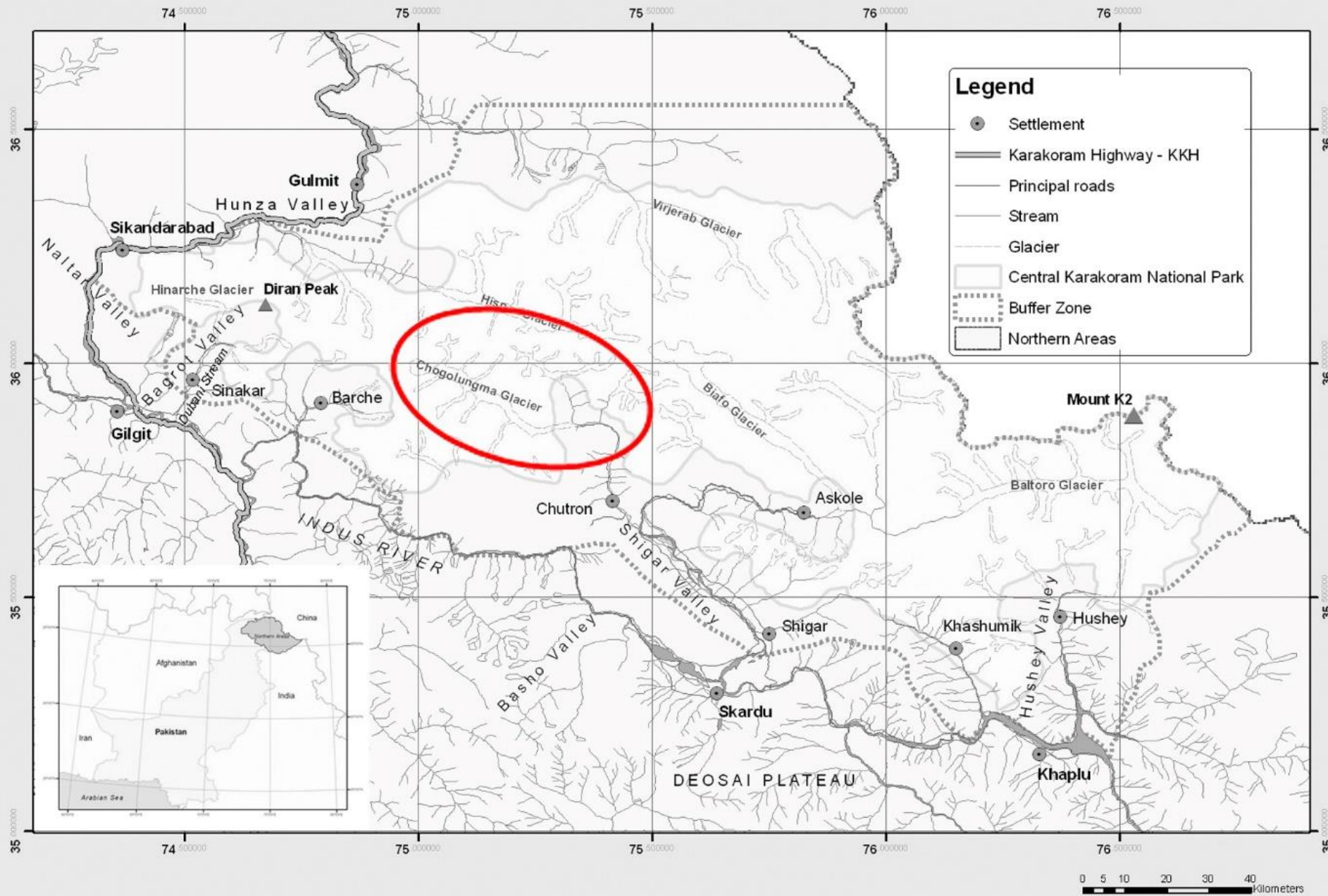


Landslide susceptibility analysis in Arandu area Shigar valley, CKNP (Gilgit- Baltistan- Pakistan)







- I miei luoghi
- [Tour panoramico](#)
Verifica che il livello Edifici 3D sia selezionato
- [Segnaposto senza titolo](#)
kante
- [Segnaposto senza titolo](#)
- Luoghi temporanei

- Database principale
- Annunci
- Confini ed etichette
- Luoghi
- Foto
- Strade
- Edifici 3D
- Tempo meteorologico
- Galleria
- Altro
- Rilievo



CHE PARAMETRI?

As previously described, several are the parameters usable in order to define a landslide susceptibility map. For the work done, the chosen parameters are the easiest to collect:

- Geology
- tectonic structures (thrusts and faults)
- plan curvature
- slope angle
- Aspect
- drainage network
- glaciated areas
- land cover

IL METODO

To prepare the LSM, the geological and lithological conditions were previously analysed, and later the main geomorphologic parameters (slope angle, aspect and plan curvatures) computed. Furthermore, the LSM was obtained combining the different parameters in accordance with their relative influence to the landslide occurrence following the **Analytical Hierarchy Process (AHP)**. The latter rates not only the parameters, but also the classes in which each parameter is classified. The parameters, arranged in hierarchical order of priority in rows and columns, generated a pair-wise comparison matrix. **Frequency ratio (FR) method** was adopted to drive each class weight. The parameters were later combined through the **Weighted Linear Combination (WLC)** where secondary-level weights are opinion-based scores. The result is the Landslide Potential Index map (LPI) calculated using the following formula:

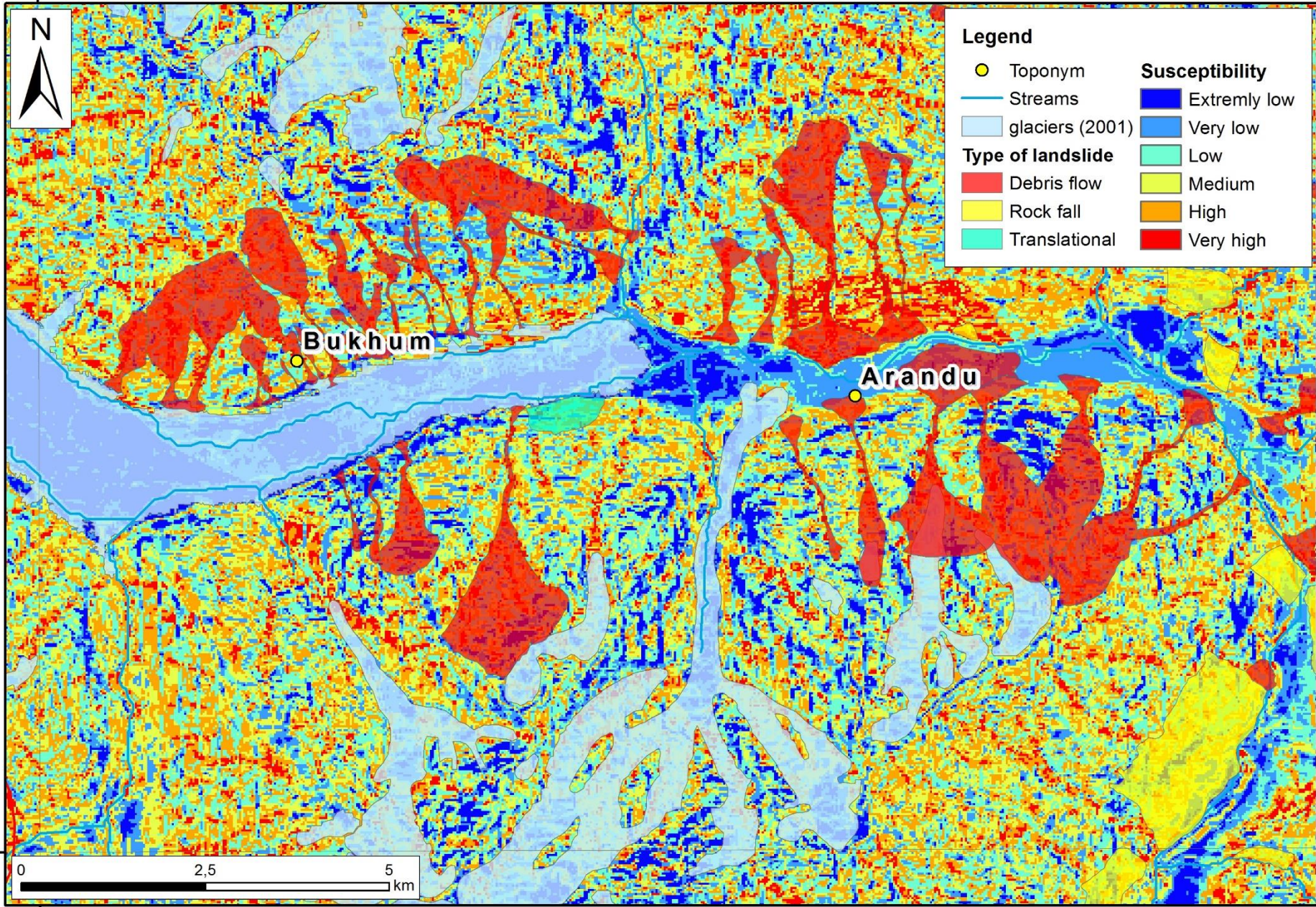
$$LPI = \sum (R_i \times W_{ij}) \quad (1)$$

where $i = 1 - 9$, R_i is the rank for parameter i , and W_{ij} is the weight for class j of i factor.

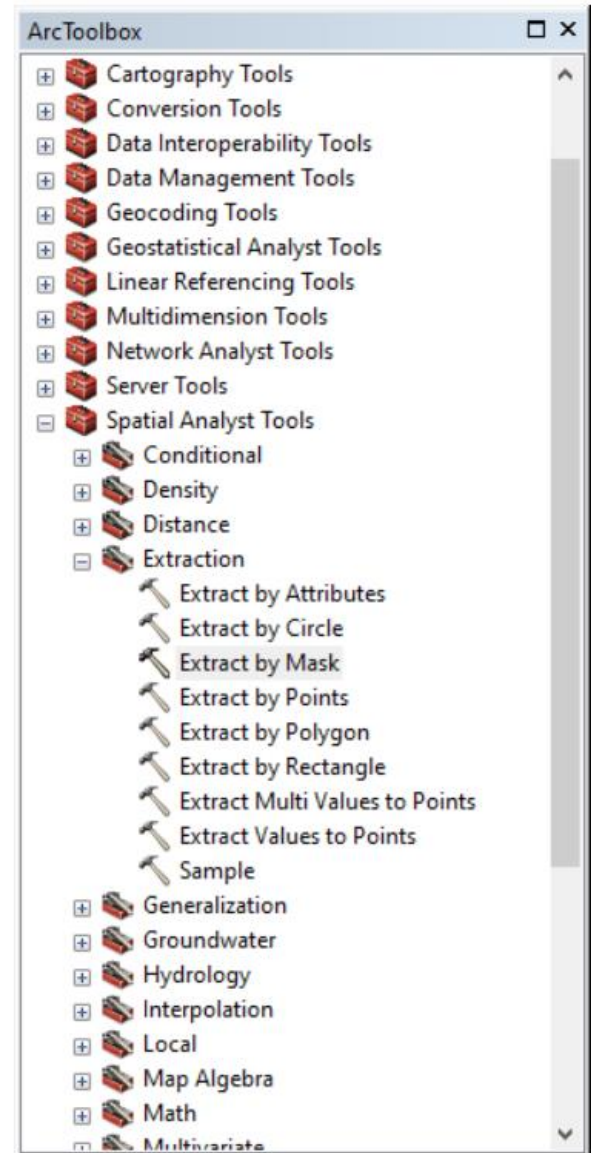
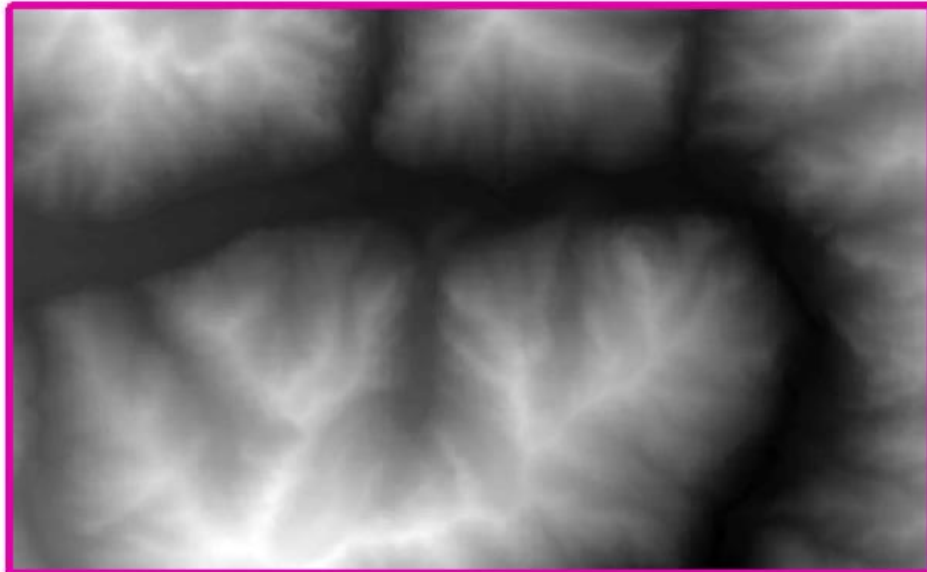
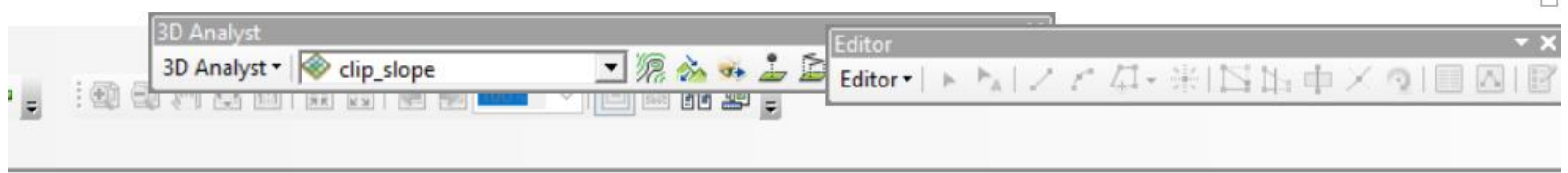
Frequency Ratio (FR) computed for each single class. For the geology, hereafter are explained the acronyms used. cgM=Miar conglomerate; csiZ=Zil felsic gneiss; Ey=Old screes and eluvial deposits; gB=Baltoro granite; gcsiMB=Mangol Bulk or Basha dome; L=Landslide; Mcsi=Magmatic gneiss; mkk= Marble; mt=Tagauri limestone; sKK Unidifferentiated meta-sedimentary rocks

	Class	FR		Class	FR
GEOLOGY	cgM	0,00	DISTANCE TO RIVER	0-50 m	0,54
	csiZ	1,15		50-100 m	0,63
	Ey	1,14		100-250 m	0,84
	gB	0,27		> 250 m	0,99
	gcsiMB	1,17	DISTANCE TO FAULTS	0-5 km	0,39
	L	2,63		5-10 km	0,99
	Mcsi	1,12		>10 km	1,07
	mKK	0,16	CURVATURE	hollow	1,25
	mT	1,00		nose	0,81
	sKK	0,62		planar	0,94
SLOPE ANGLE	0-5°	0,29	SLOPE ASPECT	flat	0,00
	5-10°	0,54		N	1,03
	10-20°	0,96		NE	0,70
	20-30°	0,94		E	0,86
	30-40°	0,98		SE	1,56
	40-50°	1,11		S	1,28
	50-60°	0,95		SW	0,97
	>60°	0,60		W	0,51
				NW	0,70
LAND COVER	Bare Rock and/or Coarse Fragments		0,72		
	Bare soil and scattered vegetation		2,31		
	Closed forest		0,44		
	Cultivated areas		0,73		
	Open forest		1,02		
	Pastures and/or Meadows < 3750 mt		0,42		
	Pastures and/or Meadows > 3750 mt		0,43		
	Snow		0,38		
	Sparse vegetation		1,75		
		0,00			

75°14'0"E



75°14'0"E



FLOW CHART MAP

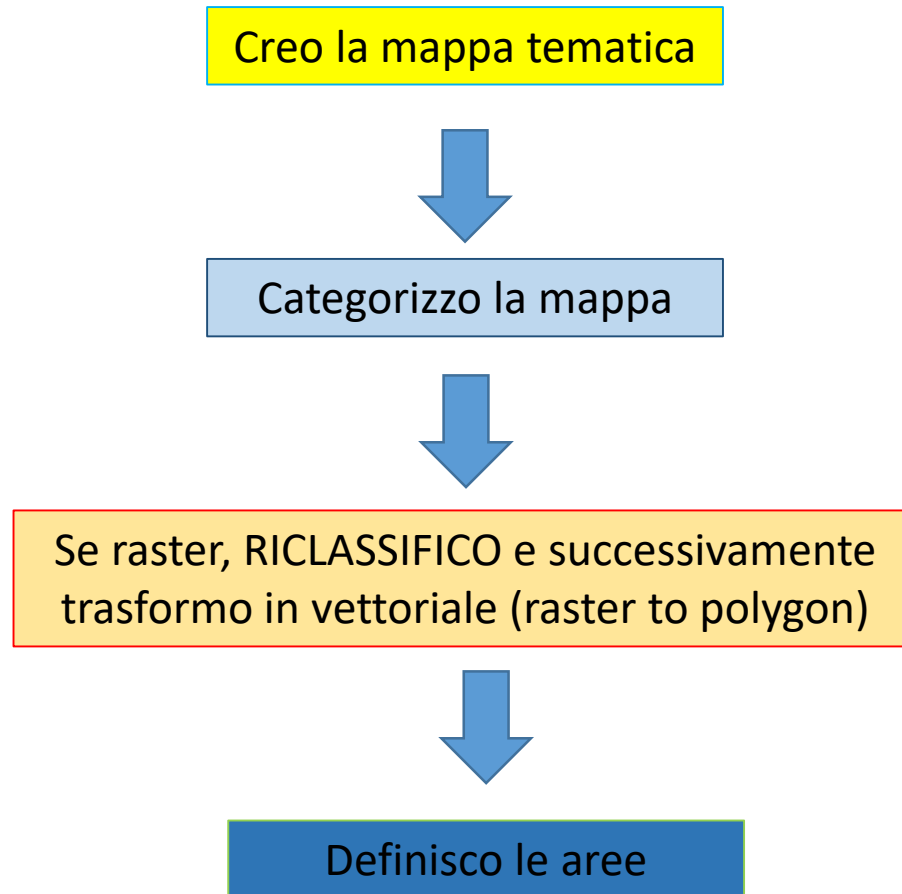
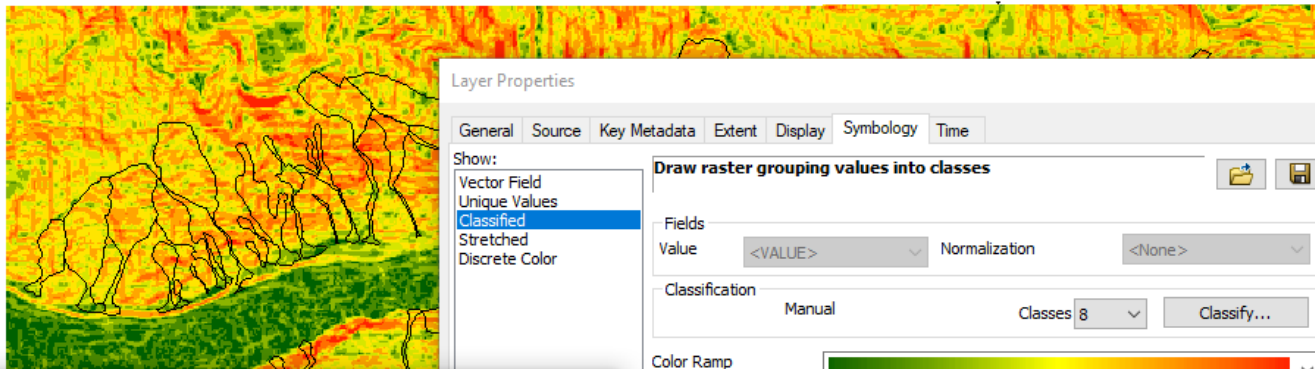


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 - 5,000000001 - 10
 - 10,000000001 - 20
 - 20,000000001 - 30
 - 30,000000001 - 40
 - 40,000000001 - 50
 - 50,000000001 - 60
 - 60,000000001 - 76,96635437



Layer Properties

General Source Key Metadata Extent Display Symbology Time

Show:

- Vector Field
- Unique Values
- Classified
- Stretched
- Discrete Color

Draw raster grouping values into classes

Fields

Value: <VALUE> Normalization: <None>

Classification: Manual Classes: 8 Classify...

Color Ramp

Symbol	Range	Label
[Green]	0 - 5	0 - 5
[Light Green]	5 - 10	5,000000001 - 10
[Yellow-Green]	10 - 20	10,000000001 - 20
[Yellow]	20 - 30	20,000000001 - 30
[Orange-Yellow]	30 - 40	30,000000001 - 40
[Orange]	40 - 50	40,000000001 - 50
[Red-Orange]	50 - 60	50,000000001 - 60
[Red]	60 - 76,96635437	60,000000001 - 76,96635437

Show class breaks using cell values
 Use hillshade effect z: 1
 Display NoData as

OK Annulla Applica

Classification

Classification Method: Manual

Classes: 8

Data Exclusion Exclusion ... Sampling ...

Columns: 100 Show Std. Dev. Show Mean

Classification Statistics

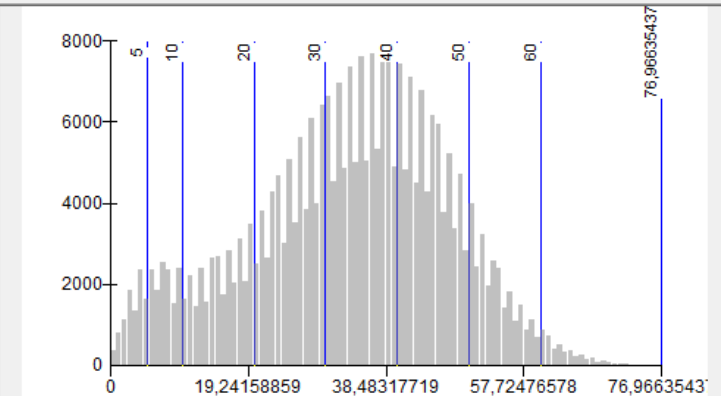
Count: 284498
 Minimum: 0
 Maximum: 76,96635437
 Sum: 9.442.030,129
 Mean: 33,18838842
 Standard Deviation: 13,89787226

Break Values %

5
10
20
30
40
50
60
76,96635437

OK Cancel

Snap breaks to data values



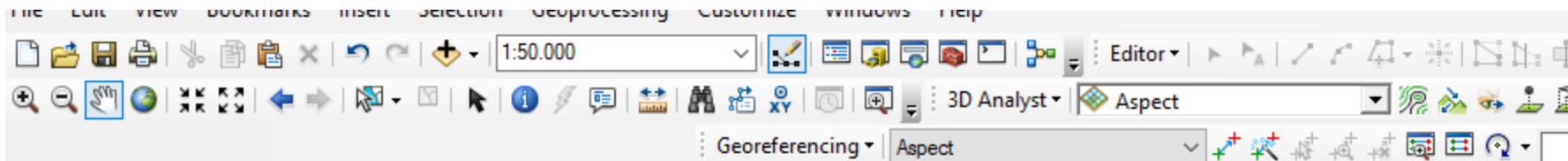
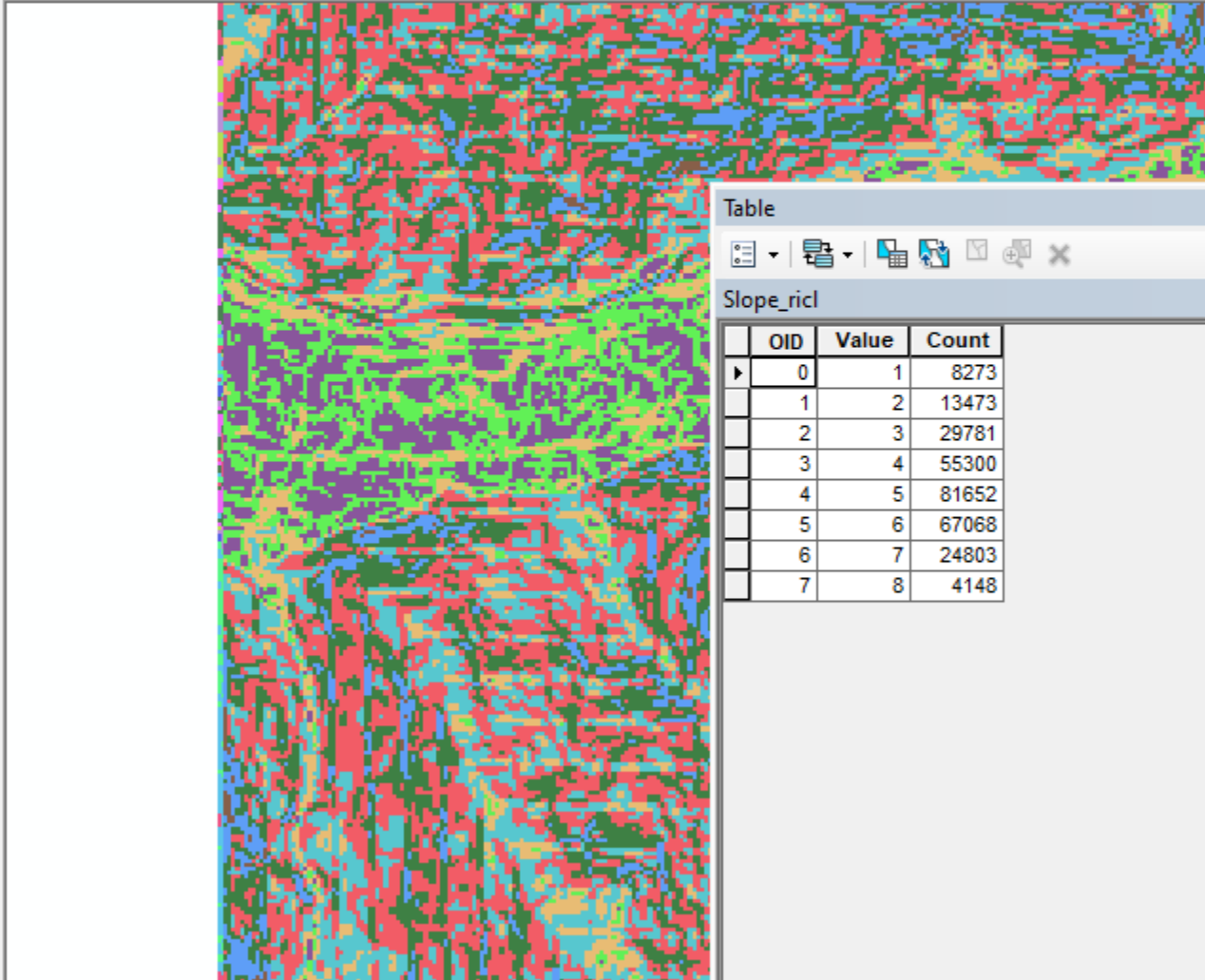


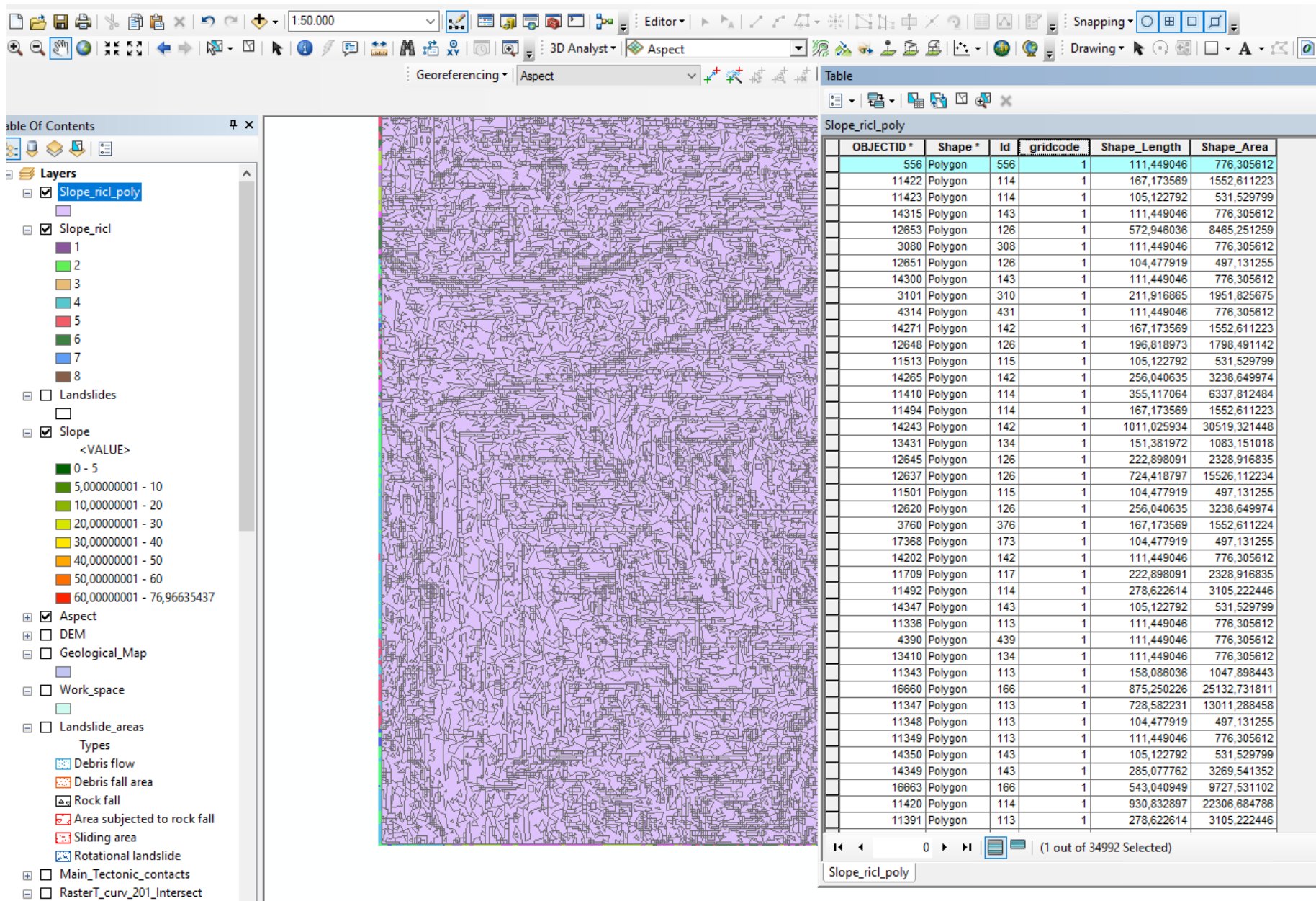
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 - 20,000000001 - 30
 - 30,000000001 - 40
 - 40,000000001 - 50
 - 50,000000001 - 60
 - 60,000000001 - 76,96635437
- Aspect
- DEM
- Geological_Map



Table

Slope_ric1		
OID	Value	Count
0	1	8273
1	2	13473
2	3	29781
3	4	55300
4	5	81652
5	6	67068
6	7	24803
7	8	4148



INTERSEZIONE (INTERSECT)

Intersect

Computes a geometric intersection of the input features. Features or portions of features which overlap in all layers and/or feature classes will be written to the output feature class.

INPUT

INTERSECT FEATURE

OUTPUT

OBJECTID	Shape	FID_Slop	Id	grido	FID_Lands	FID_alope_grad	Id	gridcode	FID_landslides	Id	Type	area	area_1	Shape_Length	Shape_Area
1	Polygon	1600	160	6	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	203,821058	685,917266
2	Polygon	1694	169	6	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	101,985108	652,342858
3	Polygon	1695	169	7	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	82,678956	308,764509
4	Polygon	1772	177	3	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	187,25044	1018,70048
5	Polygon	1773	177	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	111,449046	776,305612
6	Polygon	1774	177	6	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	220,666513	2321,660525
7	Polygon	1775	177	4	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	162,642837	1522,273334
8	Polygon	1776	177	3	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	111,449046	776,305612
9	Polygon	1777	177	4	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	111,449046	776,305612
10	Polygon	1778	177	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	1045,668929	10448,756758
11	Polygon	1779	177	4	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	309,579138	5011,587192
12	Polygon	1780	178	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	167,173569	1552,611224
13	Polygon	1781	178	6	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	139,205163	759,50477
14	Polygon	1877	187	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	109,00536	766,514219
15	Polygon	1878	187	7	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	278,622614	3105,222446
16	Polygon	1879	187	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	104,477919	497,131255
17	Polygon	1880	188	4	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	167,173569	1552,611223
18	Polygon	1881	188	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	111,449046	776,305612
19	Polygon	1882	188	6	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	78,642976	343,954142
20	Polygon	2150	215	4	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	311,462025	1230,982845
21	Polygon	2151	215	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	167,023486	1552,57429
22	Polygon	2152	215	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	355,698114	4479,714961
23	Polygon	2153	215	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	436,461304	11357,354889
24	Polygon	2154	215	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	105,122792	531,529799
25	Polygon	2155	215	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	3,56789	0,34292
26	Polygon	2195	219	3	12	6183	618	3	48	0	Debris flow	0,303	0,000471	153,398434	1113,074223
27	Polygon	2196	219	5	12	6183	618	3	48	0	Debris flow	0,303	0,000471	87,658583	429,345361
28	Polygon	2197	219	6	12	6183	618	3	48	0	Debris flow	0,303	0,000471	85,682746	214,464404
29	Polygon	2250	225	5	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	97,073771	538,163115
30	Polygon	2251	225	7	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	111,449046	776,305612
31	Polygon	2252	225	7	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	381,014676	5322,759349
32	Polygon	2289	228	3	12	6183	618	3	48	0	Debris flow	0,303	0,000471	34,850059	51,92807
33	Polygon	2290	229	4	12	6183	618	3	48	0	Debris flow	0,303	0,000471	99,825225	579,234768
34	Polygon	2291	229	5	12	6183	618	3	48	0	Debris flow	0,303	0,000471	111,449046	776,305612
35	Polygon	2292	229	6	12	6183	618	3	48	0	Debris flow	0,303	0,000471	111,449046	776,305612
36	Polygon	2353	235	7	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	248,086107	2483,185738
37	Polygon	2354	235	7	8	5094	509	5	18	0	Debris flow	1,70597	0,000532	104,477919	497,131255
38	Polygon	2386	238	4	12	6183	618	3	48	0	Debris flow	0,303	0,000471	45,548976	85,751404
39	Polygon	2387	238	5	12	6183	618	3	48	0	Debris flow	0,303	0,000471	157,596903	1418,546795
40	Polygon	2388	238	7	12	6183	618	3	48	0	Debris flow	0,303	0,000471	373,085695	5768,245904
41	Polygon	2389	238	6	12	6183	618	3	48	0	Debris flow	0,303	0,000471	111,652252	753,77726

FR - ArcMap

File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help

1:62.500 Editor Snapping 3D Analyst Aspect

Georeferencing Aspect

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 - 50,000000001 - 60
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 - Sliding area
 - Rotational landslide
- Main_Tectonic_contacts
- RasterT_curv_201_Intersect
- RasterT_curv_201

Table

Find and Replace...
 Select By Attributes...
 Clear Selection
 Switch Selection
 Select All
 Add Field...
 Turn All Fields On
 Show Field Aliases
 Arrange Tables
 Restore Default Column Widths
 Restore Default Field Order
 Joins and Relates
 Related Tables
 Create Graph...
 Add Table to Layout
 Reload Cache
 Print...
 Reports
 Export... (highlighted)

id	Shape_Length	Shape_Area
6	203,821058	685,917266
6	101,985108	652,342858
7	82,678956	308,764509
3	187,25044	1018,70048
5	111,449046	776,305612
6	220,666513	2321,660525
4	162,642837	1522,273334
3	111,449046	776,305612
4	111,449046	776,305612
5	1045,668929	10448,756758
4	309,579138	5011,587192
5	167,173569	1552,611224
6	139,205163	759,50477
5	109,00536	766,514219
7	278,622614	3105,222446
5	104,477919	497,131255
4	167,173569	1552,611223
5	111,449046	776,305612
6	78,642976	343,954142
4	311,462025	1230,982845
5	167,023486	1552,57429
5	355,698114	4479,714961
5	438,461304	11357,354889
5	105,122792	531,529799
5	3,56789	0,34292
3	153,386434	1113,074223
7	87,658583	429,345361
7	85,682746	214,464404
7	97,073771	538,163115
7	111,449046	776,305612
7	381,014676	5322,759349
3	34,850059	51,92807
4	99,82525	579,234768
5	111,449046	776,305612
6	111,449046	776,305612
7	248,086107	2483,185738
7	104,477919	497,131255
4	45,548976	85,751404
5	157,596903	1418,546795
7	373,085695	5768,245904
6	111,652252	753,77726

Export
Exports the table to a new table.

1 (0 out of *2000 Selected)

Slope_ric_poly_INT_lands



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Class	Area	%of total area (A)	Area of landslide (B)	Area of landslide (C)	Area of landslide (D)	B+C+D	%	FR ((B+C+D)/A)				
23			222,695155											
24	DISTANCE TO RIVER	0-50 m	6,7879438	3,048087777	0,1746501	0,2845208	0,0077371	0,466908	1,658800337	0,54421016				
25		50-100 m	6,7233039	3,019061596	0,2143126	0,2842564	0,0329781	0,5315471	1,888445922	0,625507583				
26		100-250 m	14,0361858	6,302869858	0,6904754	0,691353	0,1144406	1,496269	5,315847066	0,843401052				
27		> 250 m	195,150215	87,63110024	18,8728778	5,2271203	0,2269014	24,3268995	86,42702437	0,98625972				
28			222,697648											
29	SLOPE ANGLE	0-5°	6,2594577	2,808264262	0,1850585	0,0400646	0,0033871	0,2285102	0,811836158	0,289088235				B=df
30		5-10°	10,3920247	4,662313091	0,5844118	0,1111603	0,0069052	0,7024773	2,495715606	0,535295583				C=rock fall
31		10-20°	22,8841265	10,26681187	2,1527873	0,5912639	0,0257549	2,7698061	9,840386742	0,958465672				D=trasl and
32		20-30°	42,9863317	19,28553316	3,6333476	1,3836245	0,0588408	5,0758129	18,03301753	0,935054135				
33		30-40°	65,4660462	29,37090827	5,8948528	2,0670831	0,1443155	8,1062514	28,79936209	0,980540398				
34		40-50°	53,1034913	23,82452985	5,704099	1,6256455	0,1237156	7,4534601	26,48016767	1,111466536				
35		50-60°	18,7795414	8,425316936	1,6247805	0,6115879	0,0191379	2,2555063	8,013215904	0,951087771				
36		>60°	3,0231641	1,356322561	0,1729632	0,0568156	0	0,2297788	0,816343157	0,601879804				
37			222,894184											
38	SLOPE ASPECT	flat	0,0069867	0,003134534	0	0	0	0	0	0				
39		N	30,3750128	13,62753786	3,5751457	0,0171688	0,3438711	3,9361856	13,98422387	1,026173915				
40		NE	25,6948548	11,52781758	2,164267	0,0985499	0,0222519	2,2850688	8,118243629	0,70423075				
41		E	24,6272215	11,04883134	1,3525631	1,3232229	0,0013976	2,6771836	9,511323555	0,860844307				
42		SE	28,5115158	12,79149292	3,4806896	2,1500515	0,0020941	5,6328352	20,01197009	1,564474938				
43		S	30,226946	13,56110873	4,1970144	0,6959458	0	4,8929602	17,38339037	1,281856131				
44		SW	23,1479144	10,38515052	1,8194268	1,0077295	0	2,8271563	10,0441368	0,967163334				
45		W	30,7483263	13,79502236	0,9684444	0,9958862	0	1,9643306	6,978745838	0,505888693				
46		NW	29,555578	13,25990415	2,3947606	0,1986952	0,0124425	2,6058983	9,258065784	0,698200053				
47			222,894356											
48	FAULTS	0-5 km	31,33283	14,06967312	1,5275626	0	0	1,5275626	5,42702493	0,385725019				
49		5-10 km	62,22201	27,94012994	7,3663063	0	0,3820572	7,7483635	27,52788127	0,985245284				
50		>10 km	129,1428	57,99019693	11,0584465	6,4872505	0	17,545697	62,33520972	1,074926678				
51			222,69764											
52	CURVATURE	hollow	33,1666796	14,78723722	4,656034	0,5098583	0,0220242	5,1879165	18,4312919	1,246432422				
53		nose	59,2303644	26,40763138	4,4599974	1,5078899	0,0486835	6,0165708	21,37528094	0,809435751				
54		planar	131,895561	58,8051314	10,8368006	4,4766467	0,3113494	15,6247967	55,51076023	0,943978168				
55			224,292605											

RICLASSIFICO DIRETTAMENTE A PARTIRE DAL COMANDO *Reclassify*

The image displays the ArcGIS software interface with the **Reclassify** tool active. The tool's input raster is **Aspect**, and the reclassification table is as follows:

Old values	New values
-1 - 0	1
0 - 22,5	2
22,5 - 67,5	3
67,5 - 112,5	4
112,5 - 157,5	5
157,5 - 202,5	6
202,5 - 247,5	7
247,5 - 292,5	8

The **Classification** dialog box is open, showing the following settings:

- Method: Natural Breaks (Jenks)
- Classes: 9
- Columns: 100
- Classification Statistics:
 - Count: 284498
 - Minimum: -1
 - Maximum: 359,856415
 - Sum: 52339768,924684
 - Mean: 183,972362
 - Standard Deviation: 105,169102

The **Break Values** dialog box is also open, showing the following values:

Break Values	%
0	
22,5	
67,5	
112,5	
157,5	
202,5	
247,5	
292,5	
337,5	

The background shows a colorful map of a terrain, and the **Toolbox** on the right side of the screen is visible, listing various tool categories such as **Triangulated Surface**, **Visibility**, **Analysis Tools**, **Cartography Tools**, **Conversion Tools**, **Data Interoperability Tools**, **Data Management Tools**, **Geocoding Tools**, **Geostatistical Analyst Tools**, **Linear Referencing Tools**, **Multidimension Tools**, **Network Analyst Tools**, **Server Tools**, **Spatial Analyst Tools**, **Conditional**, and **Density**.

The Analytical Hierarchy Process (AHP) was used to extract the factor weights in a pairwise comparison matrix. Frequency ratio (FR) method was adopted to drive each class weight. The Weighted linear combination was used in the end to determine the landslide susceptibility index value (LSI).

Quindi riclassifico i raster tematici sulla base dei FR ottenuti
E solo successivamente multiplico ciascun raster per il suo peso.

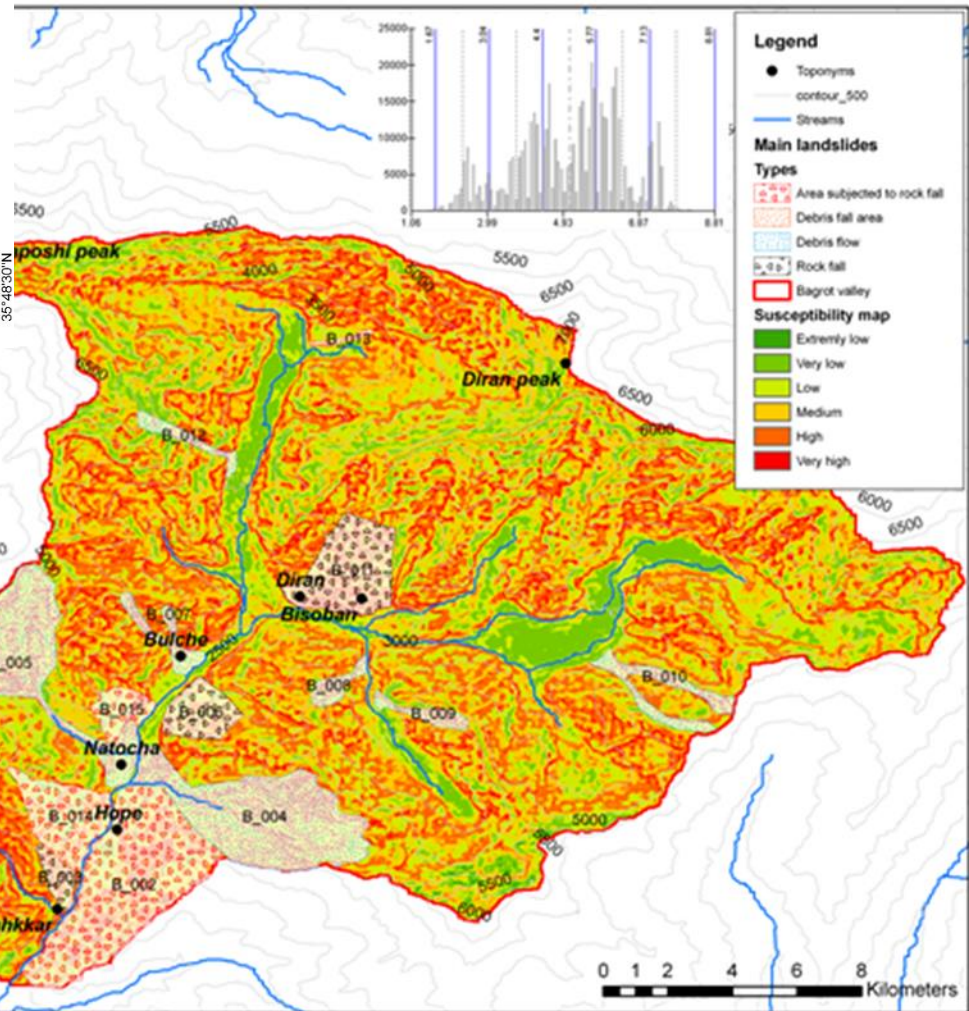
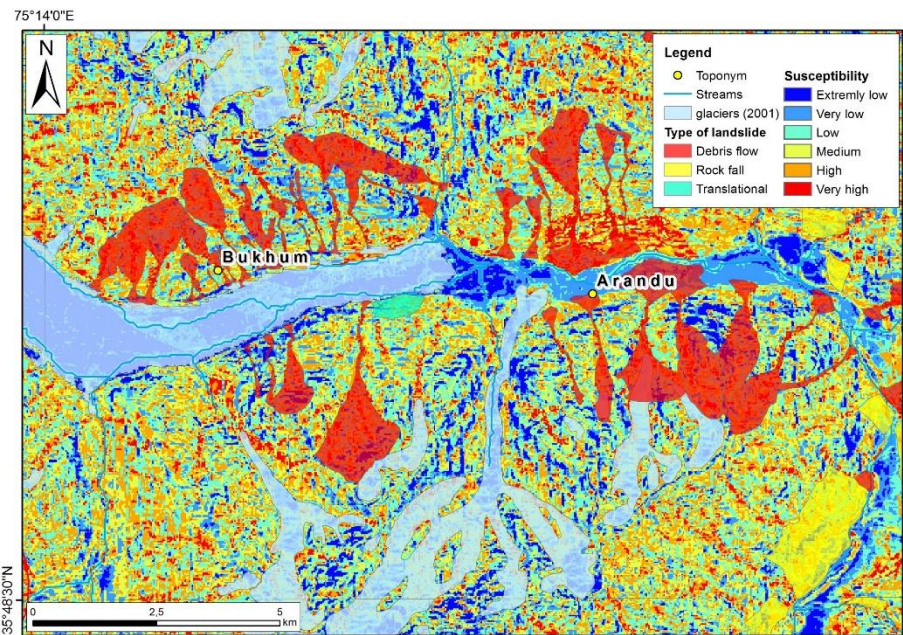
Parameters	1	2	3	4	5	6
(1) Slope	1	5	2	6	7	3
(2) Plan curvature	0,2	1	3	5	7	1
(3) Geology	0,5	0,33	1	3	5	3
(4) Distance from drainage	0,16	0,14	0,33	1	2	4
(5) Distance from lineaments	0,14	0,14	0,2	0,5	1	4
(6) Aspect	0,33	1	0,33	0,25	0,25	1

Tabella 13	Litologia	Acclività	Uso del suolo	Assetto strutturale	Precipitazioni	Esposizione	Caratterizzazione sismica
Litologia	1	3	5	5	7	8	9
Acclività	1/3	1	3	3	4	5	6
Uso del suolo	1/5	1/3	1	1	3	4	5
Assetto strutturale	1/5	1/3	1	1	3	4	5
Precipitazioni	1/7	1/4	1/3	1/3	1	2	3
Esposizione	1/8	1/5	1/4	1/4	1/2	1	2
Caratterizzazione sismica	1/6	1/6	1/5	1/5	1/3	1/2	1
Totale	2.112	5.283	10.783	10.783	18.883	24.5	31



	Litologia	Acclività	Uso del suolo	Assetto strutturale	Precipitazioni	Esposizione	Caratterizzazione sismica	Valore medio
Litologia	0.4735	0.5679	0.4637	0.4637	0.3717	0.3265	0.2903	0.423
Acclività	0.1893	0.2782	0.2782	0.2782	0.2124	0.2041	0.1935	
Uso del suolo	0.0947	0.0631	0.0927	0.0927	0.1593	0.1633	0.1613	0.118
Assetto strutturale	0.0947	0.0631	0.0927	0.0927	0.1593	0.1633	0.1613	0.118
Precipitazioni	0.0676	0.0473	0.0309	0.0309	0.0531	0.0816	0.0968	0.058
Esposizione	0.0592	0.0379	0.0232	0.0232	0.0265	0.0408	0.0645	0.039
Caratterizzazione sismica	0.0526	0.0315	0.0185	0.0185	0.0177	0.0204	0.0323	0.028

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Classes	N. of cells	%	Susceptibility description
1	647	0.13	Extremely low susceptible
2	46760	9.71	Very low susceptible
3	107003	22.22	Low susceptible
4	160054	33.25	Medium susceptible
5	166666	27.76	High susceptible
6	246	6.91	Very high susceptible

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