Use of GIS for Landslide Susceptibility Mapping

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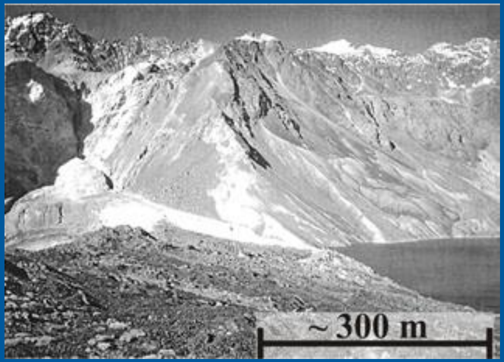
GFZ Centre for Early Warning

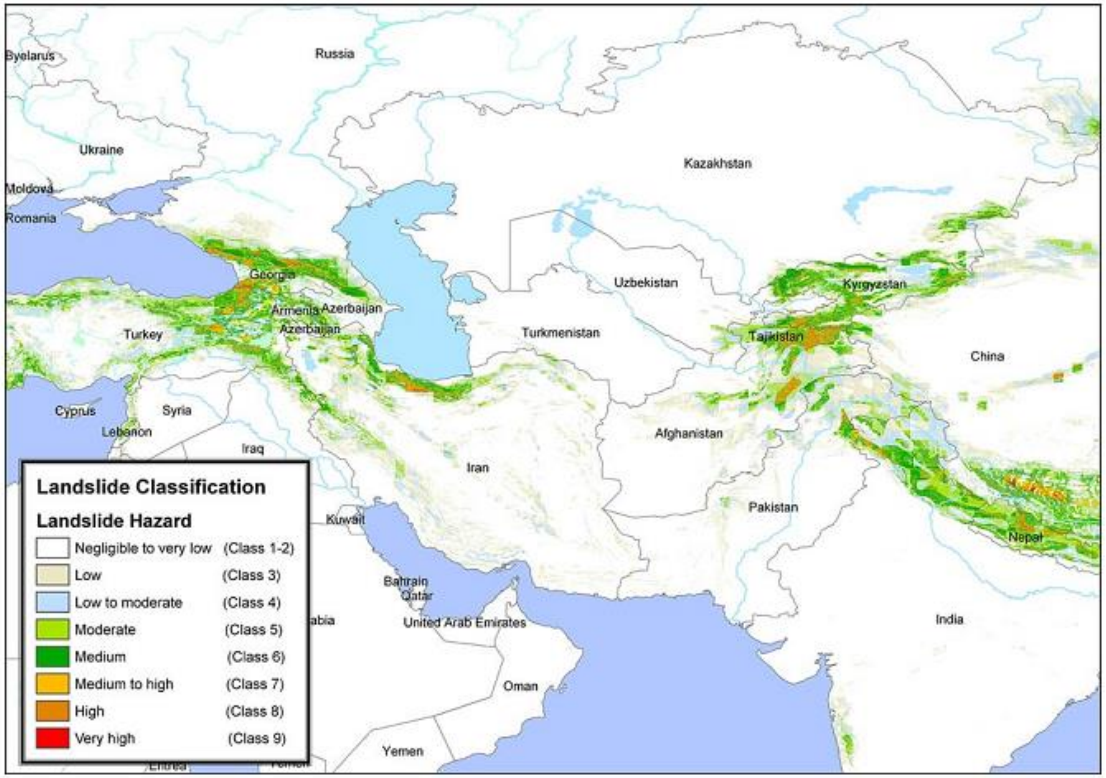


Outline

- Introduction to the problem, the research question and objective
- How can GIS be used for landslide susceptibility mapping in Kyrgyzstan (Central Asia)
- Overview of GIS functionalities for spatial management of raster and vector layers
- Landslide susceptibility results and conclusions

(USGS, 2008)

Central Asia: a global landslide hotspot



Original Article

Landslides (2006) 3: 159–173
DOI: 10.1007/s10346-006-0036-1
Received: 11 August 2005
Accepted: 9 January 2006
Published online: 8 February 2006

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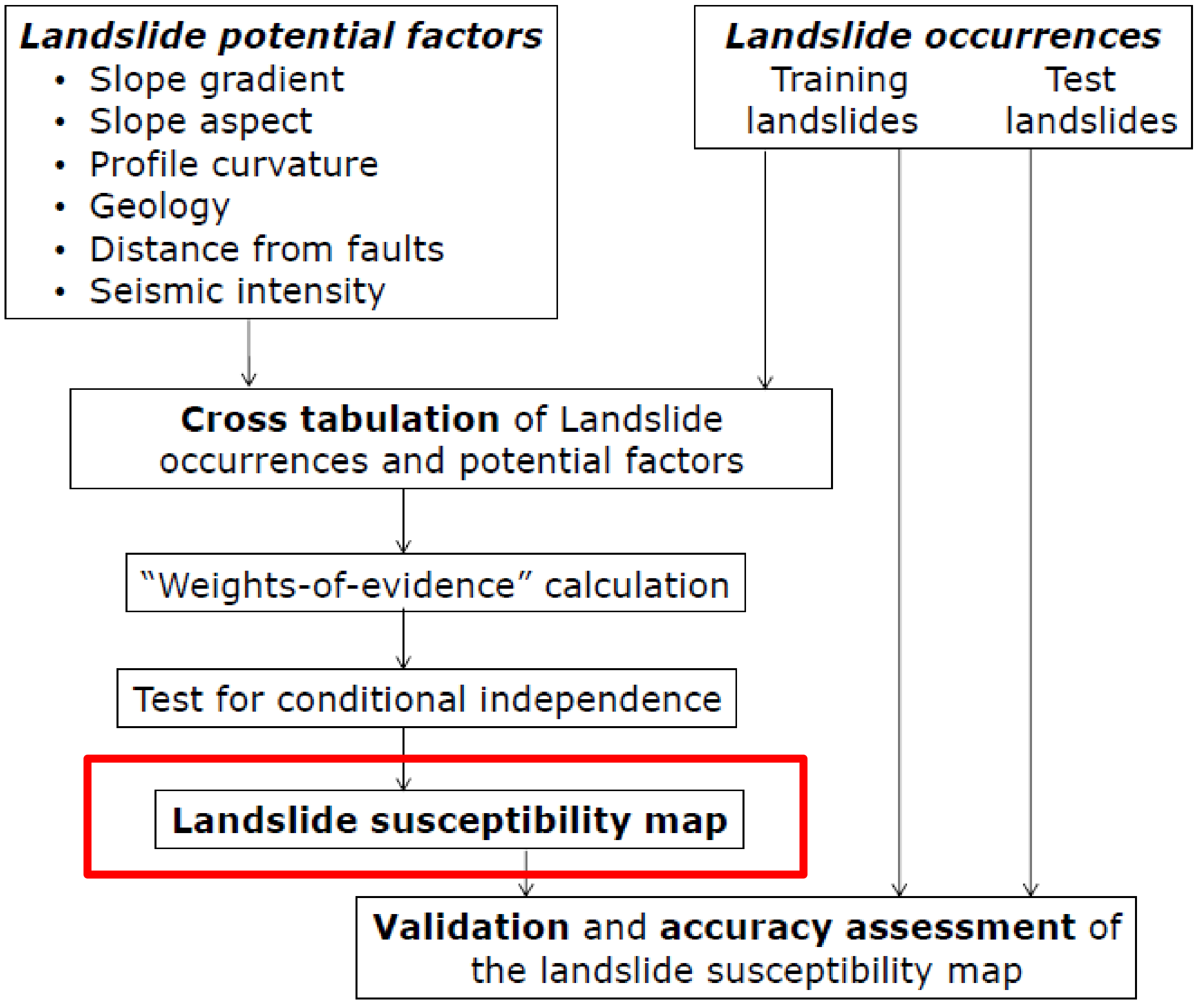
Global landslide and avalanche hotspots

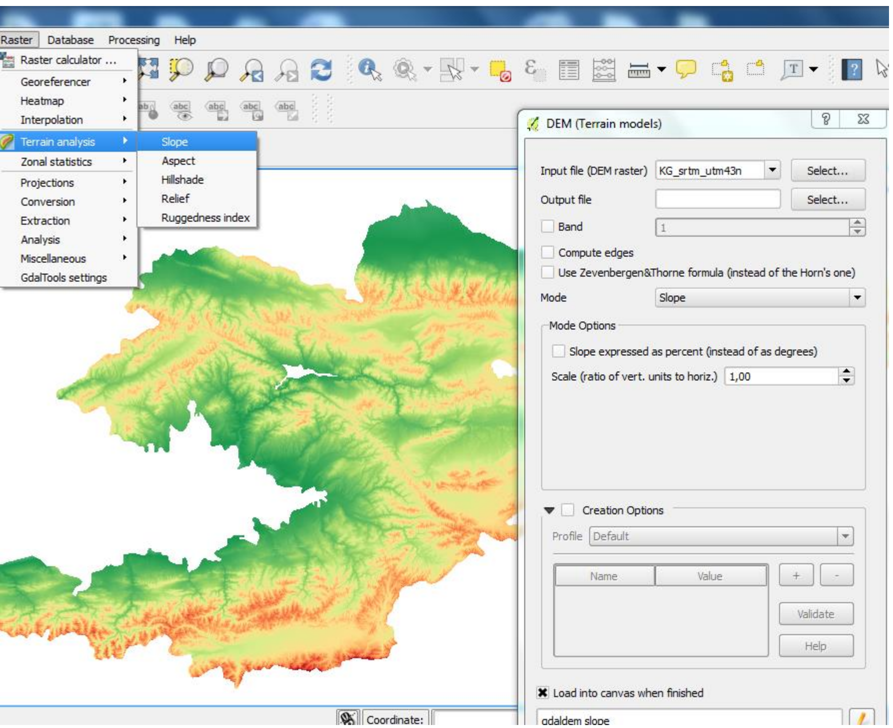
- The **high seismicity** of the area
- The presence of **high topographic relieves**
- The geology of **local materials**

Towards landslide risk evaluation



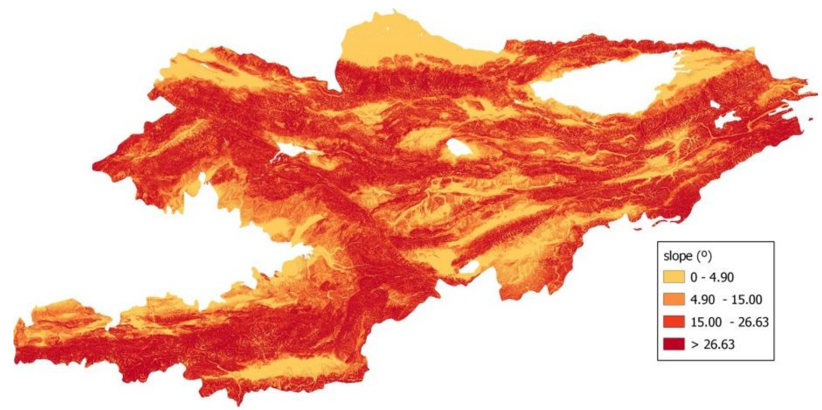
Terrain analysis plugin

- Slope gradient
- Slope aspect
- Profile curvature
- Geology
- Distance from Faults
- Seismic intensity



SRTM Digital Elevation Model (2004)

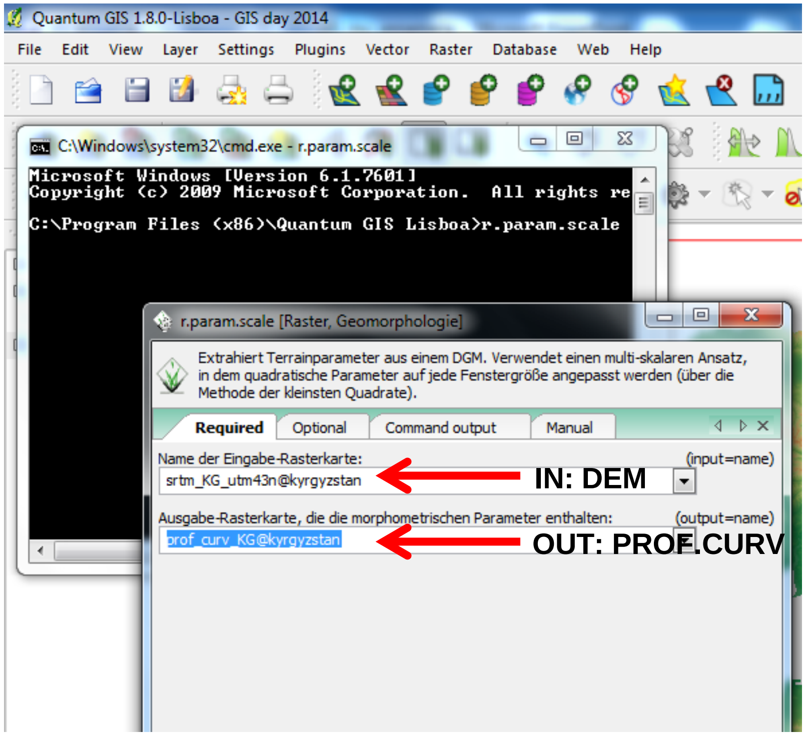
slope



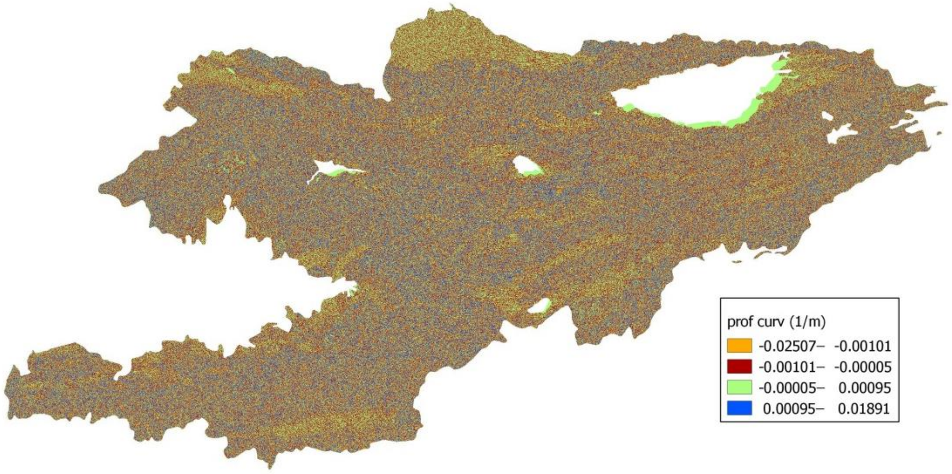
aspect

- Slope gradient
- Slope aspect
- Profile curvature
- Geology
- Distance from Faults
- Seismic intensity

GRASS r.param.scale



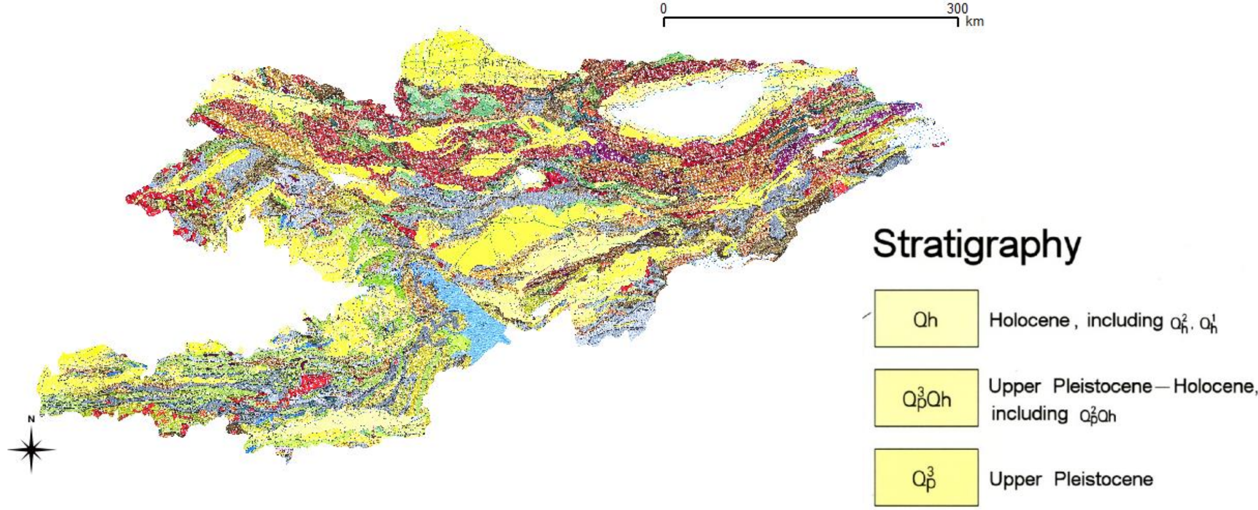
Profile curvature

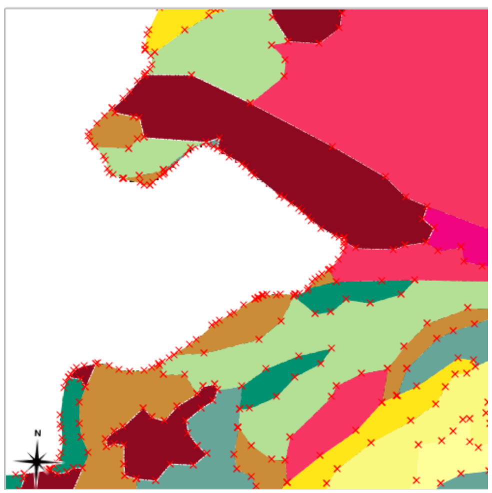


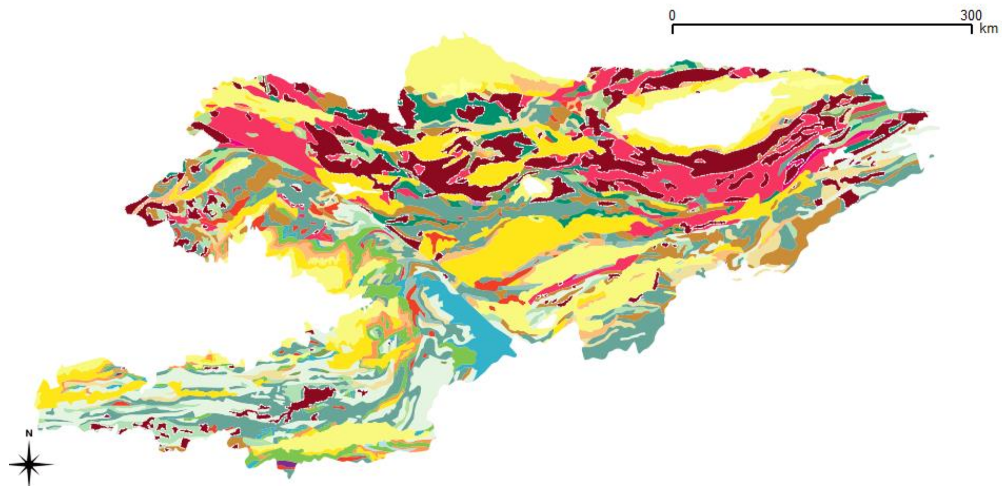
GRASS (Geographic Resources Analysis Support System)

- Slope gradient
- Slope aspect
- Profile curvature
- Geology
- Distance from Faults
- Seismic intensity

Digitization



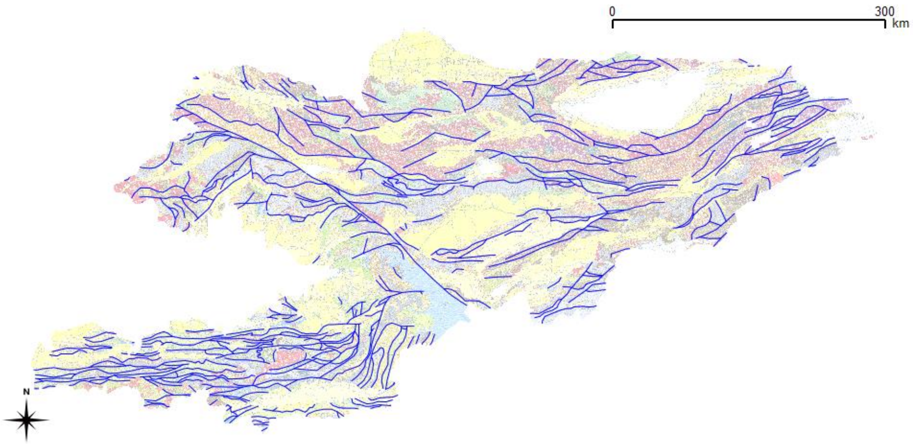


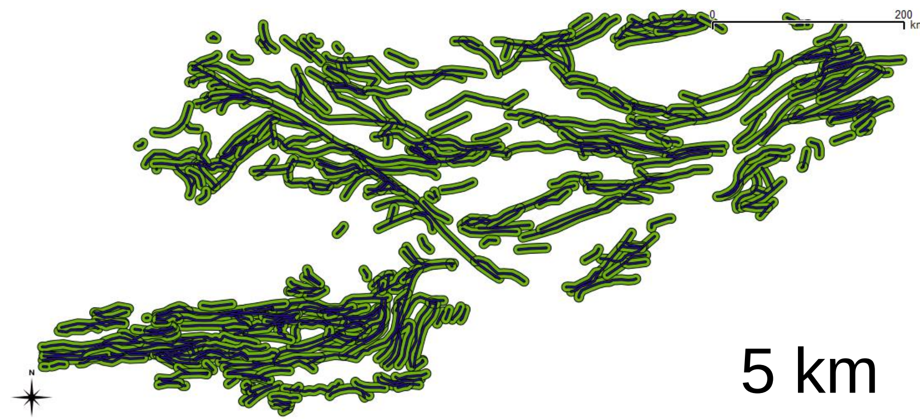


Geological map of Central Asia (2008)

- Slope gradient
- Slope aspect
- Profile curvature
- Geology
- Distance from Faults
- Seismic intensity

Creation of buffer zones

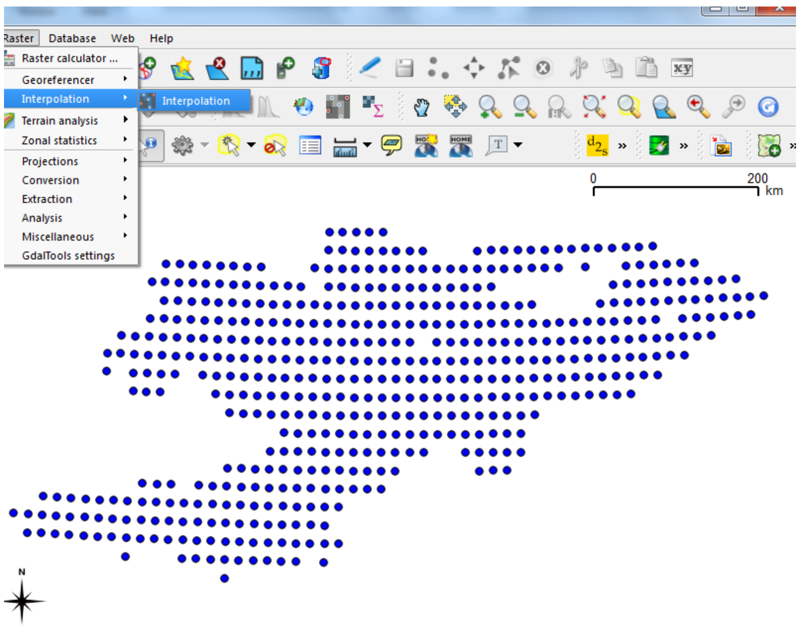


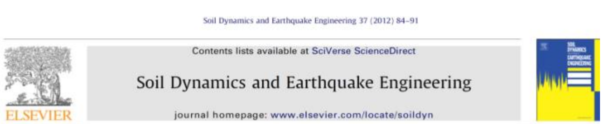


Geological map of Central Asia (2008)

Interpolation

- Slope gradient
- Slope aspect
- Profile curvature
- Geology
- Distance from Faults
- Seismic intensity




Soil Dynamics and Earthquake Engineering 37 (2012) 84–91

Contents lists available at SciVerse ScienceDirect

Soil Dynamics and Earthquake Engineering

journal homepage: www.elsevier.com/locate/soildyn

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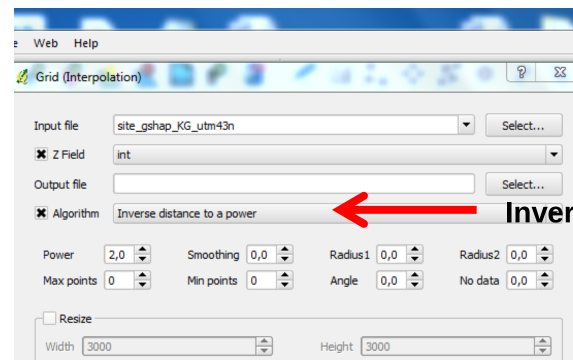
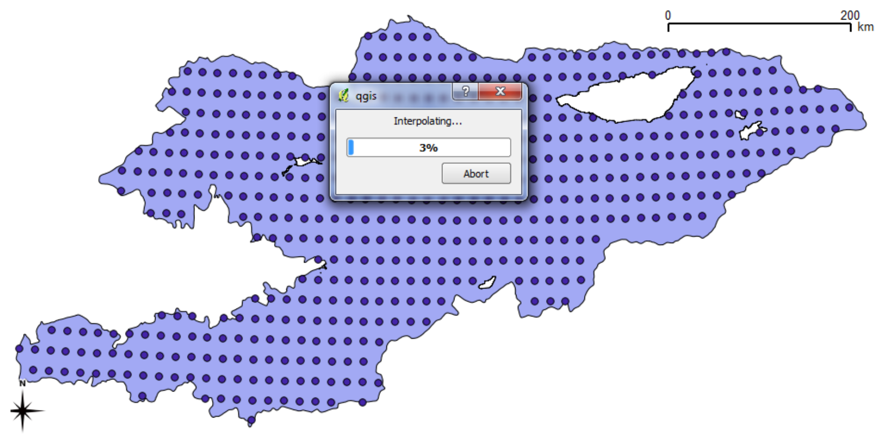
Seismic hazard assessment in Central Asia: Outcomes from a site approach

D. Bindi[a,b,*], K. Abdrakhmatov[c], S. Parolai[d], M. Mucciarelli[e], G. Grünthal[d], A. Ischuk[f], N. Mikhailova[g], J. Zschau[d]

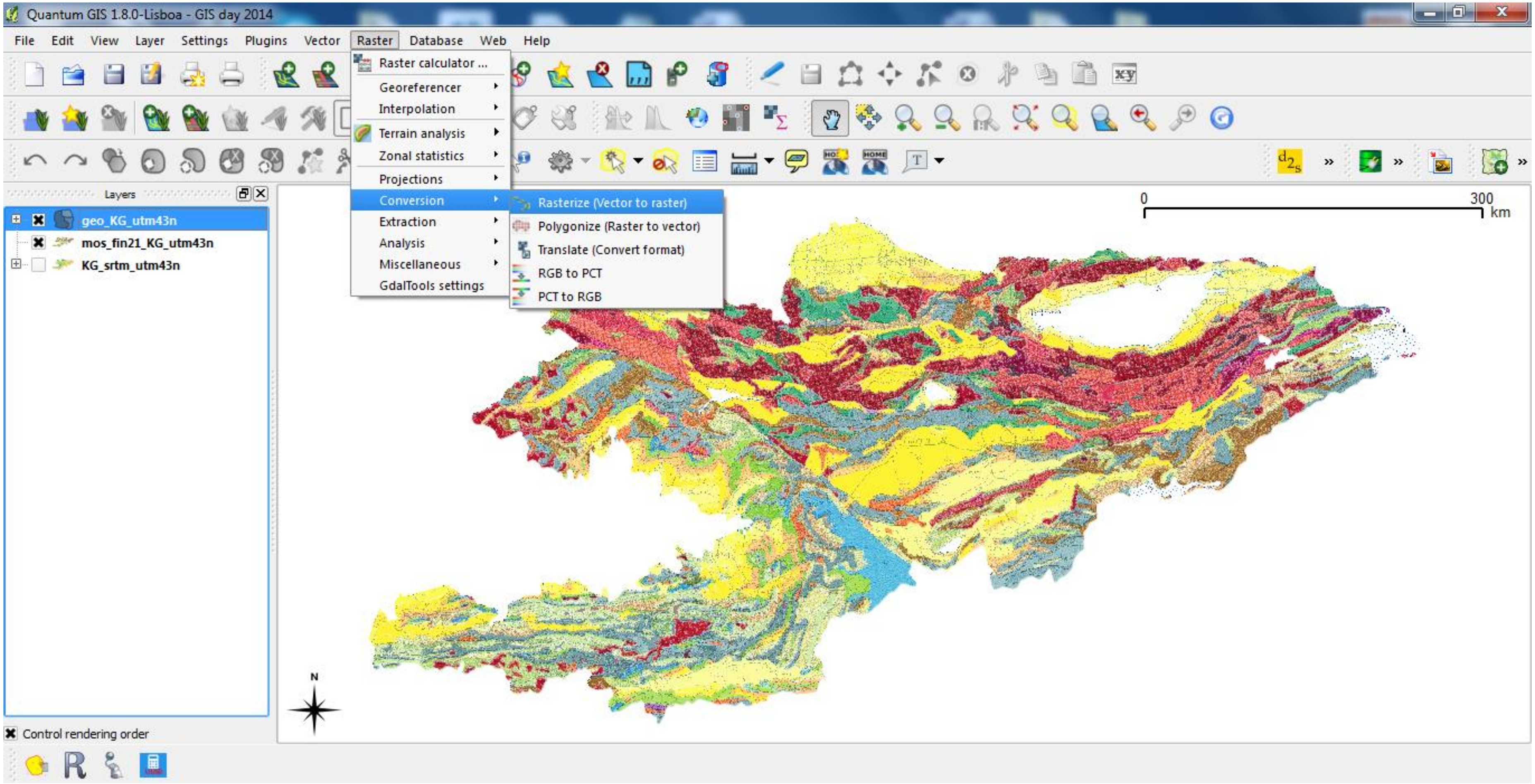
Intensity values with a 10% probability of being exceeded in 50 years



Inverse distance algorithm



Conversion to raster

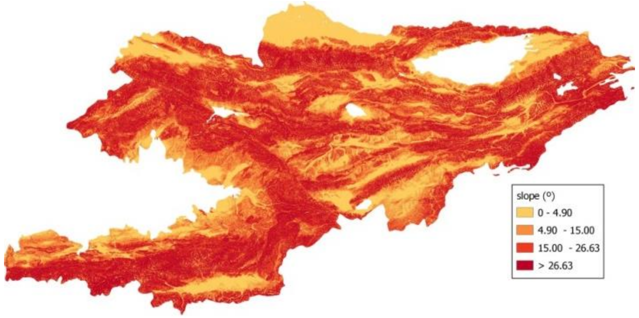


GFZ Helmholtz Centre Potsdam

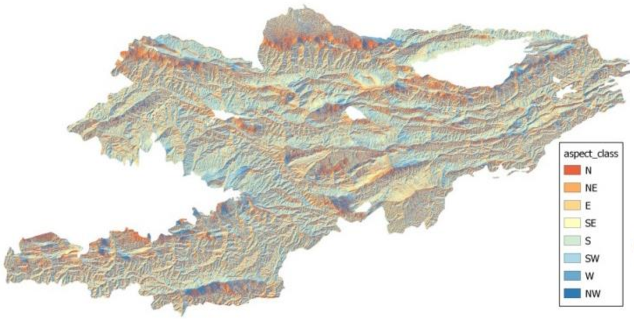
HELMHOLTZ ASSOCIATION

Landslide potential factors

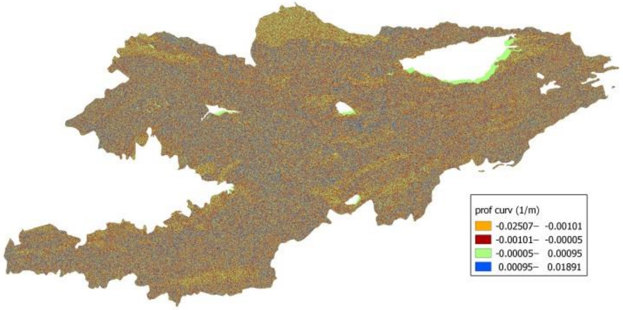
slope



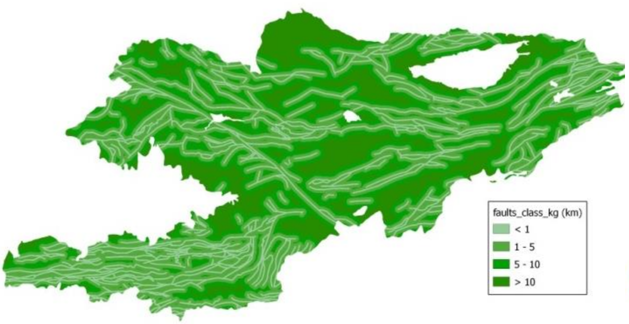
aspect



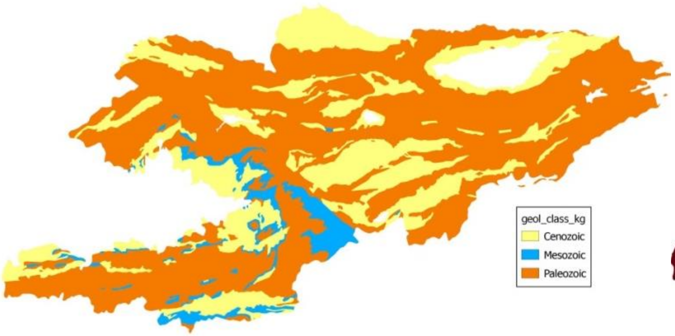
Profile curvature



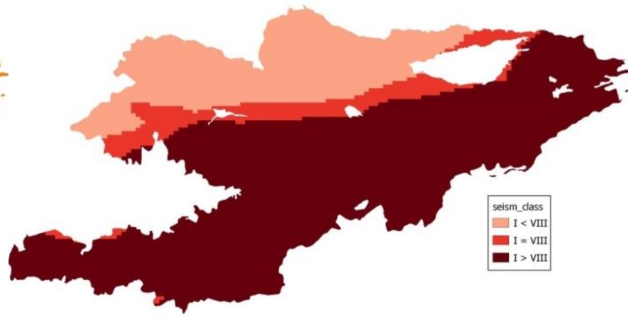
distance from faults



Geology



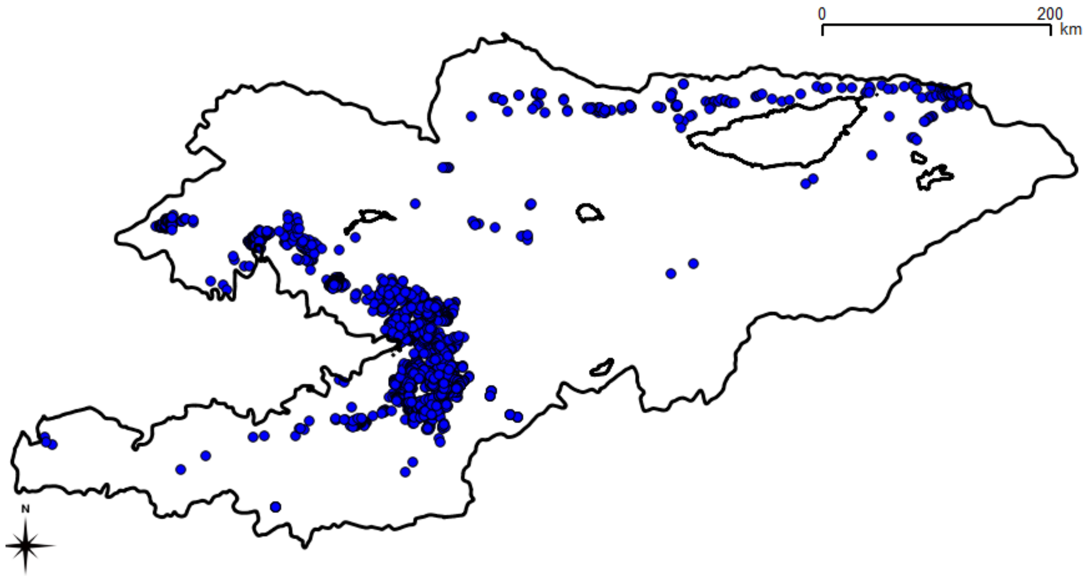
Seismic intensity (MSK)

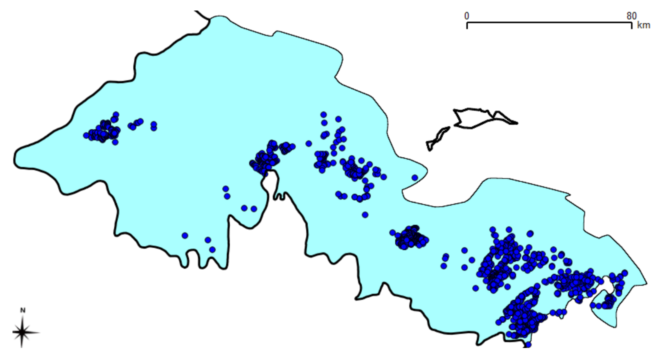


Landslide occurrences

Training landslides | Test landslides

Landslide sample





(CAIAG)

1. Wide variability of landslide factors

2. Study area representative of existing relationships among landslide factors in KG

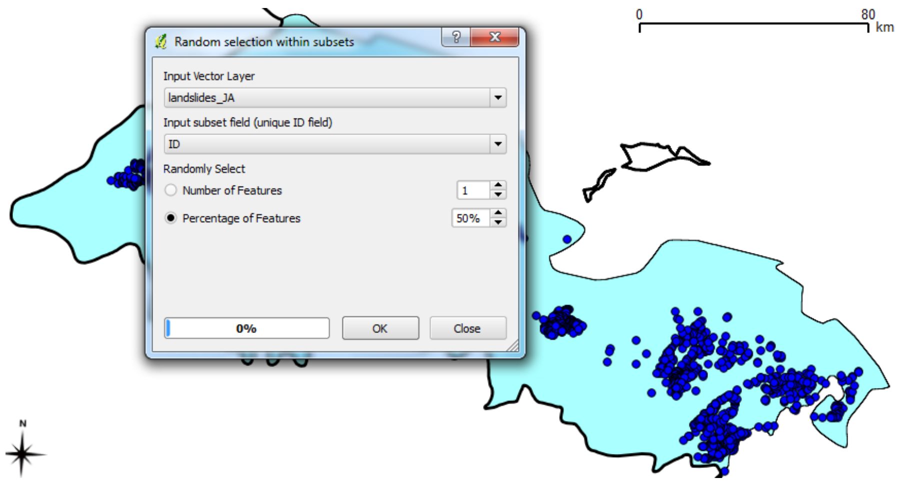
Landslide occurrences

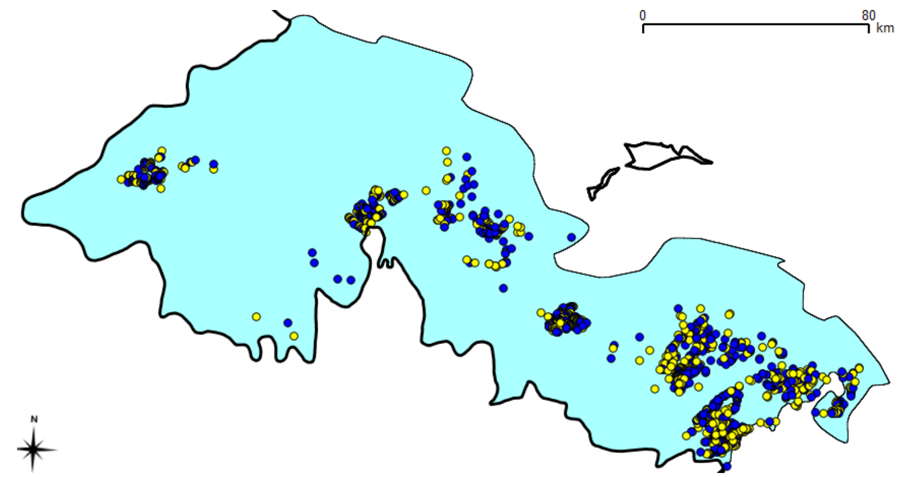
Training landslides　Test landslides

Random selection

Training dataset & landslide factors -> landslide susceptibility **modeling**

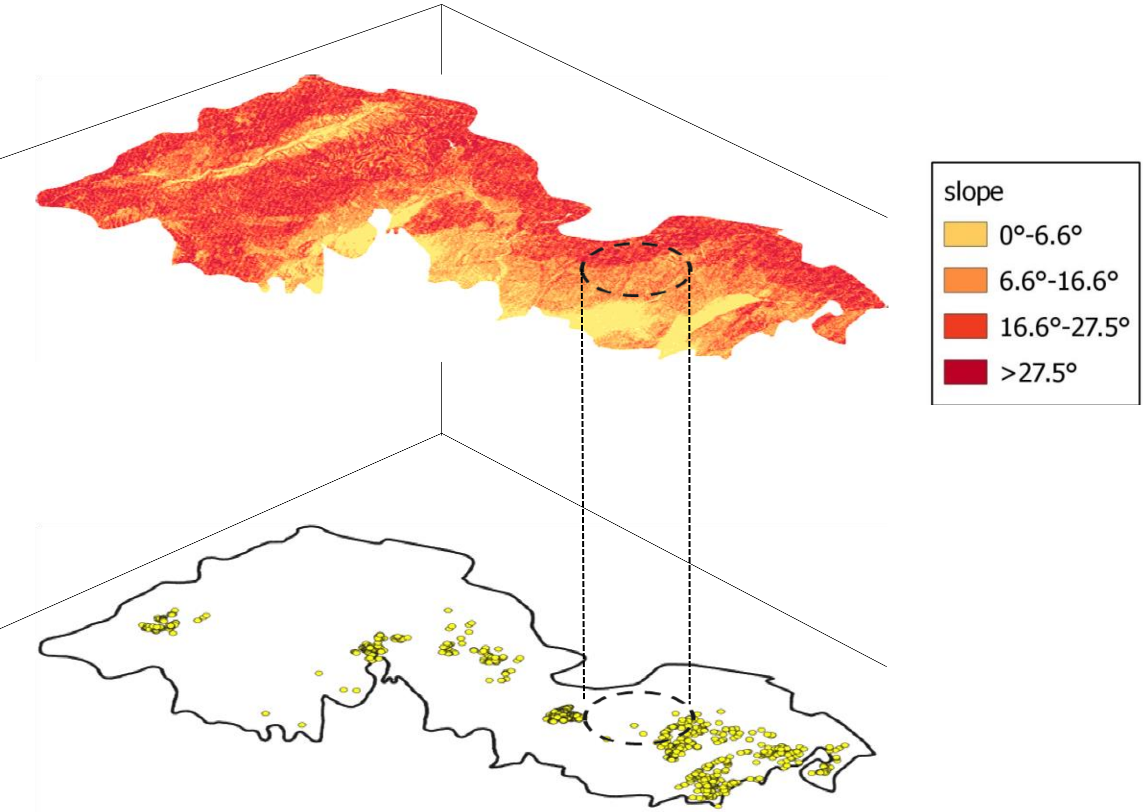
Test dataset & landslide susceptibility -> landslide susceptibility **validation**





Cross tabulation of Landslide occurrences and potential factors

Weights-of-Evidence



How much influent is a landslide factor on landslide occurrence?

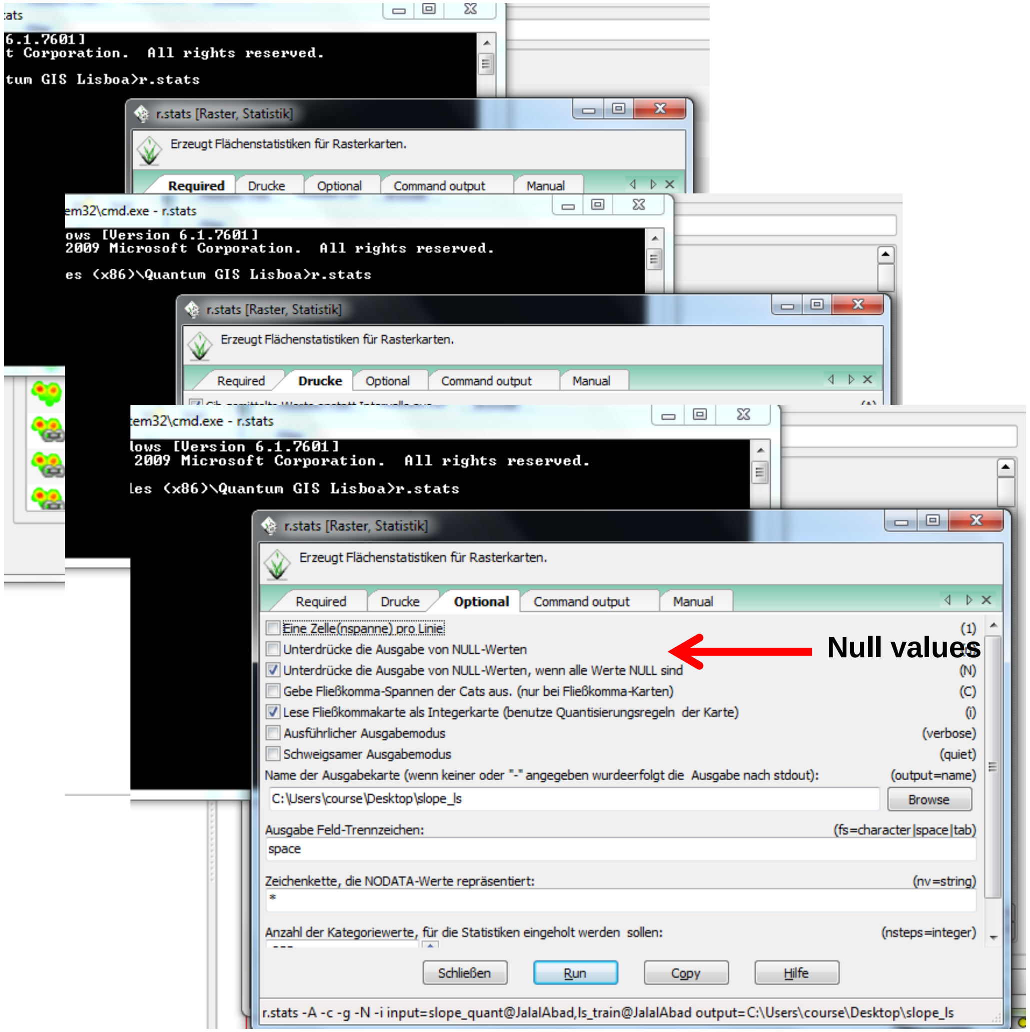
$$W^{+} = \ln \frac{P(F \mid L)}{P(F \mid \bar{L})} = \ln \frac{N\{F \cap L\} / N\{L\}}{N\{F \cap \bar{L}\} / N\{\bar{L}\}}$$

$$W^{-} = \ln \frac{P(\bar{F} \mid L)}{P(\bar{F} \mid \bar{L})} = \ln \frac{N\{\bar{F} \cap L\} / N\{L\}}{N\{\bar{F} \cap \bar{L}\} / N\{\bar{L}\}}$$

(Bonham-Carter et al., 1989)

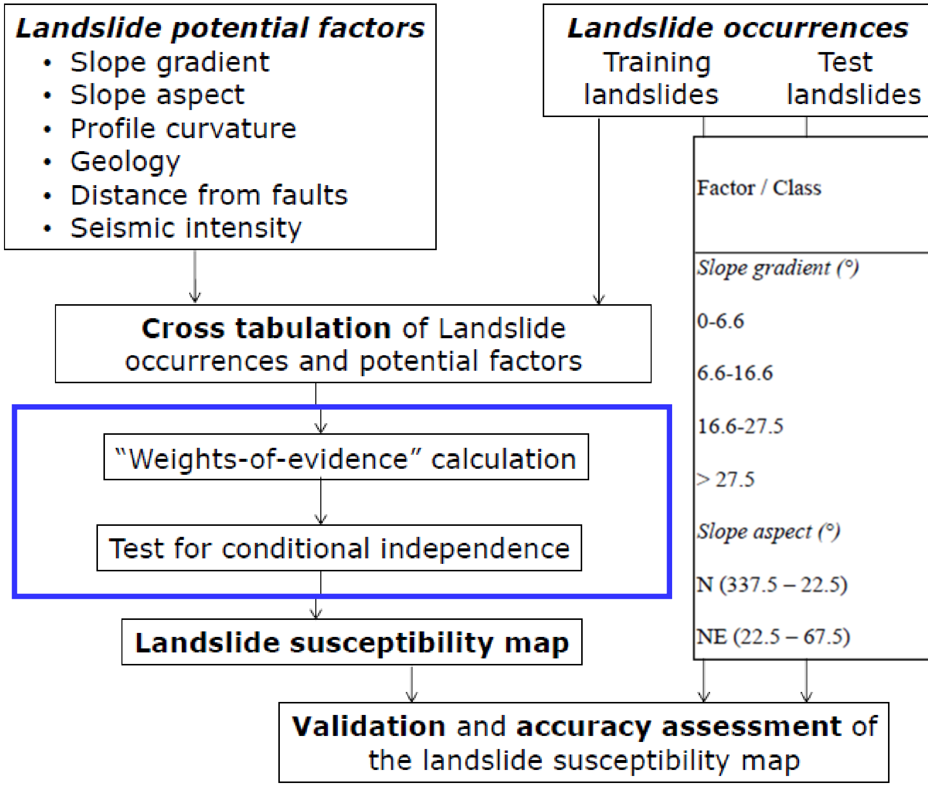
Cross tabulation of Landslide occurrences and potential factors

GRASS r.stats



slope_cl	ls	cells_num
1	1	36
2	1	356
3	1	250
4	1	25

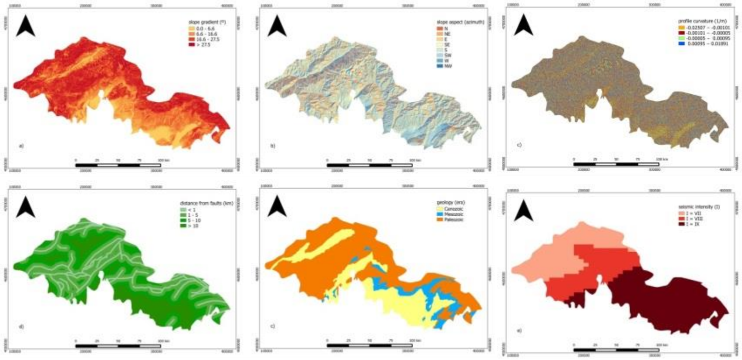
Statistical analysis in R

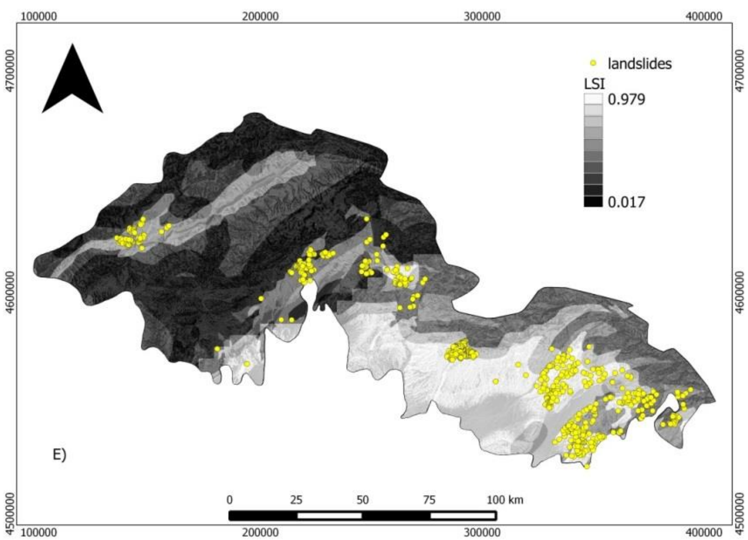


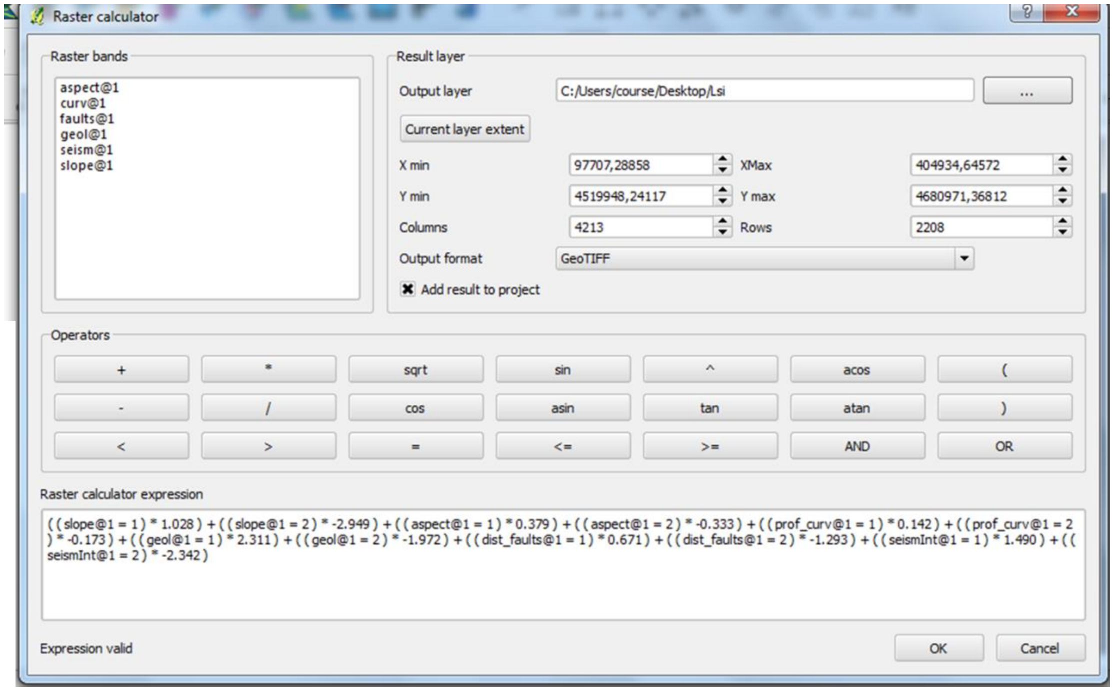
Factor / Class	total cells	landslide cells	free from landslides cells	W^+	$S^2(W^+)$	W^-	$S^2(W\ )$	C	$C/S(C)$
Slope gradient (°)									
0-6.6	560,923	36	560,887	-0.970	0.028	0.098	0.002	-1.069	-6.235
6.6-16.6	1,144,613	356	1,144,257	0.608	0.003	-0.420	0.003	1.028	13.240
16.6-27.5	1,193,560	250	1,193,310	0.213	0.004	-0.109	0.002	0.321	4.017
> 27.5	1,025,605	25	1,025,580	-1.938	0.040	0.263	0.002	-2.202	-10.801
Slope aspect (°)									
N (337.5 – 22.5)	353,555	84	353,471	0.339	0.012	-0.041	0.002	0.379	3.249
NE (22.5 – 67.5)	364,992	57	364,935	-0.081	0.018	0.008	0.002	-0.089	-0.642

Landslide susceptibility map

Raster calculator

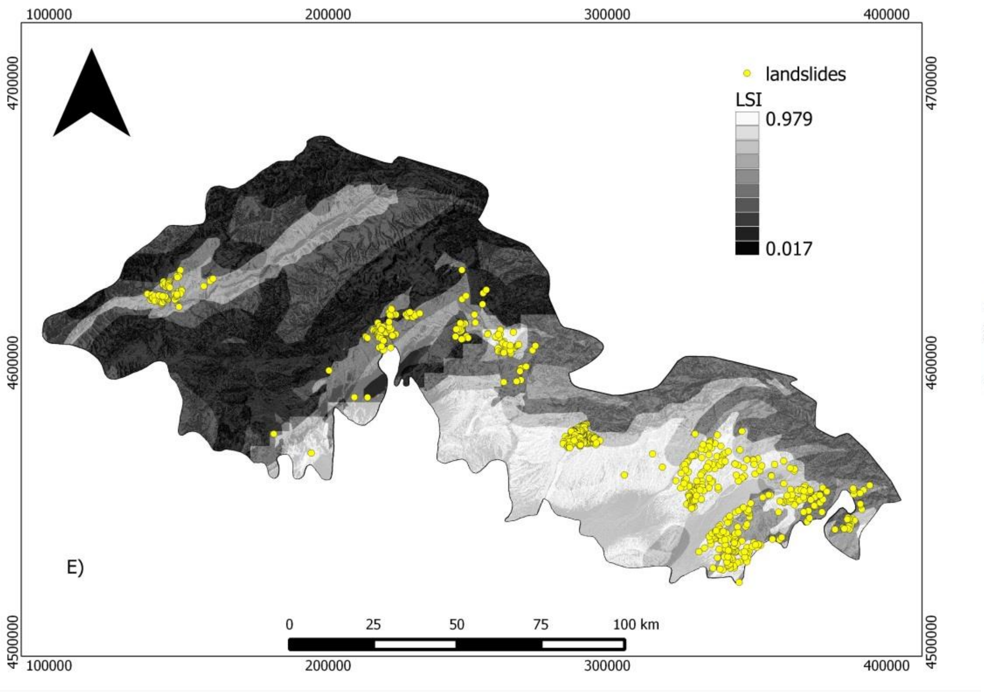


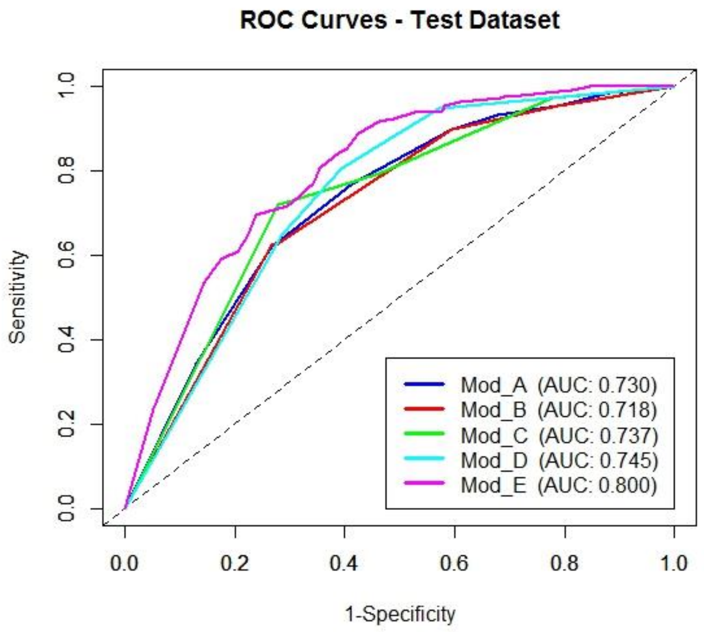




Validation and **accuracy assessment** of the landslide susceptibility map

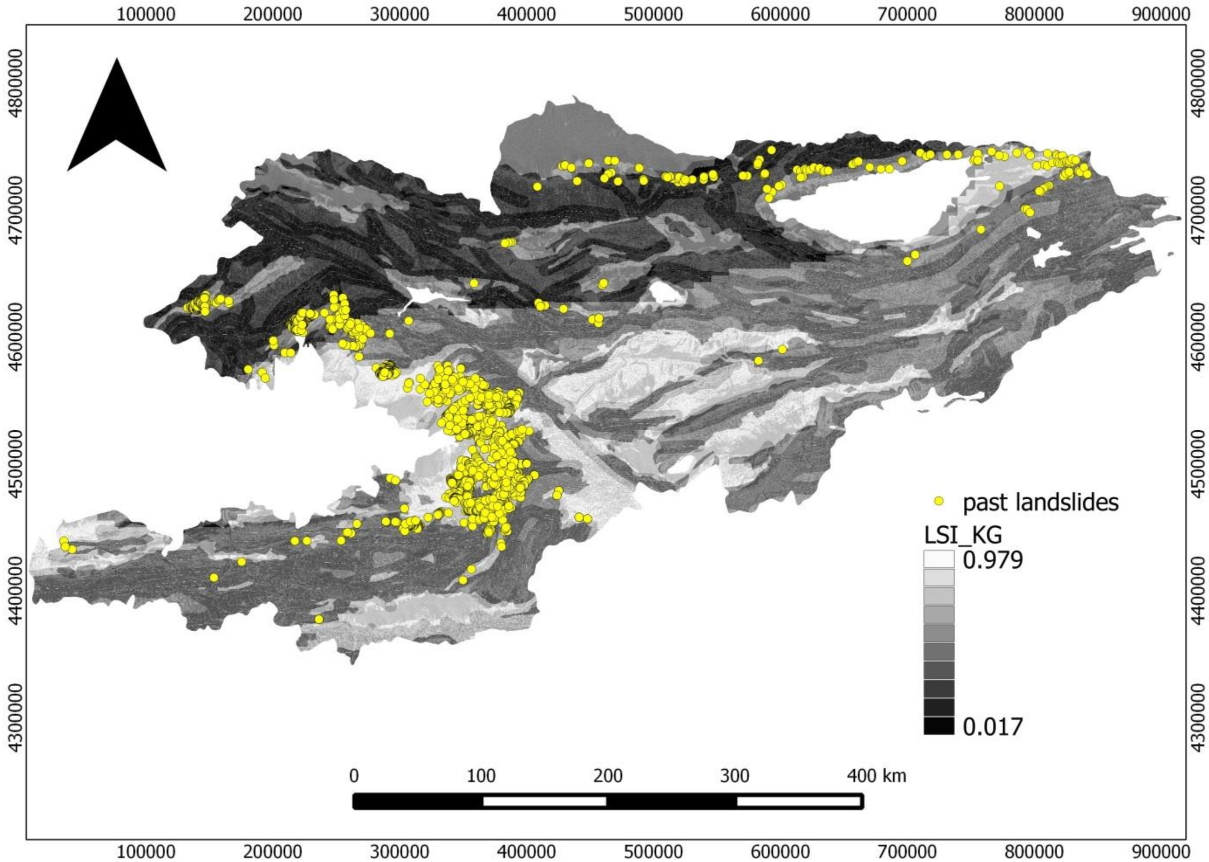
ROC curves





(Saponaro et al., submitted)

Landslide susceptibility results: Kyrgyzstan



(Saponaro et al., submitted)

Conclusions

- One of the preliminary steps in the direction of **minimizing landslide risk** is represented by susceptibility analysis
- A procedure for **landslide susceptibility mapping** is presented
- A range of GIS functionalities and plugins allow for landslide factors analysis and processing, in particular **terrain analysis, interpolation, cross-tabulation of maps**
- Combined with **R**, **QGIS** can be a powerful tool for identifying areas where exists a potential for landslide activation

Thank you!