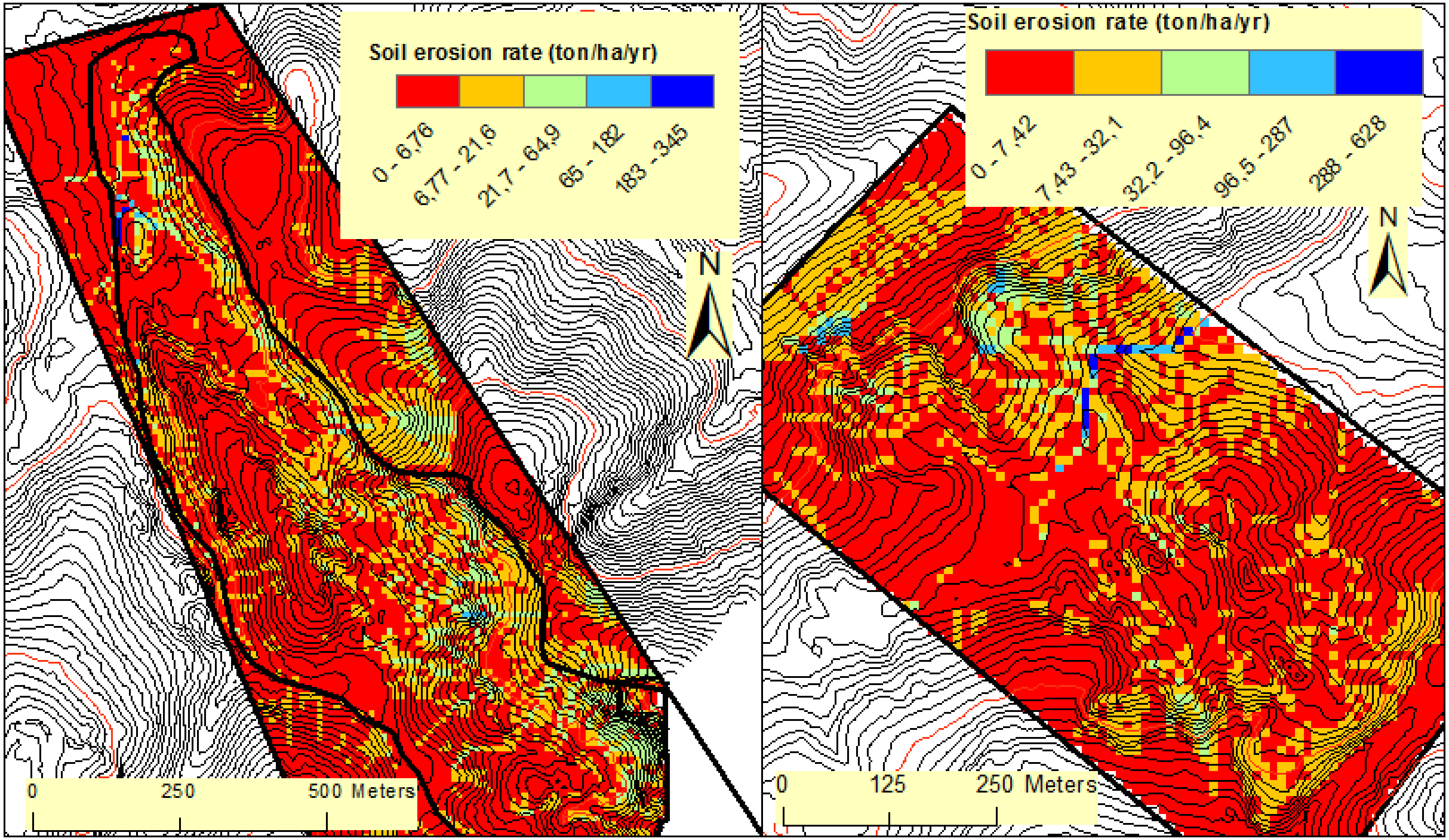
Mean Soil Erosion Rate Potential (t. ha^{-1}. yr^{-1}) based on different OM and P (support practice) scenarios

Support practice technique	**OM content**		
	0,5% OM	2% OM	>2% OM
Contour	105.6	94.4	91.8
Strip	53.4	48.0	45.8
Terrace	21.2	18.8	17.8

The magnitude of soil loss (t. ha^{-1}. yr^{-1}) in sub-catchments of the Gatumba watershed



Soil erosion rates in Ruhanga (left side) and Gatare (right side) mines



Discussion

Manageability of slopes of the Gatumba watershed after *Kevers* and *Ostyn* (in *Ilunga* 2000)

1. Manageability of slopes of the Gatumba watershed after *Kevers* and *Ostyn* (in *Ilunga* 2000)

Slope Class (°)	Total Area (ha)	% Total Slope	Category of the terrain
0-15	1679.11	28.6	Easily manageable
15 -35	**4043.3**	**66.8**	**Difficultly manageable**
>35	272.95	4.6	Not manageable
Total	6004.9	100	

Local impacts of SSOM on soil properties

- The clayey **soil texture** of the study area is potentially a conducive indicator for a successful reclamation of mine sites, if a **well-balanced OM** is provided (*Shepherd* et al. 2002).

- Organic matter content (**OM**) influences most of soil properties (BD; TP; SSA). Increase in OM would sensibly improve most of soil properties (*USDA* 2010)

- AWC is less than 4% while the recommended limit 5 % (*Maiti* et al. 2002) The elevated clay content could be associated with the low PAWC.

Soil erosion risk

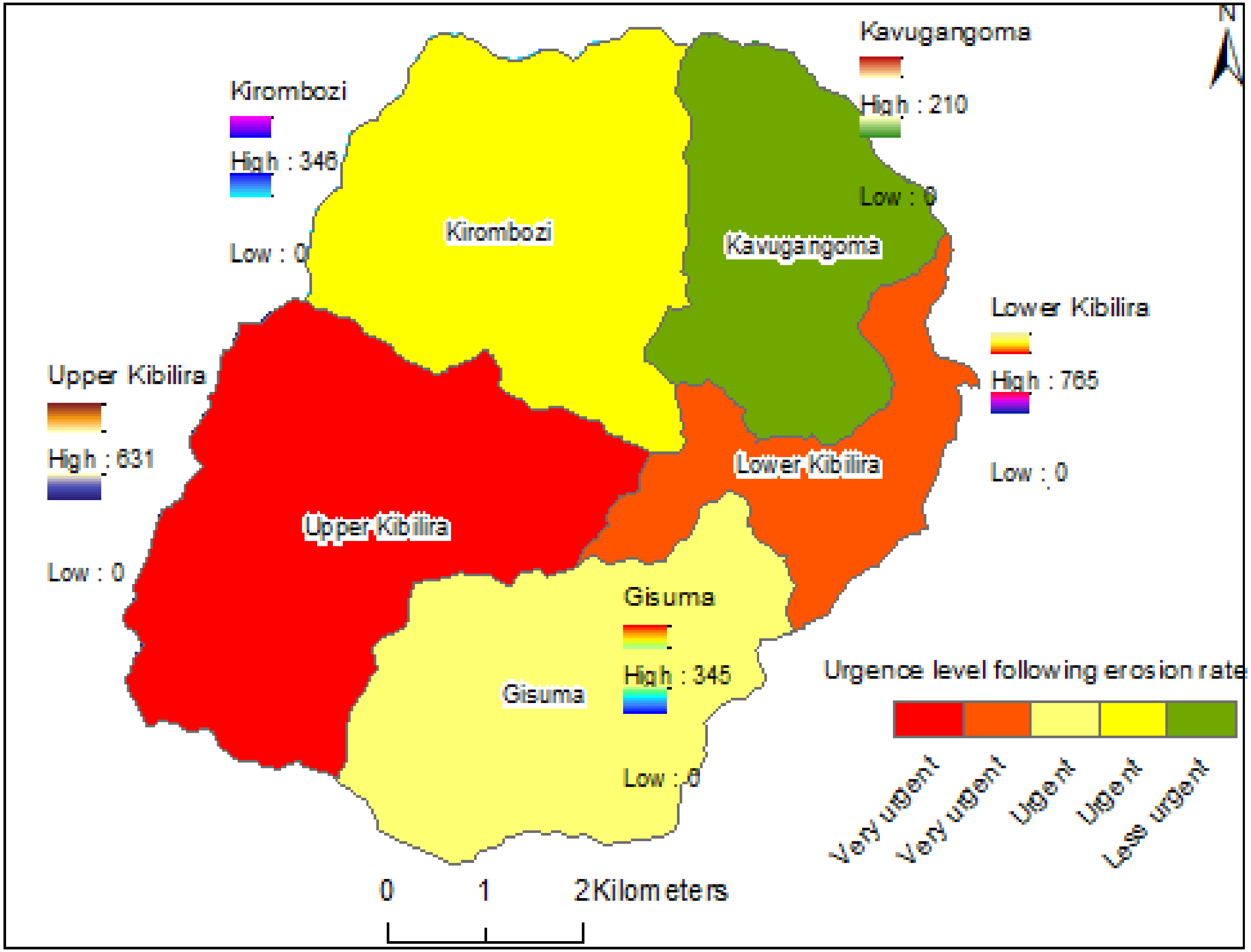
- The actual soil erosion risk was **27 t. $ha^{-1}.yr^{-1}$** in average.

- The estimated soil loss is in the same order of magnitude as other studies:
  - Northern highlands of Ethiopia (9.63 t.$ha^{-1}.yr^{-1}$) (*Tripathi* and *Raguwanshi* 2003);
  - highlands of Ethiopia and in Eritrea with average of and measured amount of more than 300 t.ha^{-1}. yr^{-1} on specific plots (20 t.ha^{-1}. yr^{-1}) (Hurni, in *Shiferaw* 2011)

- The average values of soil loss found in Gatumba are yet higher if we consider the standards for defining soil loss tolerance **(T)** (**10 t. $ha^{-1}.yr^{-1}$**) (USDA-NRCS, described in *Liu* et al. 2009)

- Among the 5 factors of **RUSLE Model**, soil erodibility (**K**) and management support practice (**P**) were found to be more determinant in soil loss magnitude in the study area.
- Different scenarios applied showed that with increased **K** and a better P practice (Terracing) soil loss is sensibly reduced.

Urgency level of erosion control practice in sub catchments of the Gatumba watershed



Conclusions

The objective was to asses the **Soil erosion risk in the Gatumba Mining Sector**

- ❑ Exposition of the ground caused by mining operations induces OM depletion (which causes the degradation of many soil properties) and reduces stability of soil aggregates.
- ❑ These could explain partially the accelerated soil erosion in the mine sites and formation of rills
- ❑ SSOM impacts negatively on land use potentials because it reduces lands for cultivation and contributes to alteration of soil properties
- ❑ As shown by soil erosion modelling, SSOM increase soil loss yields
- ❑ Various scenarios of erosion control (conservation) practices and improved soil organic matter content in the soil contribute to stabilise soil aggregate and reduce significantly soil erosion.