

Universal Soil Loss Equation (USLE)

Introduction

The Universal Soil Loss Equation (USLE) is a widely used mathematical model that describes soil erosion processes.


$$A = R \times K \times LS \times C \times P \left(\text{metric: } \frac{\text{tonnes}}{\text{ha}} \frac{\text{yr}}{\text{yr}} \right)$$

- ✓ R - rainfall Erosivity
- ✓ K - soil erodibility;
- ✓ L - slope length;
- ✓ S -slope steepness;
- ✓ C - cover and management;
- ✓ P - support practice.

This tutorial uses the K factor, derived from HWSD v1.2 database soil properties.

Soil Erodibility (K)

- Soil erodibility represents the effect of soil properties and soil profile characteristics on soil loss.
- Data source: Harmonized World Soil Database v 1.2
(<https://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/>)
- Spatial coverage: World
- Pixel size: 30 arc-seconds (~ 1 km at the equator)
- Limitation: It can overestimate the soil erosion.



2. Data Acquisition

Step 1: Download HWSD Dataset

Go to: Harmonized World Soil Database v1.2

In the left sidebar, click on "Download data only"

Download:

- ✓ hwsd_raster.zip (holding raster file)
- ✓ hwsd.mdb (Microsoft Access metadata file)

Harmonized World Soil Database

**Harmonized World Soil Database
HWSD Database**

The data available on this page is automatically installed with the HWSD Viewer, in a subdirectory called "Data" of the installation directory. The data is duplicated here for those who do not wish to install the viewer, or already have the viewer and only want to update or repair the database. If updates to the database are necessary and created, they will be documented here.

DATA FILES	DESCRIPTION	DATE
HWSD_RASTER.zip	Raster soil map in .bil file format	07.03.12
HWSD.mdb	Soil Attribute Database (MS Access)	07.03.12
HWSD_META.mdb	Soil Attribute Database metadata	07.03.12

If you have a version of the HWSD viewer installed and wish only to update the database, the files above can be copied into the "Data" directory of the installation directory (by default c:\Program Files\HWSD_v1.xx\Data). In order to update the raster (HWSD_RASTER.zip) in the viewer, the cache directory must also be deleted. Note that with version 1.20, older versions of the viewer must be uninstalled, and version 1.20 must be installed in order for the database to work with the viewer.

Updates and fixes in HWSD version 1.21 (dated 07.03.12)

- Bulk Density fixed for MU_GLOBAL 31418
- Sequence numbering fixed for MU_GLOBAL 31651
- Sequence number set for MU_GLOBAL 7000
- MU_SOURCE code for MU_GLOBAL 31800 changed to TNns1 representing a non-soil
- Error codes (999) removed from database and from raster map
- Older redundant mapping units that are no longer used on the raster map have been removed. Note that this means raster maps from previous versions can no longer be read with the viewer

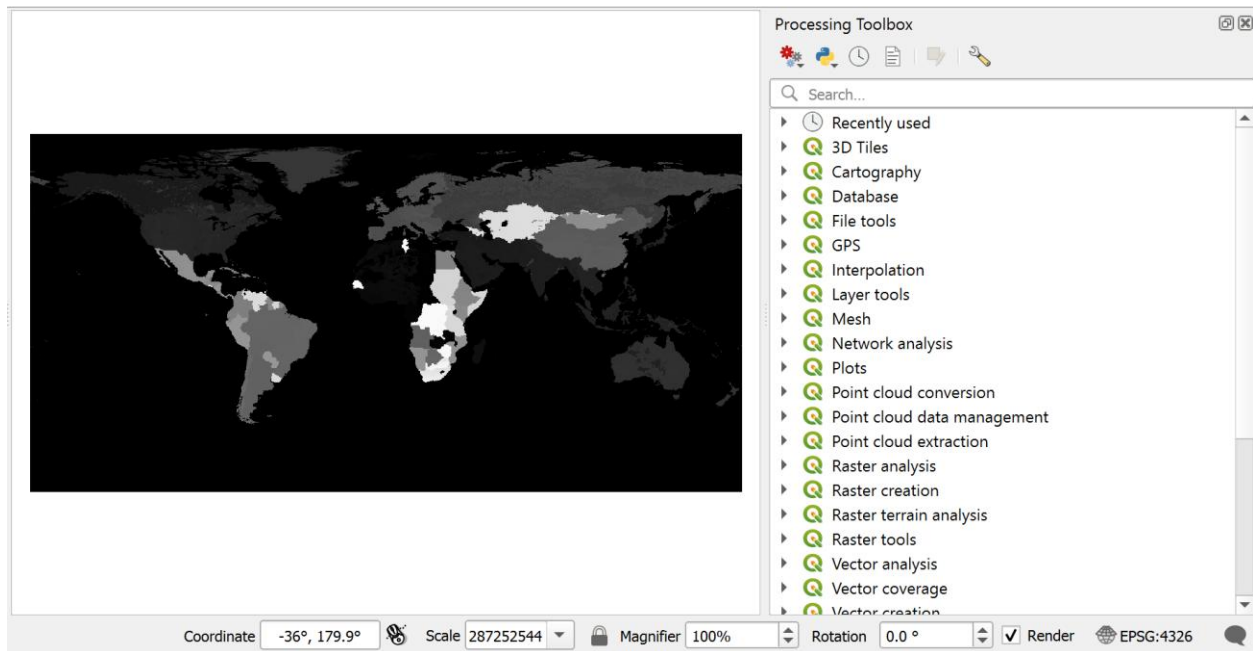
3. Load and Clip the Raster in QGIS

Step 2: Load Raster in QGIS

Extract hwsd_raster.zip

Open QGIS, *Layer* → *Add Layer* → *Add Raster Layer*

Load the raster file



Step 3: Clip Raster to Your Area of Interest (AOI)

Open Processing Toolbox

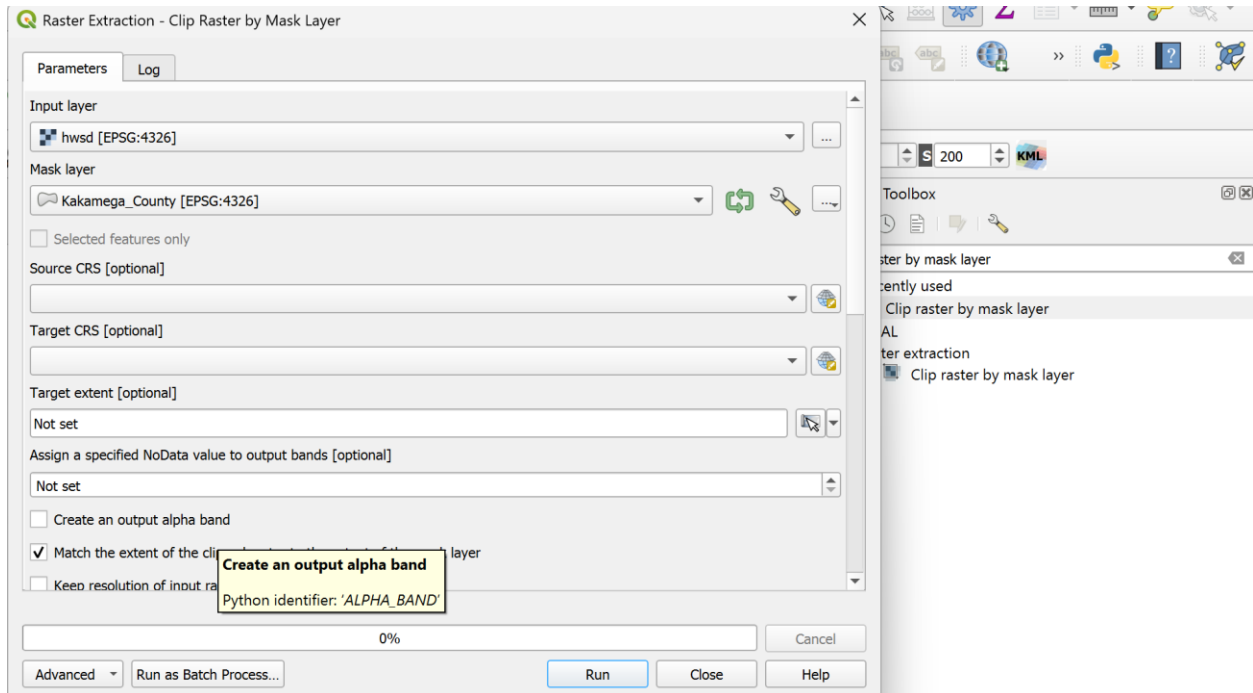
Choose "Clip raster by mask layer"

Input layer: HWSD raster

Mask layer: e.g., your County or Study Area shapefile

Set output file path

Run

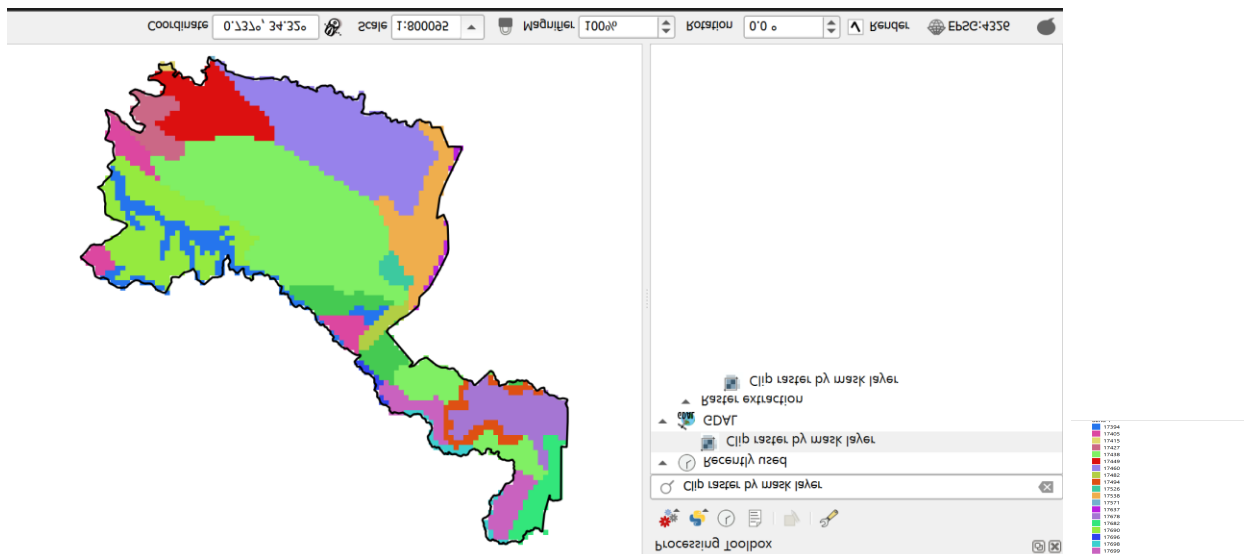


Step 4: Visualize Unique Soil Units

Right – click clipped raster → Properties → Symbology

Render type: Palletted/Unique values

Use a color ramp to display distinct soil units



4. Extract Soil Attribute Data

Step 5: Identify Unique Raster Values

Note the unique raster values



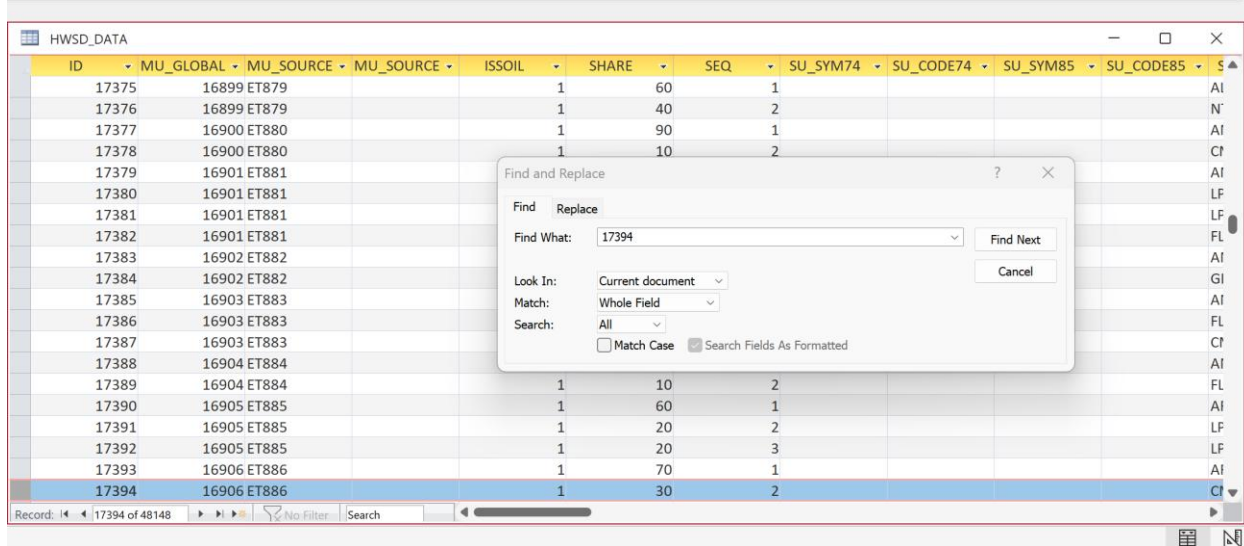
Step 6: Get Soil Properties from Metadata

Open hwsd.mdb in Microsoft Access

Go to table: HWSD_DATA

ID	MU_GLOBAL	MU_SOURCE	MU_SOURCE	SSOIL	SHARE	SEQ	SU_SYM74	SU_CODE74	SU_SYMB5	SU_CODEB5	SU_CODEB5	SU_CODEB5
1	7001.1	1	0	100	1	UR						
2	7002.2	2	0	100	1	HD						
3	7003.3	3	0	100	1	WR						
4	7004.4	4	0	100	1	Od						
5	7005.5	5	0	100	1	GG						
6	7006.70001	70001	1	70	1	Tv						
7	7006.70001	70005	1	20	2	Th						
8	7006.70001	70086	1	10	3	Tv						
9	7007.70002	70001	1	80	1	Tv						
10	7007.70002	70085	1	20	2	Th						
11	7008.70003	70001	1	90	1	Tv						
12	7008.70003	70011	1	10	2	Ox						
13	7009.70004	70001	1	90	1	Tv						
14	7009.70004	70012	1	10	2	Oe						
15	7010.70005	70001	1	90	1	Tv						
16	7010.70005	70050	1	10	2	Gm						
17	7011.70006	70001	1	100	1	Tv						
18	7012.70007	70002	1	100	1	Qa						
19	7013.70008	70003	1	80	1	Qc						
20	7013.70008	70099	1	10	2	XK						

For every unique raster value, locate and copy the row by searching in the ms access document



Paste output into an Excel file

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
ID	MU_GLOBAL	MU_SOURCE	MU_SOURCE	ISSOIL	SHARE	SEQ	SU_SYM74	SU_CODE74	SU_SYM85	SU_CODE85	SU_SYM90	SU_CODE90	TEXTURE	DRAINAGE	REF_DEPTH	AWC_CLASS	PHASE1
17394	16906 ET886			1	30	2				CMv		67	3	4	100	1	

Repeat the process for every unique raster value

5. Prepare Data in Excel

Step 7: Export Significant Columns

Export the following columns:

ID, MU_GLOBAL, T_SAND, T_SILT, T_CLAY, T_OC

J2 \times \checkmark f_x $=1.72*J2$

	A	B	C	D	E	F	G	H	I	J
1	ID	MU_GLOBAL	MU_SOURCE1	MU_SOURCE2	ISSOIL	T_SAND	T_SILT	T_CLAY	T_OC	OM
2	17394	16906	ET886		1	30	28	42	0.78	1.3416
3	17405	16911	ET892		1	43	29	28	0.39	0.6708
4	18077	17415	KE19		1	33	16	51	1.08	1.8576
5	18099	17427	KE20		1	22	21	57	1.65	2.838
6	18112	17438	KE21		1	42	25	33	1.48	2.5456
7	18127	17449	KE22		1	19	22	59	1.03	1.7716
8	18153	17460	KE23		1	11	18	71	1.78	3.0616
9	18198	17482	KE25		1	84	8	8	0.39	0.6708
10	18220	17494	KE260		1	55	15	30	1.15	1.978
11	18264	17526	KE29		1	19	24	57	3.5	6.02
12	18284	17538	KE30		1	36	25	39	2.18	3.7496
13	18346	17571	KE33		1	52	15	33	0.84	1.4448
14	18426	17637	KE39		1	57	14	29	1.33	2.2876
15	18496	17678	KE69		1	26	10	64	1.17	2.0124
16	18503	17682	KE72		1	24	14	62	1	1.72
17	18514	17690	KE8		1	81	8	11	0.54	0.9288
18	18524	17696	KE85		1	44	16	40	1.38	2.3736
19	18527	17698	KE87		1	4	26	70	3.18	5.4696
20	18528	17699	KE88		1	37	16	47	1.19	2.0468

Step 9: Assign Texture Class

Apply T_SAND, T_SILT, T_CLAY, and apply Roose (1996) table to acquire a Textural Class (e.g., sandy clay loam, silty clay, etc.)

Roose (1996)

Estimating soil erodibility (K) based on soil texture and organic material content.

Textural Class	Spanish Texture Class	Soil composition			Mean K (based on % organic material)		
		Sand	Silt	Clay	unknown	< 2%	≥ 2%
Clay	Arcilloso	0-45	0-40	40-100	0.22	0.24	0.21
Sandy Clay	Arcilloso arenoso	45-65	0-20	35-55	0.2	0.2	0.2
Silty Clay	Arcilloso limoso	0-20	40-60	40-60	0.26	0.27	0.26
Sand	Arenoso	86-100	0-14	0-10	0.02	0.03	0.01
Sandy Loam	Franco arenoso	50-70	0-50	0-20	0.13	0.14	0.12
Clay Loam	Franco - arcilloso	20-45	15-52	27-40	0.3	0.33	0.28
Loam	Franco	23-52	28-50	7-27	0.3	0.34	0.26
Loamy Sand	Franco arenoso	70-86	0-30	0-15	0.04	0.05	0.04
Sandy Clay Loam	Franco arenoso arcilloso	45-80	0-28	20-35	0.2	0.2	0.2
Silty Clay Loam	Franco limoso arcilloso	0-20	40-73	27-40	0.32	0.35	0.3
Silt	Limoso	0-20	88-100	0-12	0.38	0.41	0.37
Silty Loam	Franco limoso	20-50	74-88	0-27	0.38	0.41	0.37

Note that the table in the guide accounts for % organic matter (OM), not just organic carbon (OC). If we do not know the conversion value for the area, the value OC is multiplied by 1.72 to get OM.

$$OM = 1.72 * OC$$

The references for conversion factors are given in IPCC-AFOLU report 2006.

Insert this as a new column: TEXTURE_CLASS

K1											
TEXTURE_CLASS											
	A	B	C	D	E	F	G	H	I	J	K
1	ID	MU_GLOBAL	MU_SOURCE1	MU_SOURCE2	ISSOIL	T_SAND	T_SILT	T_CLAY	T_OC	OM	TEXTURE_CLASS
2	17394	16906 ET886			1	30	28	42	0.78	1.3416	Clay
3	17405	16911 ET892			1	43	29	28	0.39	0.6708	Clay Loam
4	18077	17415 KE19			1	33	16	51	1.08	1.8576	Clay
5	18099	17427 KE20			1	22	21	57	1.65	2.838	Clay
6	18112	17438 KE21			1	42	25	33	1.48	2.5456	Clay Loam
7	18127	17449 KE22			1	19	22	59	1.03	1.7716	Clay
8	18153	17460 KE23			1	11	18	71	1.78	3.0616	Clay
9	18198	17482 KE25			1	84	8	8	0.39	0.6708	Loamy Sand
10	18220	17494 KE260			1	55	15	30	1.15	1.978	Sandy Clay Loam
11	18264	17526 KE29			1	19	24	57	3.5	6.02	Clay
12	18284	17538 KE30			1	36	25	39	2.18	3.7496	Clay Loam
13	18346	17571 KE33			1	52	15	33	0.84	1.4448	Sandy Clay Loam
14	18426	17637 KE39			1	57	14	29	1.33	2.2876	Sandy Clay Loam
15	18496	17678 KE69			1	26	10	64	1.17	2.0124	Clay
16	18503	17682 KE72			1	24	14	62	1	1.72	Clay
17	18514	17690 KE8			1	81	8	11	0.54	0.9288	Loamy Sand
18	18524	17696 KE85			1	44	16	40	1.38	2.3736	Clay Loam
19	18527	17698 KE87			1	4	26	70	3.18	5.4696	Clay
20	18528	17699 KE88			1	37	16	47	1.19	2.0468	Clay

Step 10: Assign Mean K Value

Apply the Roose (1996) table to acquire a mean K value on:

Texture class

OM content

Insert a new column in Excel: K_VALUE

A	B	C	D	E	F	G	H	I	J	K	L
ID	MU_GLOBAL	MU_SOURCE1	MU_SOURCE2	ISSOIL	T_SAND	T_SILT	T_CLAY	T_OC	OM	TEXTURE_CLASS	K_VALUE
17394	16906 ET886			1	30	28	42	0.78	1.3416	Clay	0.24
17405	16911 ET892			1	43	29	28	0.39	0.6708	Clay Loam	0.33
18077	17415 KE19			1	33	16	51	1.08	1.8576	Clay	0.24
18099	17427 KE20			1	22	21	57	1.65	2.838	Clay	0.21
18112	17438 KE21			1	42	25	33	1.48	2.5456	Clay Loam	0.28
18127	17449 KE22			1	19	22	59	1.03	1.7716	Clay	0.24
18153	17460 KE23			1	11	18	71	1.78	3.0616	Clay	0.21
18198	17482 KE25			1	84	8	8	0.39	0.6708	Loamy Sand	0.05
18220	17494 KE260			1	55	15	30	1.15	1.978	Sandy Clay Loam	0.2
18264	17526 KE29			1	19	24	57	3.5	6.02	Clay	0.21
18284	17538 KE30			1	36	25	39	2.18	3.7496	Clay Loam	0.28
18346	17571 KE33			1	52	15	33	0.84	1.4448	Sandy Clay Loam	0.2
18426	17637 KE39			1	57	14	29	1.33	2.2876	Sandy Clay Loam	0.2
18496	17678 KE69			1	26	10	64	1.17	2.0124	Clay	0.21
18503	17682 KE72			1	24	14	62	1	1.72	Clay	0.24
18514	17690 KE8			1	81	8	11	0.54	0.9288	Loamy Sand	0.05
18524	17696 KE85			1	44	16	40	1.38	2.3736	Clay Loam	0.28
18527	17698 KE87			1	4	26	70	3.18	5.4696	Clay	0.21
18528	17699 KE88			1	37	16	47	1.19	2.0468	Clay	0.21

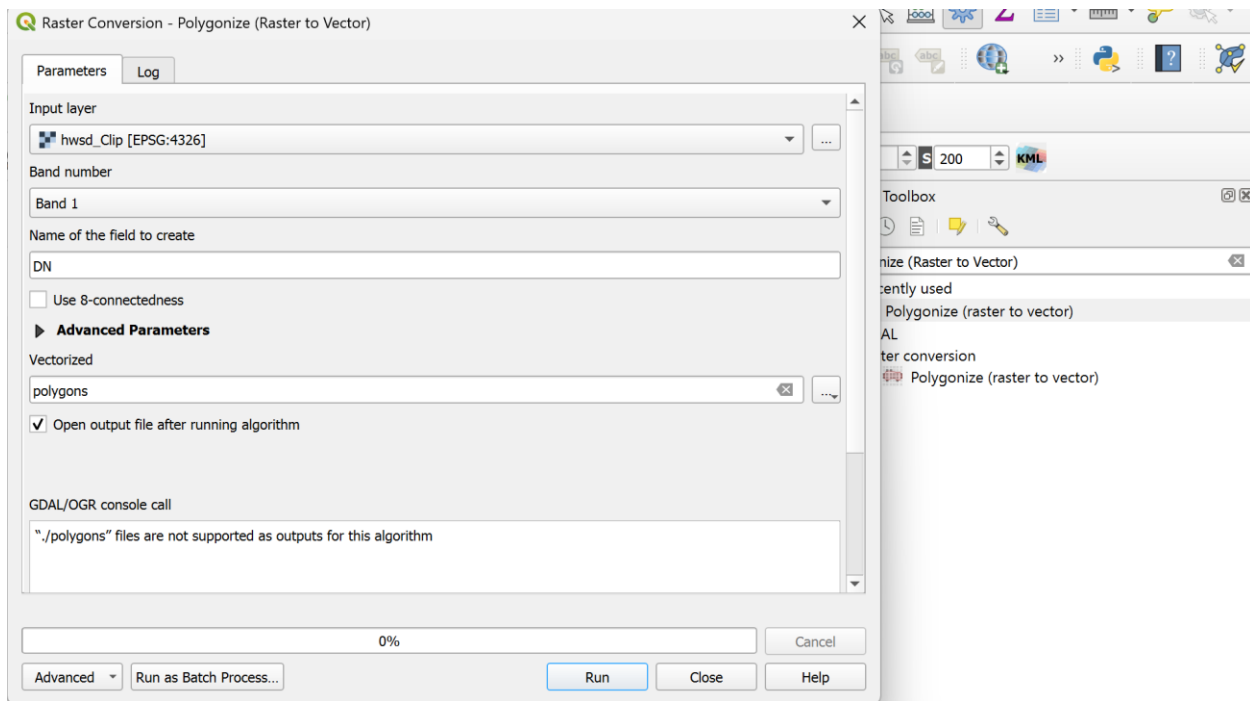
6. Combine K Values to QGIS Layer

Step 11: Raster to Polygon

Raster → Conversion → Polygonize (Raster to Vector)

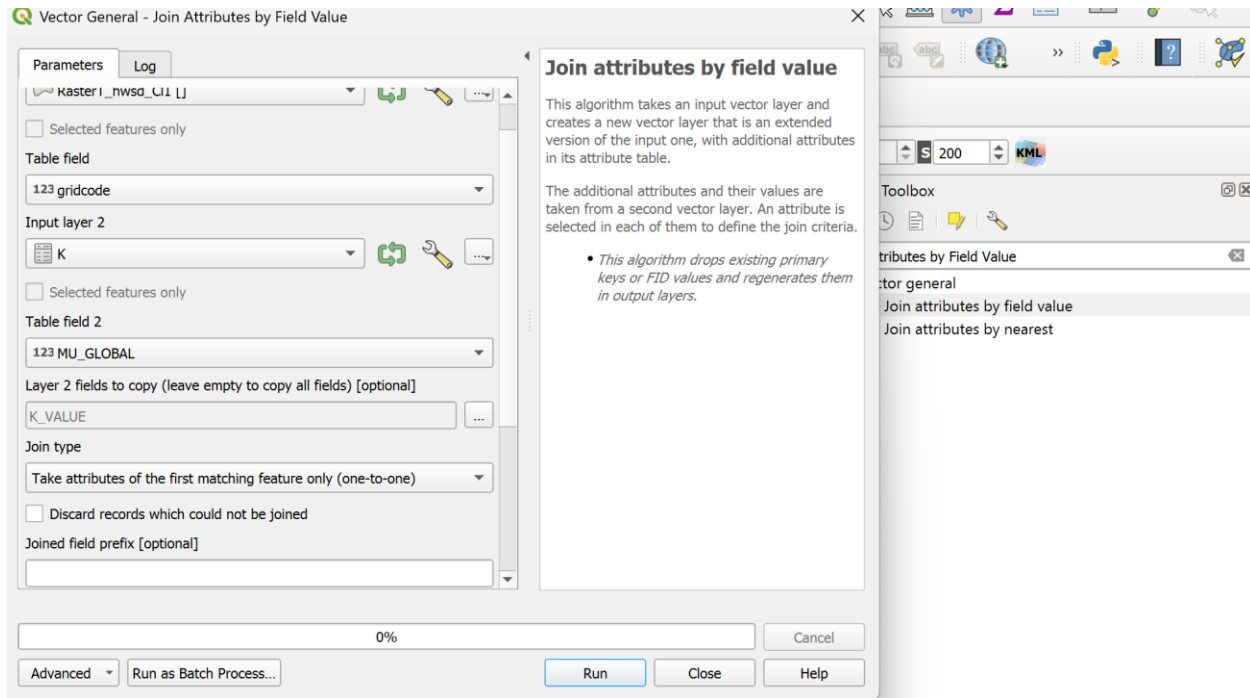
Input: Clipped raster layer

Output: A vector polygon shapefile in MU_GLOBAL units



Step 12: Join Excel Data to Polygon Layer in QGIS

- ✓ Convert the Excel file to CSV format.
- ✓ Load the polygon layer and the CSV file into QGIS.
- ✓ Ensure both layers contain a common field (used as a common key).
- ✓ Open the polygon layer's attribute table and confirm the existence of the K_VALUE field.
- ✓ Use the "Join Attributes by Field Value" tool:
 - Input Layer: polygon layer
 - Table Field: Unique Field
 - Input Layer2: CSV file
 - Table Field2: Unique Field
 - Layer2 fields to copy: K_VALUE
 - Join Type: Take attributes of the first matching feature only

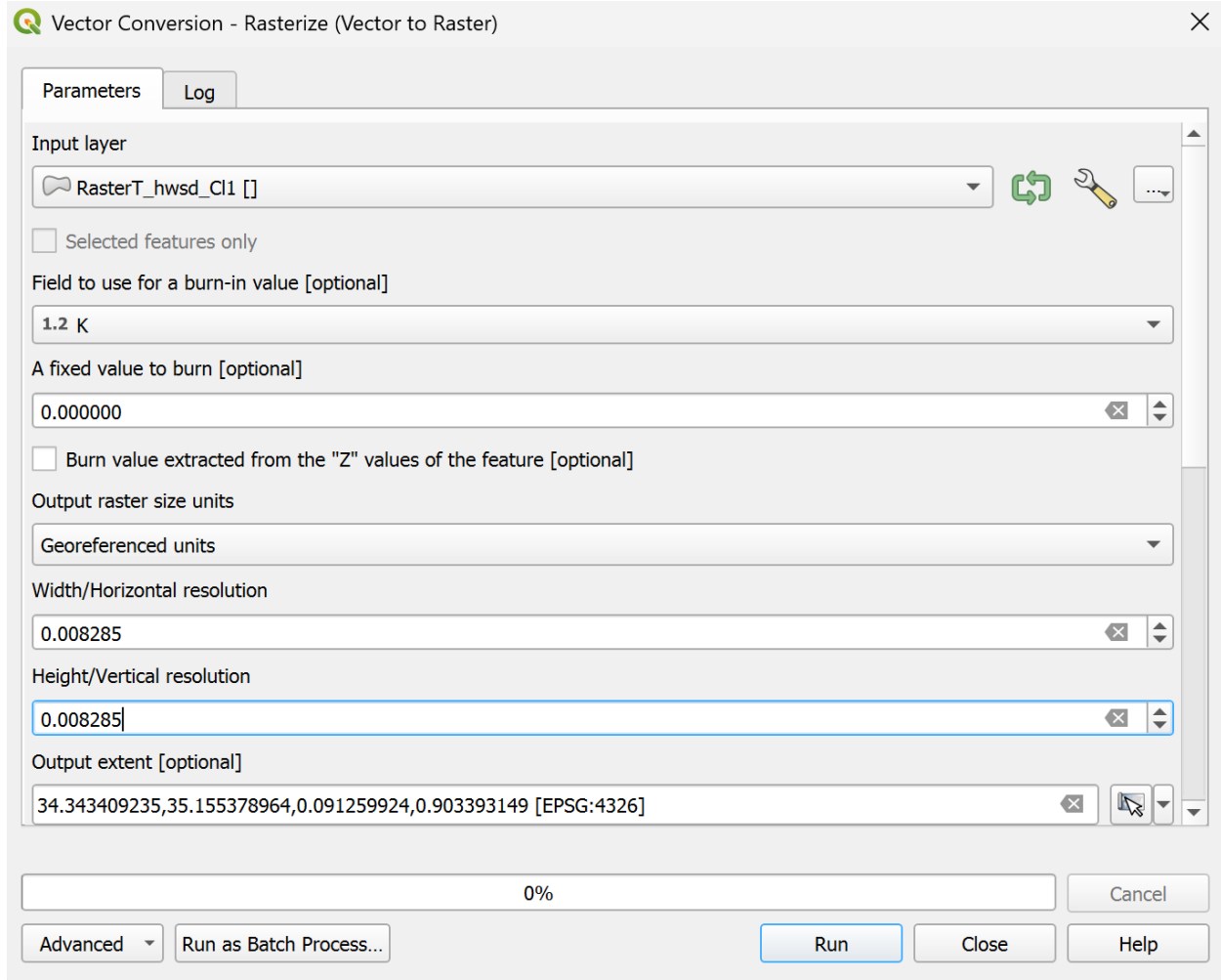


The tool populates the existing K_VALUE field in the polygon layer with matching values from the CSV.

7. Convert the polygons to raster

Step 13: Convert Polygon to Raster (Rasterize K_VALUE Field)

- ✓ In the Processing Toolbox, search for and open "Rasterize (vector to raster)".
- ✓ For the Input layer, select your polygon layer.
- ✓ Set the Field to use for a burn-in value to K_VALUE.
- ✓ Define the Output raster size units (e.g., pixel size in map units per pixel).
 - Common values: 10, 30, or 100 meters, depending on your scale and need.
 - Use the same as the hwsd raster for the vertical and horizontal resolution
 - Specify the extent as your area of interest
- ✓ Specify the Output file location and give the raster a meaningful name (e.g., K_factor_raster.tif).
- ✓ Click Run.

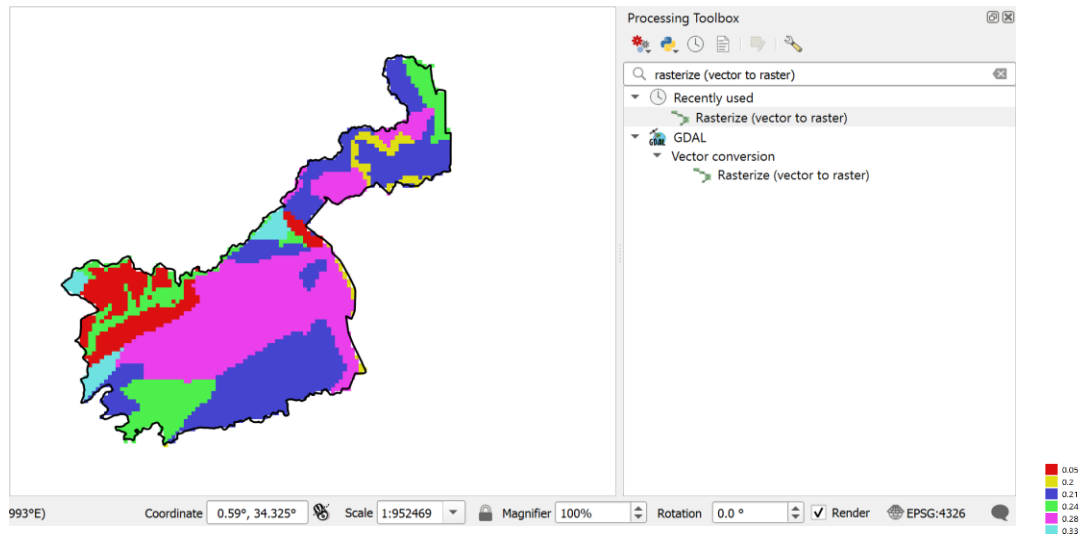


Step 14: Symbolize K Factor

Right – click polygon layer → Properties → Symbology

Render type: Categorized or Graduated

Choose a color ramp, e.g., Green-Yellow-Red for increasing erodibility



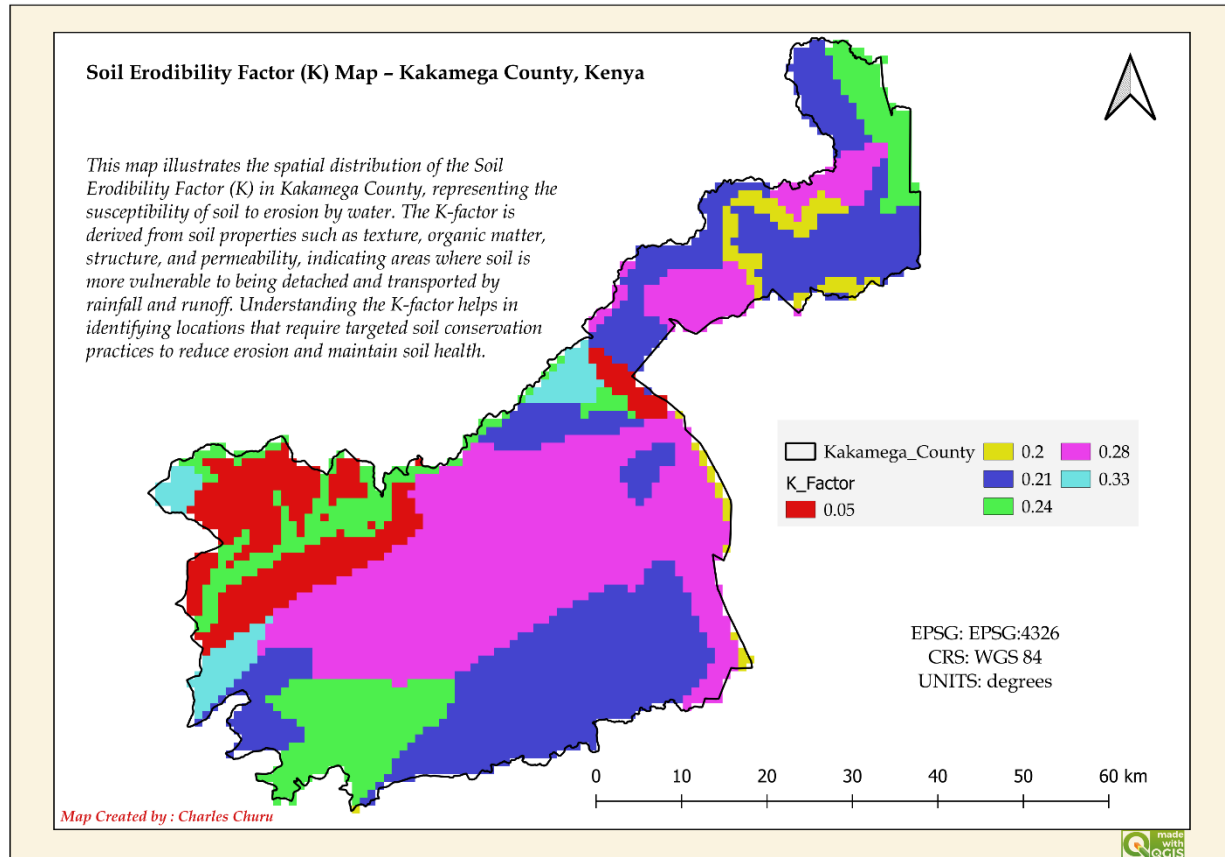
Step 15: Final Map Preparation

Go to Project → New Print Layout

Insert:

- ✓ Title
- ✓ Legend
- ✓ Scale bar
- ✓ North arrow
- ✓ Labels (use on a case-by-case basis)

Export the map as PDF, JPEG, and PNG



Final Output

You now have ready a high-resolution map of the Soil Erodibility (K) Factor to be used in further USLE-based soil erosion modeling in QGIS.

References

- QGIS Project. (2024). *QGIS training manual*. QGIS Documentation.
https://docs.qgis.org/latest/en/docs/training_manual/
- QGIS Development Team. (2024). *QGIS Geographic Information System (Version 3.x)* [Software]. Open Source Geospatial Foundation.
<https://qgis.org>
- Roose, E. (1996). *Land husbandry: Components and strategy*. FAO Soils Bulletin No. 70. Food and Agriculture Organization of the United Nations.
- United States Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS). (1993). *Soil survey manual*. U.S. Government Printing Office.
- Wischmeier, W. H., & Smith, D. D. (1978). *Predicting rainfall erosion losses: A guide to conservation planning* (Agriculture Handbook No. 537). U.S. Department of Agriculture.