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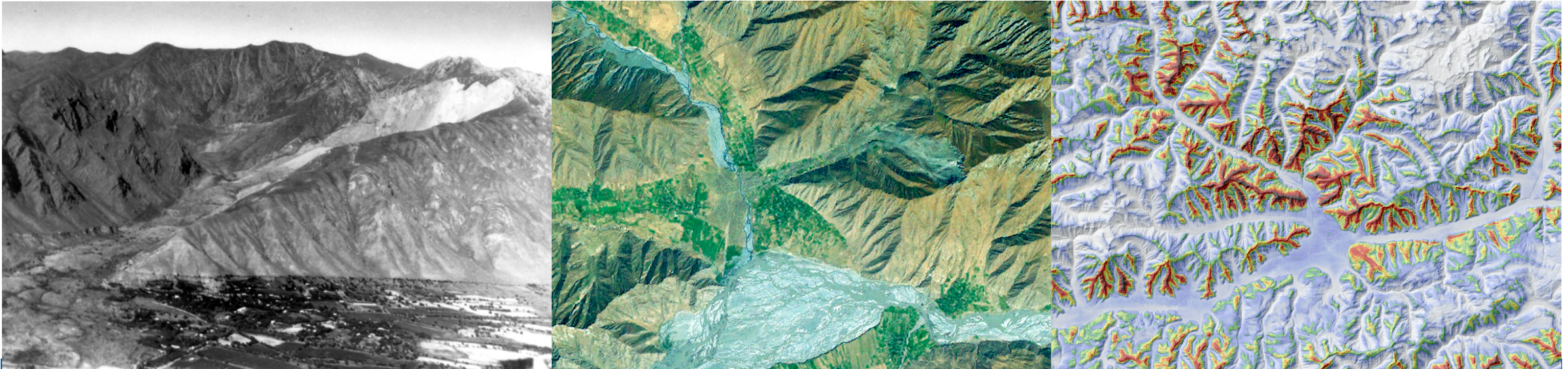
HiF

HELMHOLTZ INSTITUTE FREIBERG
FOR RESOURCE TECHNOLOGY



CLIENT II

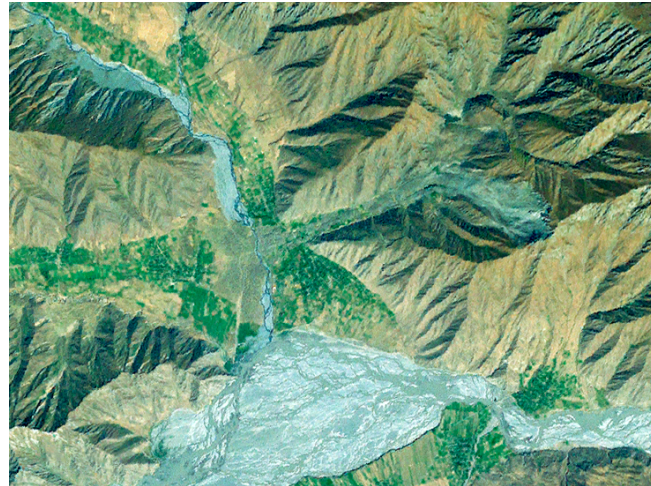
International Partnerships
for Sustainable Innovations



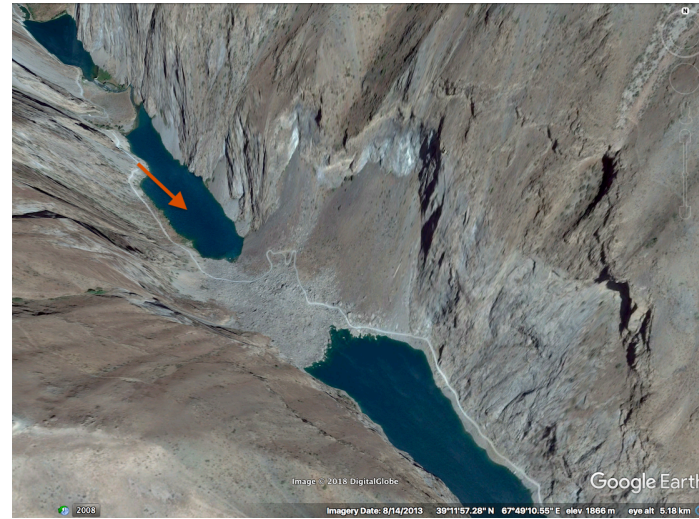
Regional landslide susceptibility assessment in SW Tien Shan using Random forest and DEM derivatives

Natalie Barbosa, Louis Andreani, Richard Gloaguen.

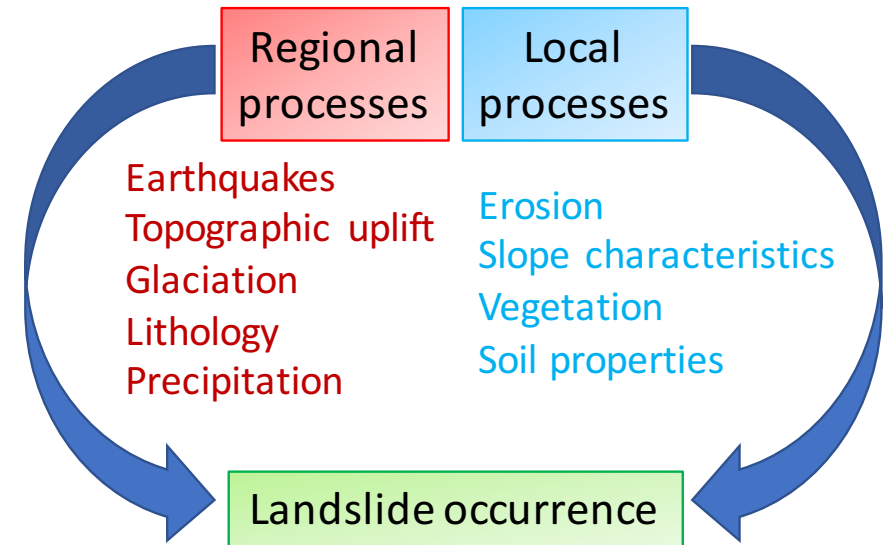
LANDSLIDES



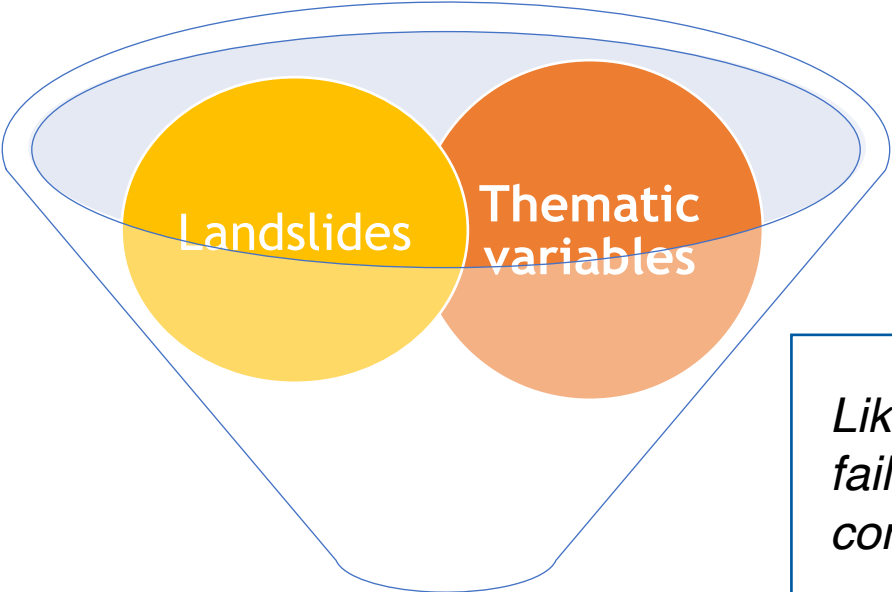
Khait Earthquake (M 7.4), 1949



Seven Lakes – Tien Shan



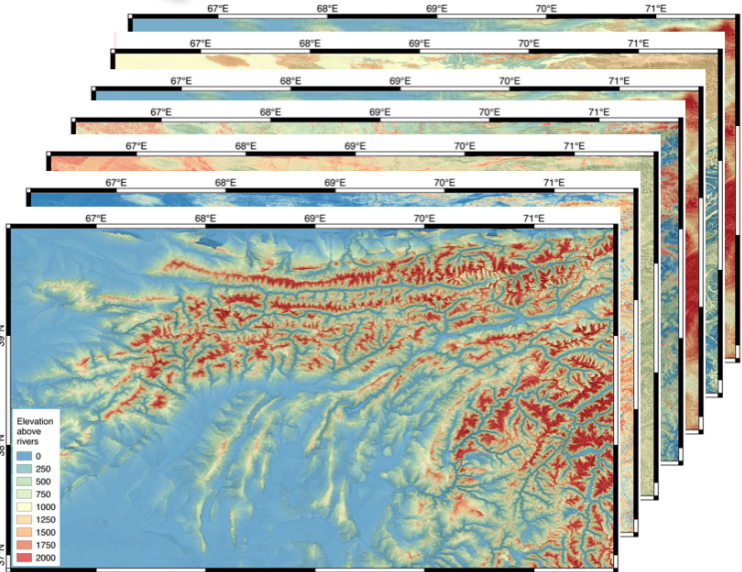
LANDSLIDE SUSCEPTIBILITY



Likelihood of occurrence of a slope failure in an area given certain local conditions (Brabb, 1985).

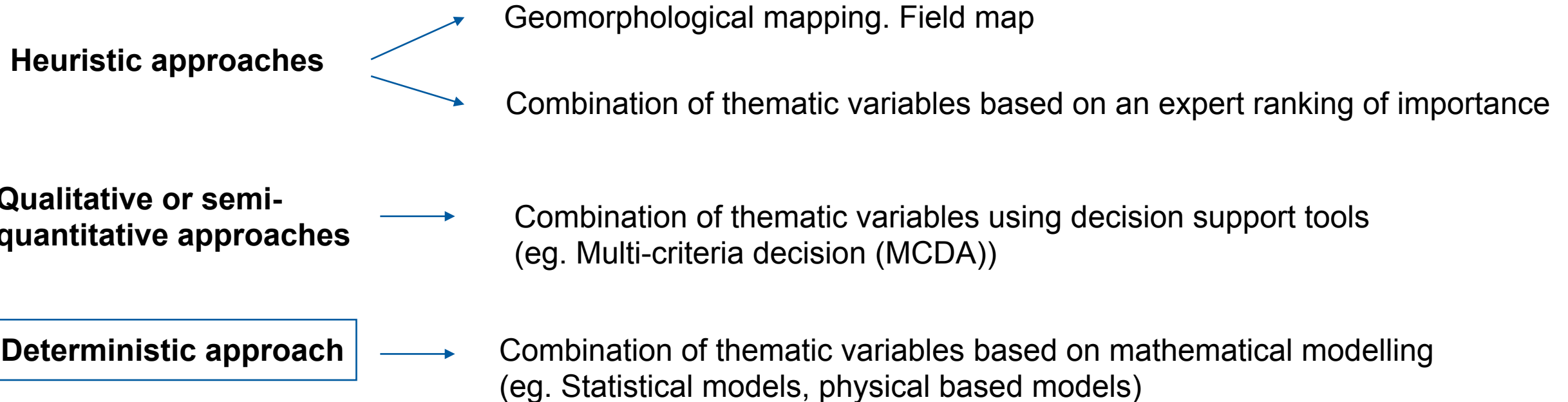


Landslide susceptibility model

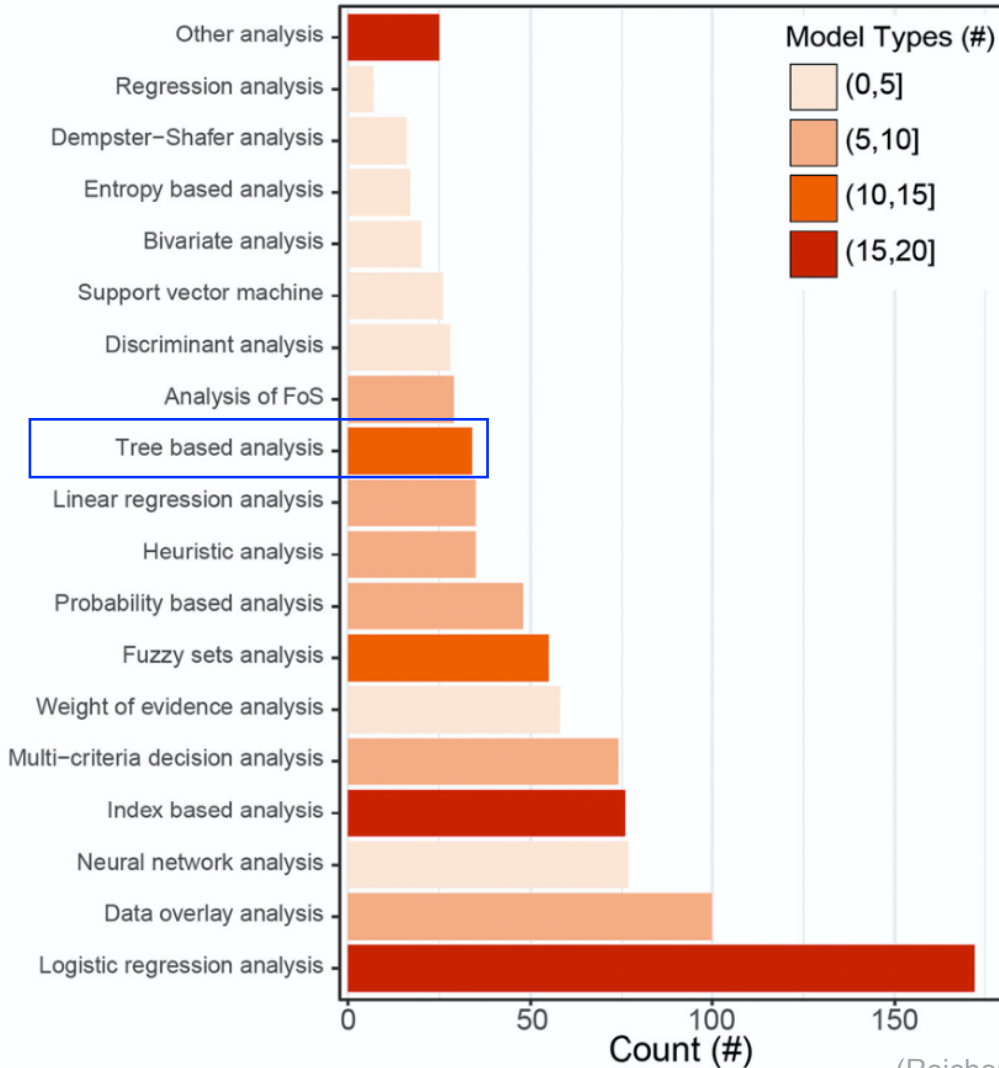


LANDSLIDE SUSCEPTIBILITY MODELS

Landslide susceptibility predicts “**where**” landslides are likely to occur (Guzzetti et al.,2006). It does not consider “when”, “how frequently” and nor the magnitude of the expected landslide.



STATISTICALLY BASED MODELS



(Reichenbach et al, 2018)

Indirect methods. Partially based field on observations, expert knowledge and statistical computation

The **computations determine the importance of the thematic variables** based on relationship with the landslide catalogue

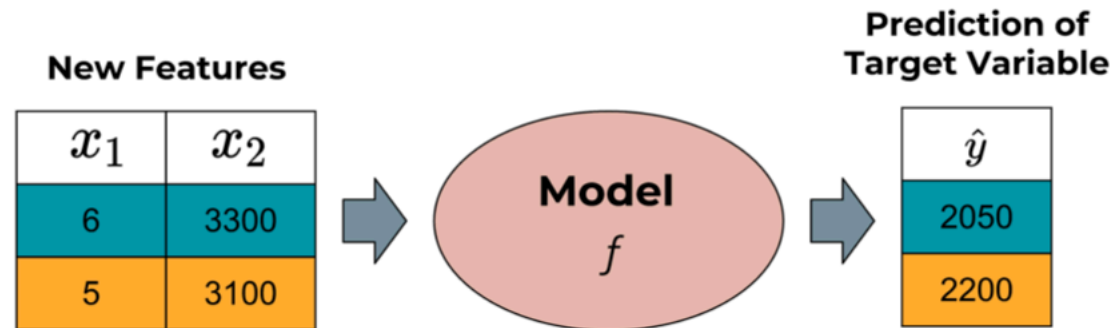
The **probability of occurrence of a landslide is given based on the identified relationships**

RANDOM FOREST

Machine learning is a branch of statistics and computer science.

A computer program is said to learn from **experience E** with respect to some **task T** and some **performance measure P**, if performance on T, as measured by P, improve with experience E.

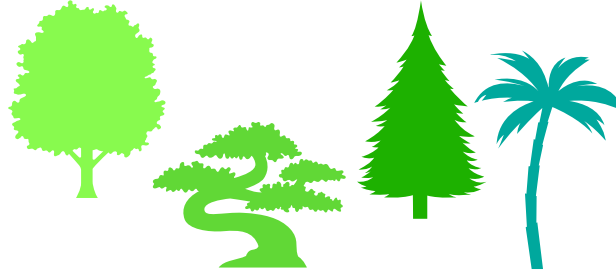
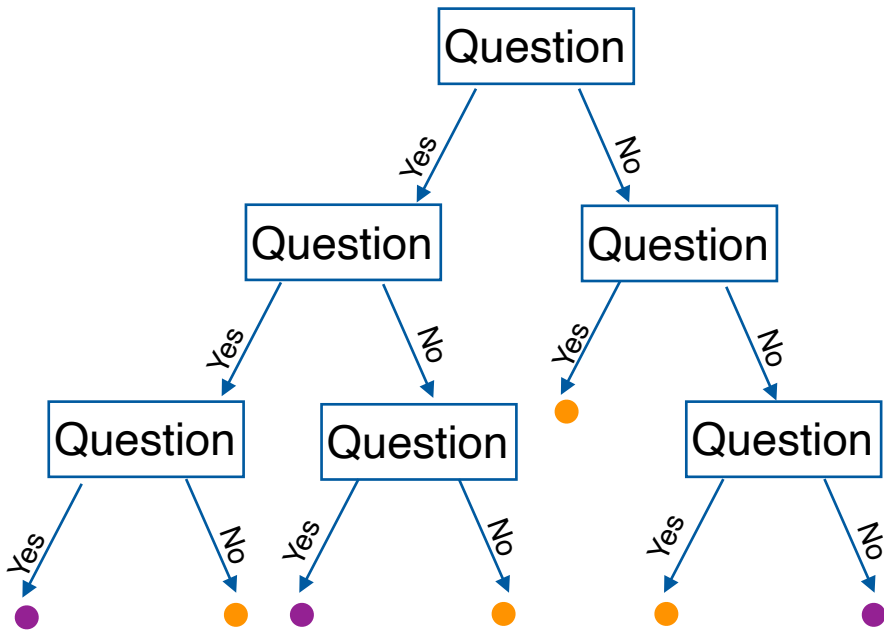
A machine learning model is a function that maps thematic variables into predictions based on **pattern recognition**.



RANDOM FOREST

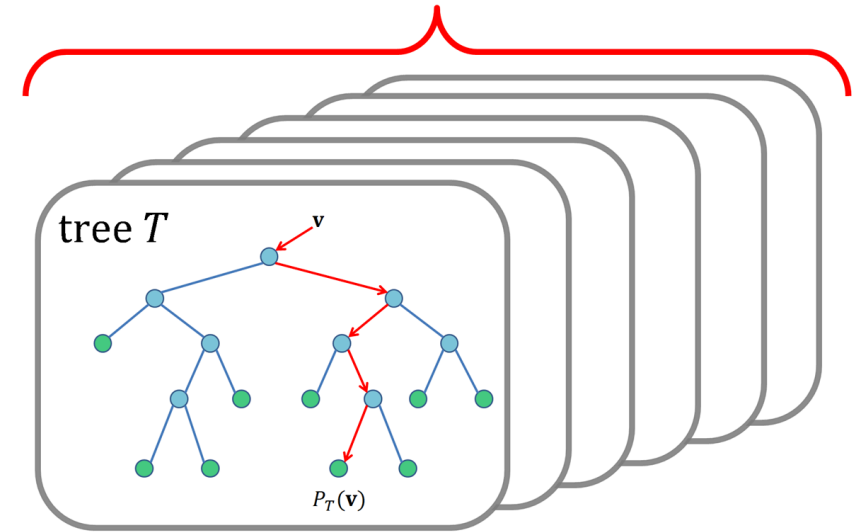
Algorithm based on multiple classification trees
— Forest— (Breiman, 2001)

Single decision tree



Ensemble of decision trees

Decision Forest

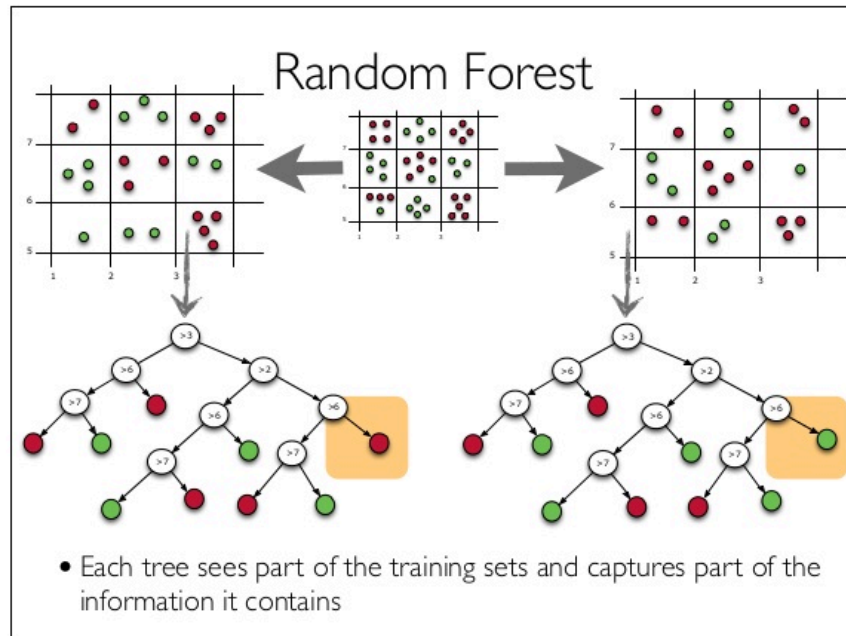


<https://dimensionless.in/introduction-to-random-forest/>

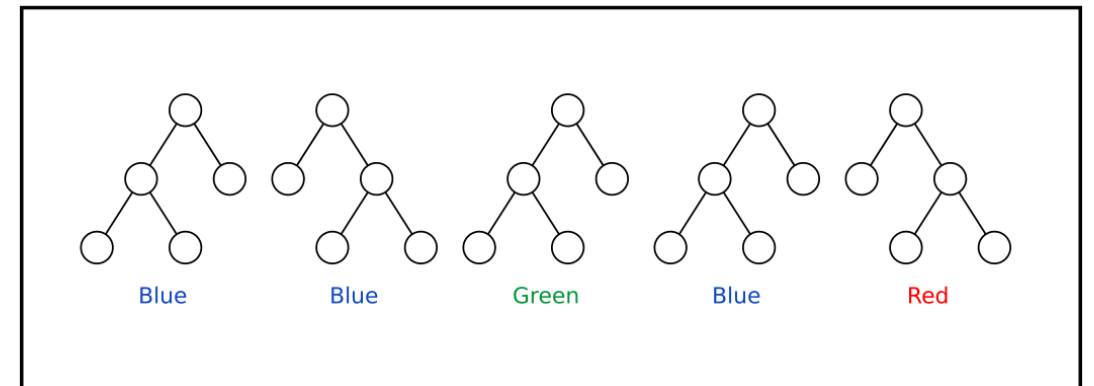
RANDOM FOREST

The forest is created by selecting different thematic variables and different subset of the dataset to create each tree (boot-strapping)

This randomised approach improves the results by creating decorrelated trees



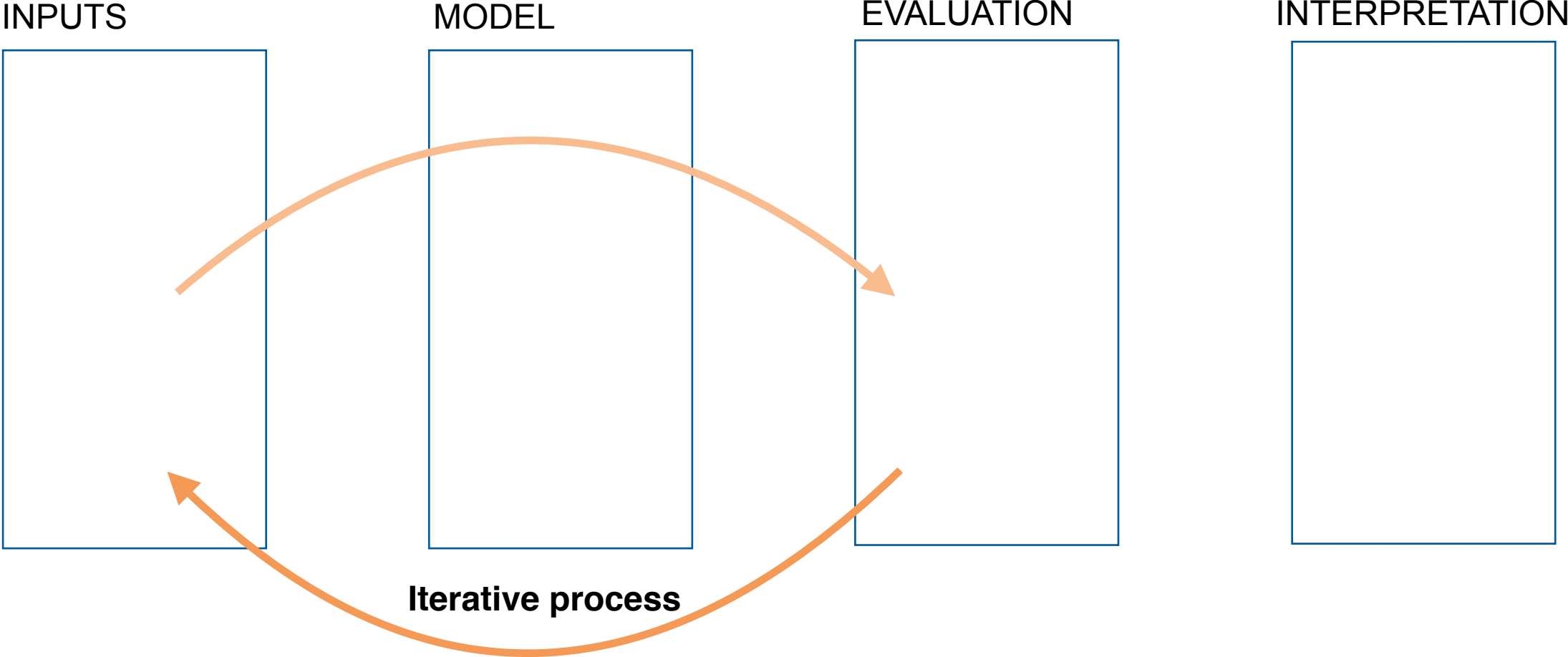
The results or final decision of the forest is the mean or the median of the votes of the forest



↓
Blue

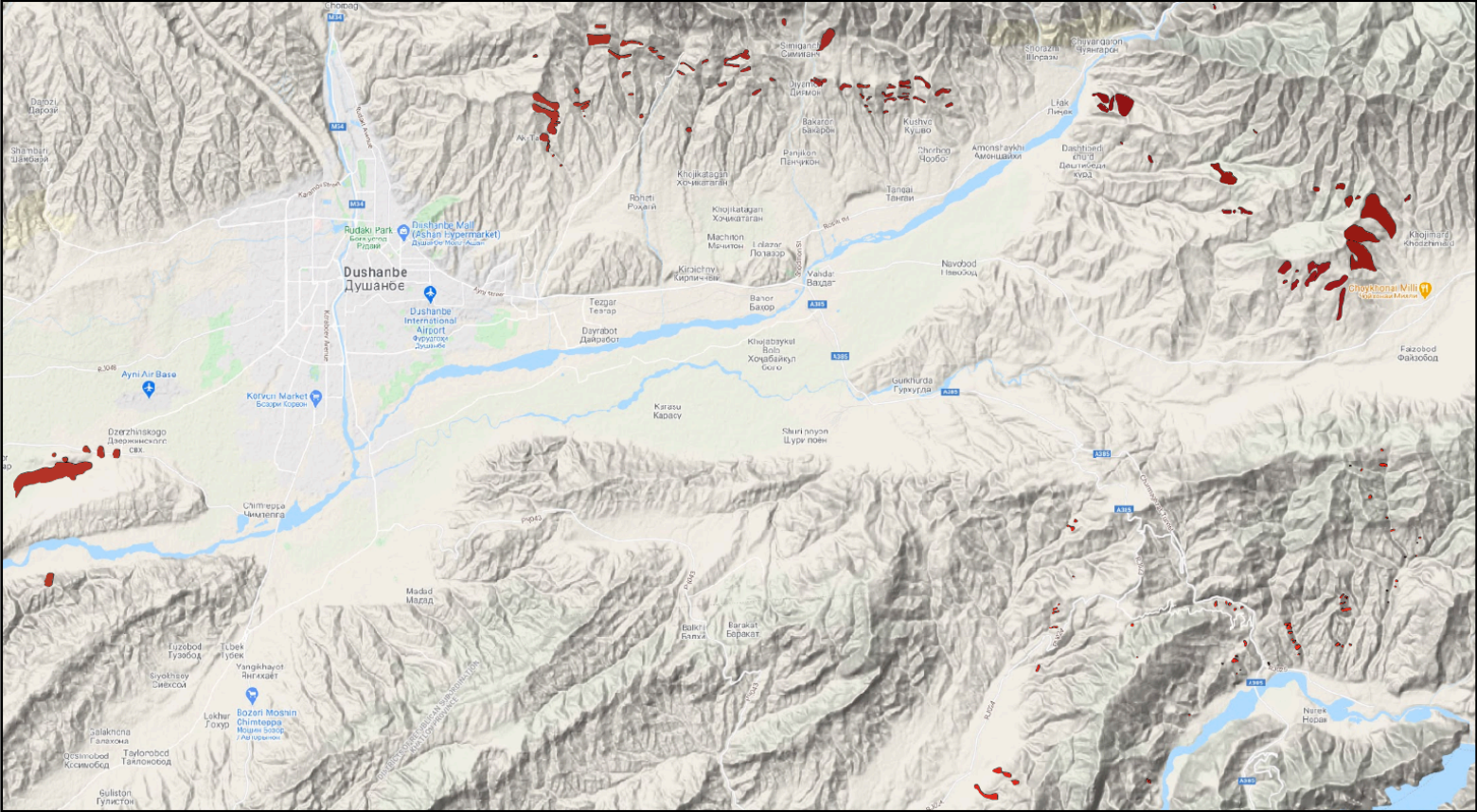
RANDOM FOREST FOR LANDSLIDE SUSCEPTIBILITY

Study case: South Tien Shan

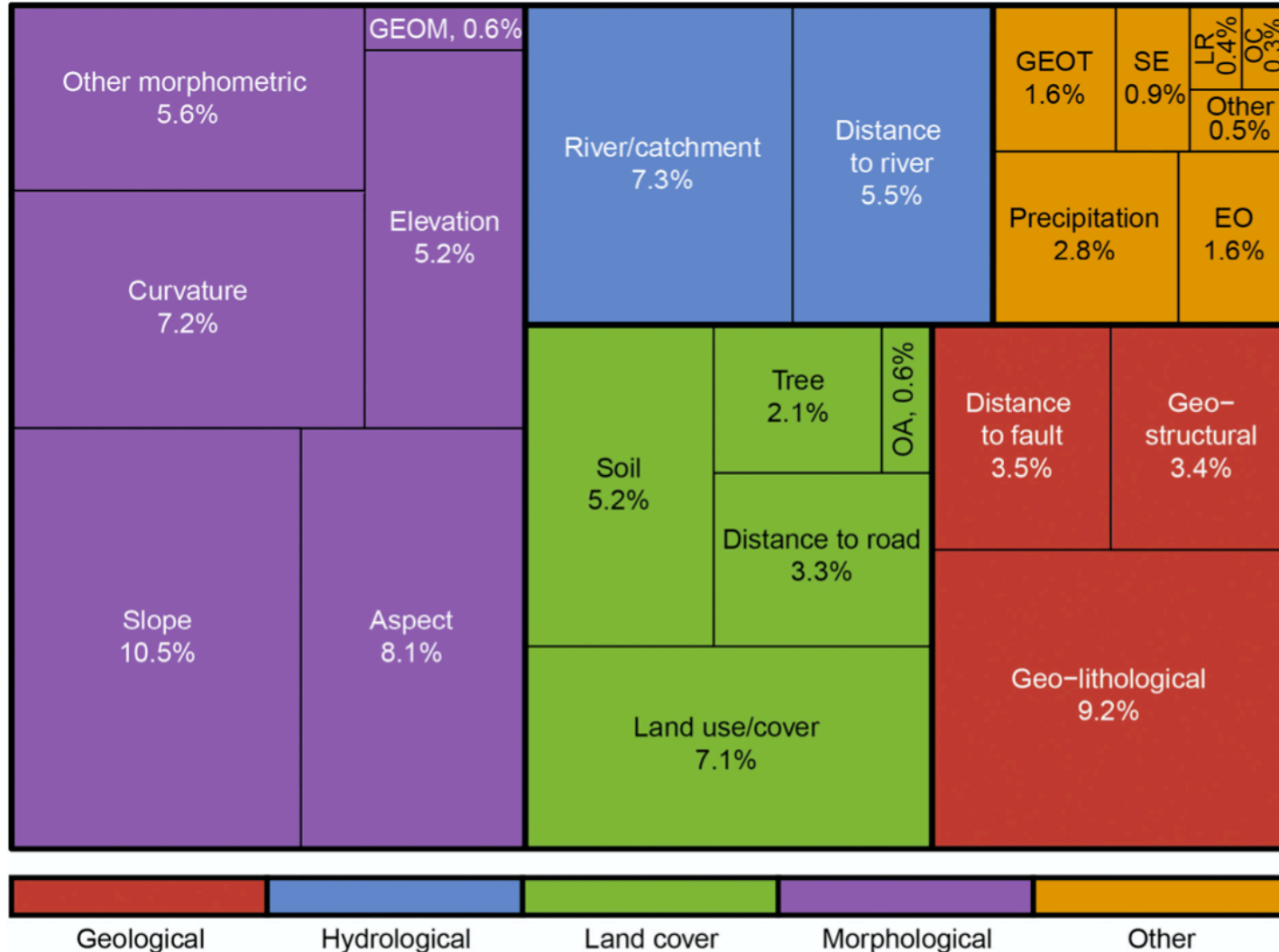


LANDSLIDE CATALOGUE

Collection of information related to where, when and why landslides occurred (Guzzetti *et al.* , 2012)



THEMATIC VARIABLES

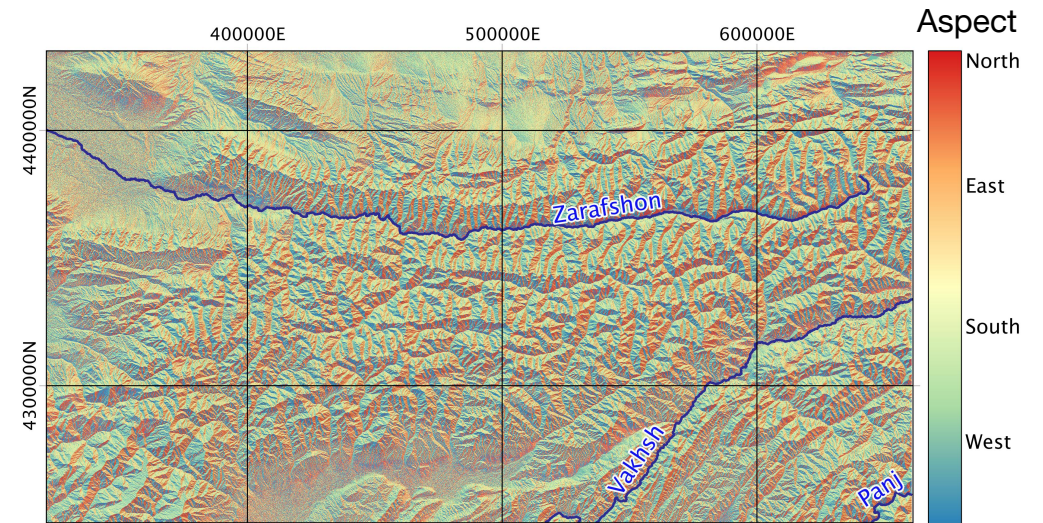
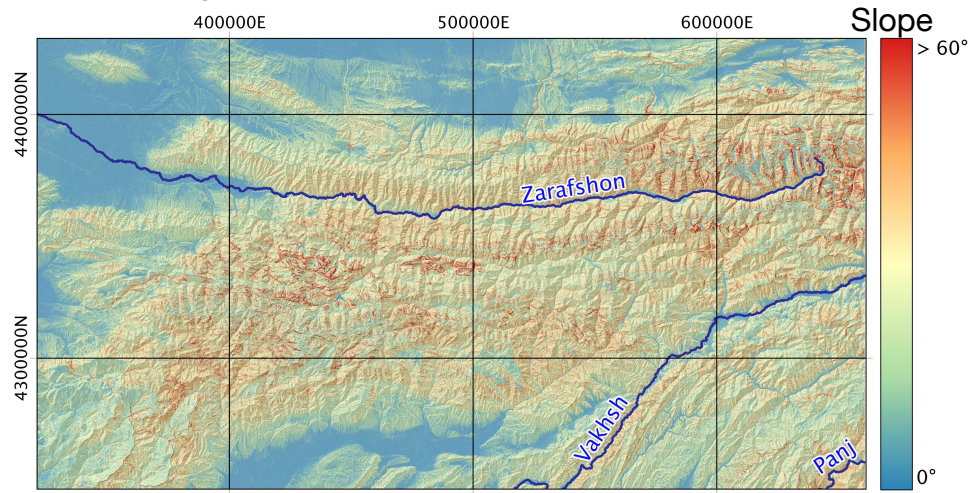


Thematic variables use in landslide susceptibility depends on the area of study and the availability of detailed datasets

Most of the cases landslide susceptibility models highly rely on parameters describing the landscape (morphometric indices)

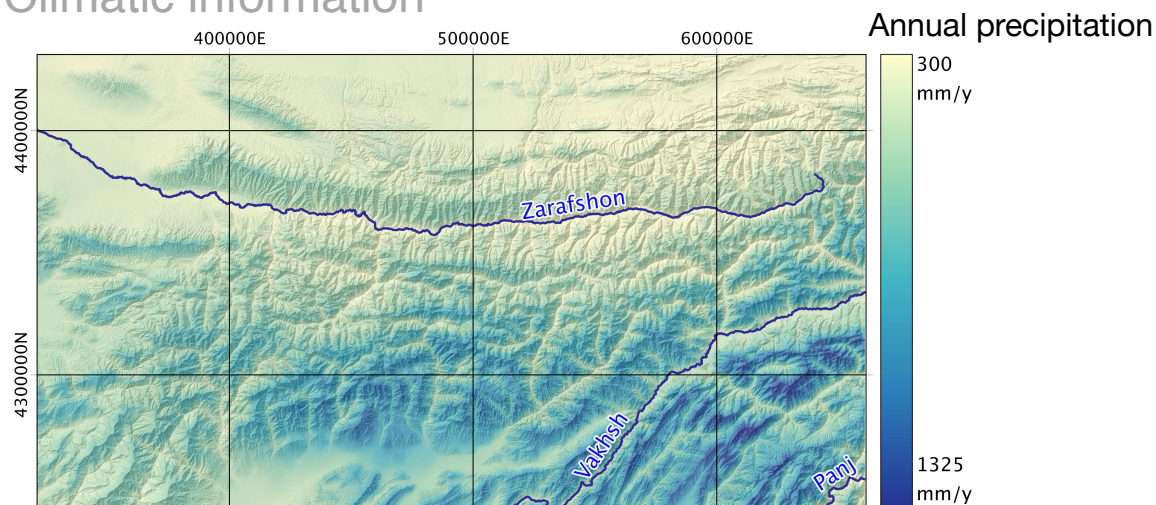
INPUTS - THEMATIC VARIABLES

Local morphometric indices

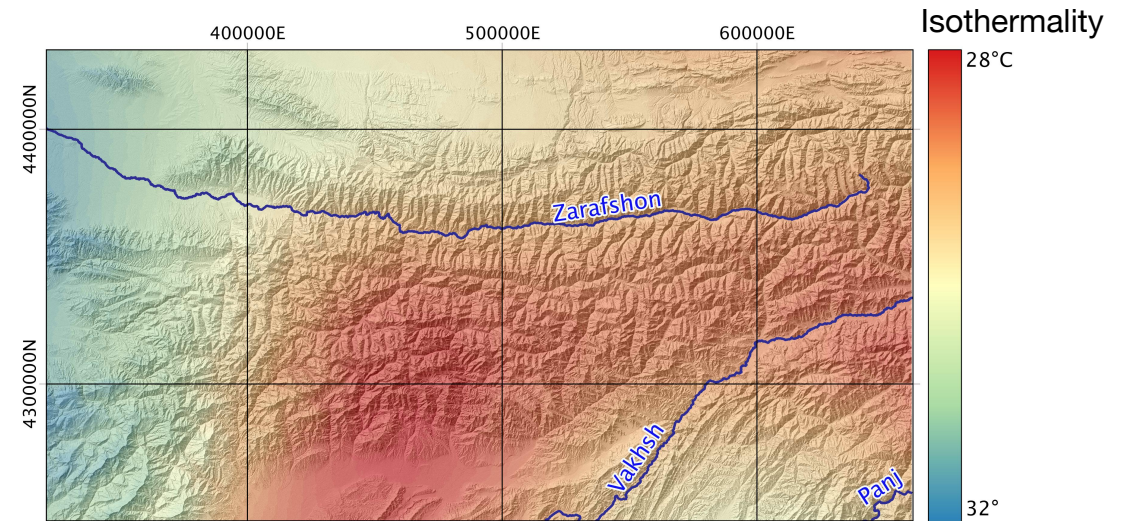


Climatic information

Source: 1 arcsec SRTM data



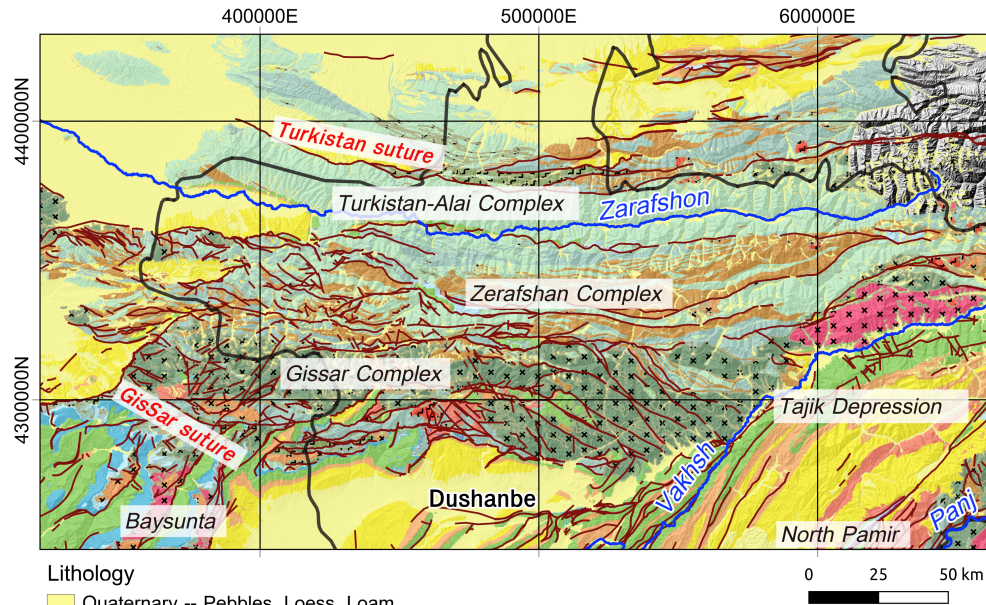
Source: Karger, et al., 2017



Source: Karger, et al., 2017

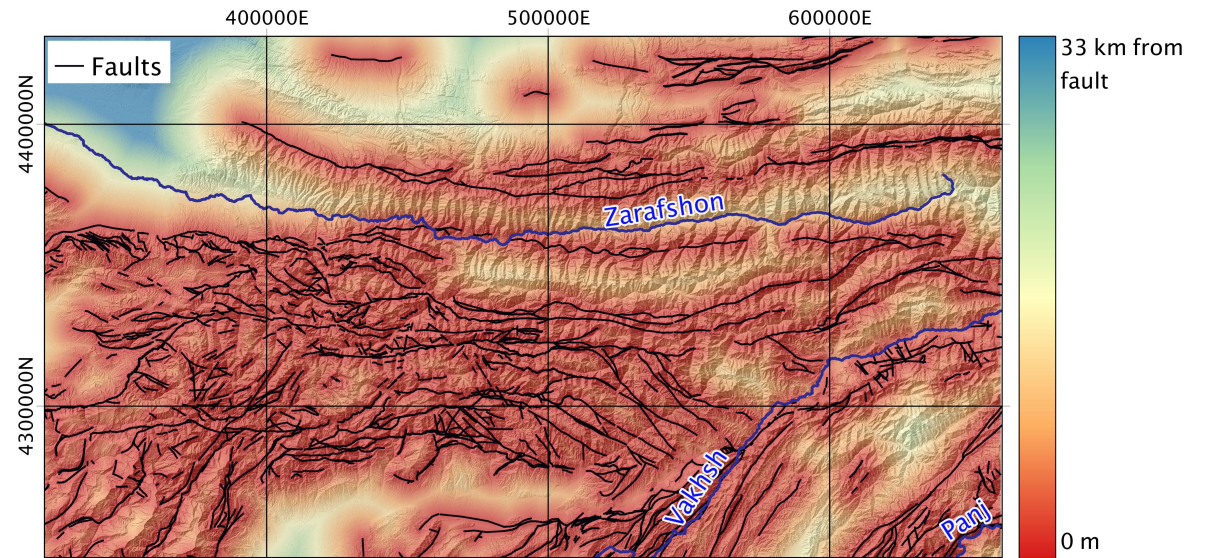
INPUTS - THEMATIC VARIABLES

Geological setting



- Lithology**
- Quaternary -- Pebbles, Loess, Loam
 - Neogene -- Siltstone, Clay, Sandstone, Conglomerates
 - Paleogene -- Limestones, Sandstones, Clays, Dolomites, Gypsum
 - Paleogene intrusive -- Granite
 - Cretaceous -- Conglomerates, Sandstones, Dolomites, Clays, Silstones
 - Upper-Mid Jurassic -- Conglomerates, Shales, Coal, Porphyritis tuffs, Tuff breccias
 - Lower Jurassic -- Limestones, Marl, Mudstones, Clays, Sandstones, Gypsum
 - Triassic -- Gravelites, Sandstones, Coals, Breccia, Conglomerates, Allite, Bauxite
 - Permian -- Monazite
 - Permian -- Sandstones, Siltstone, Limestone, Porphyrites, Tuffs
 - Carboniferous intrusive -- Granite, Grandiorite
 - Carboniferous extrusive -- Basalt/Basic and ultrabasic rocks
 - Carboniferous -- Conglomerates, Sandstones, Shales, Gravel, Limestones, Silstones, Dolomites
 - Devonian -- Limestones, Dolomites, Sandstones, Shales, Conglomerates, Siliceous rocks
 - Silurian -- Dolomites, Limestones, Shales, Sandstones, Slates
 - Cambrian -- Schist, Marble, Gneiss
 - Precambrian -- Porphyry leucocratic granites
 - Faults

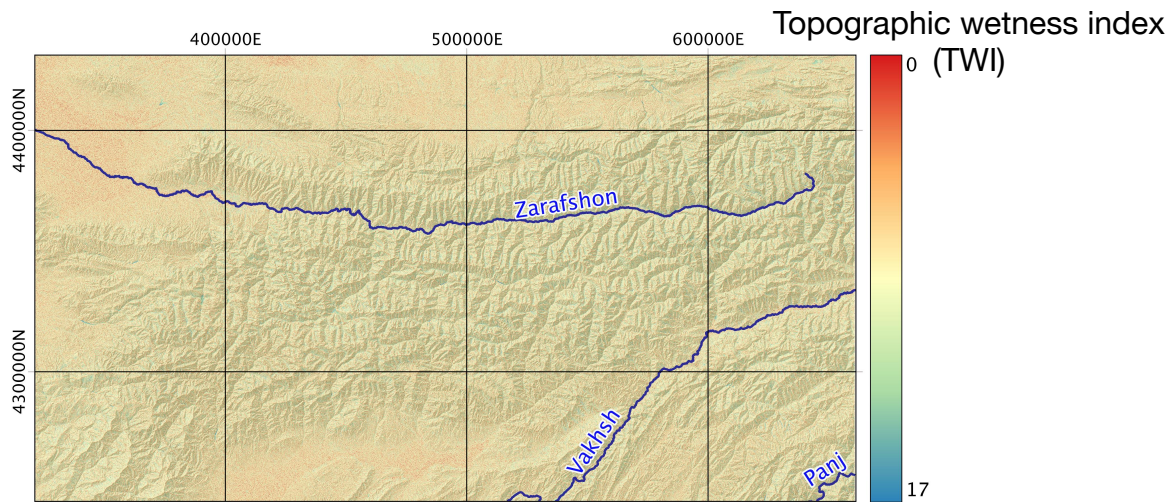
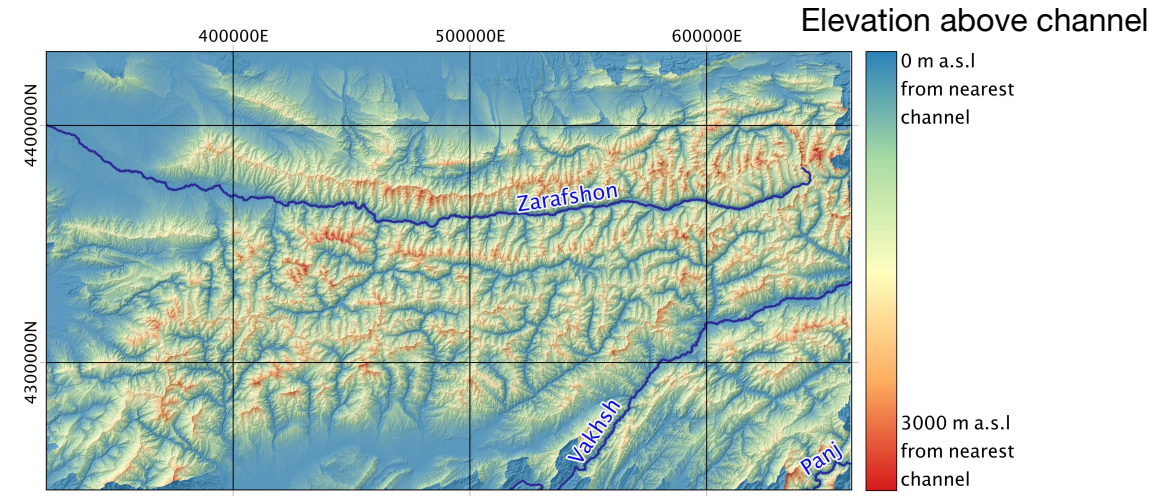
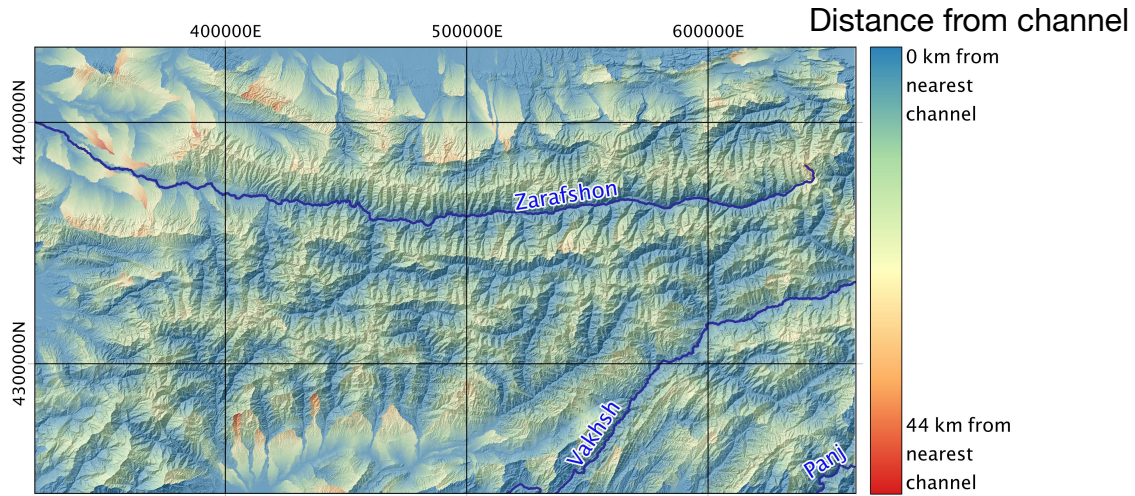
Source : Kufner et al., 2018., Federal State Budgetary Institution A.P. Karpinsky Russian Geological Research Institute.



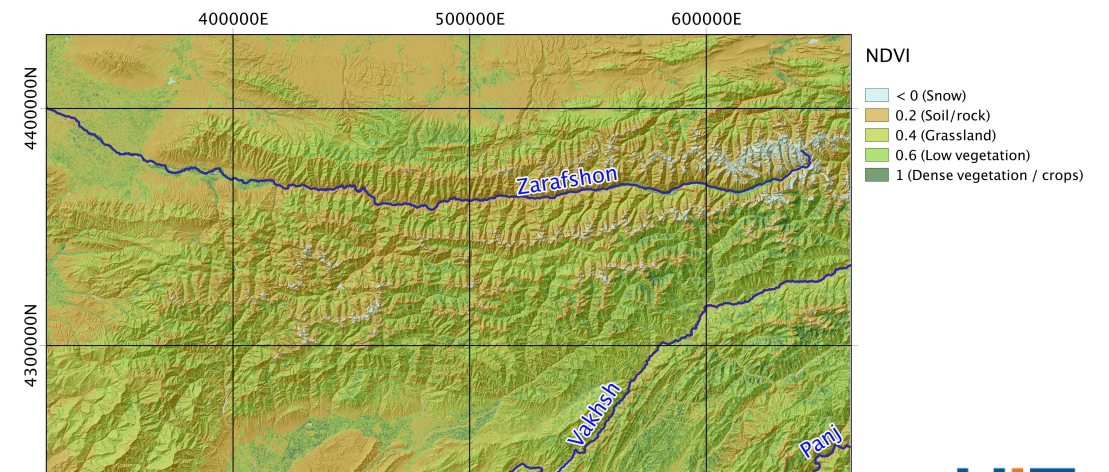
Source: Central Asia Fault Database (CAFD)

INPUTS - THEMATIC VARIABLES

Hydrological parameters extracted from the river network

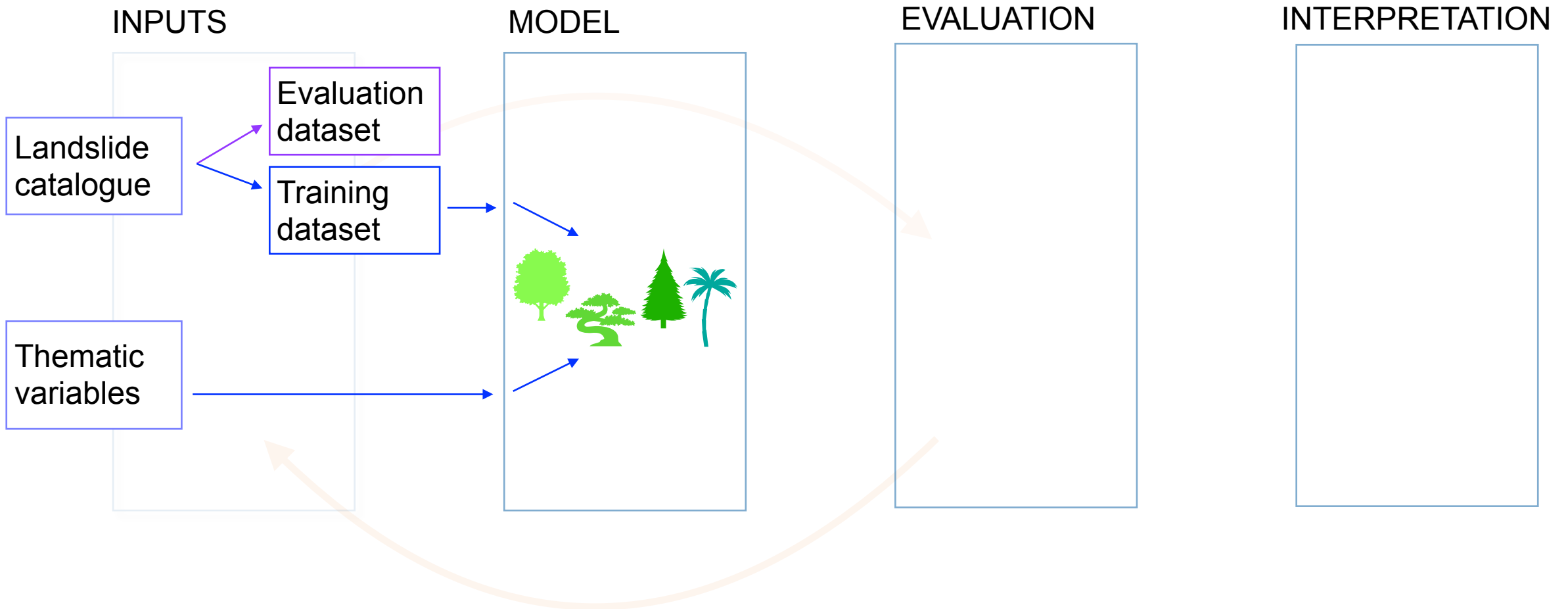


NDVI extracted from satellite data



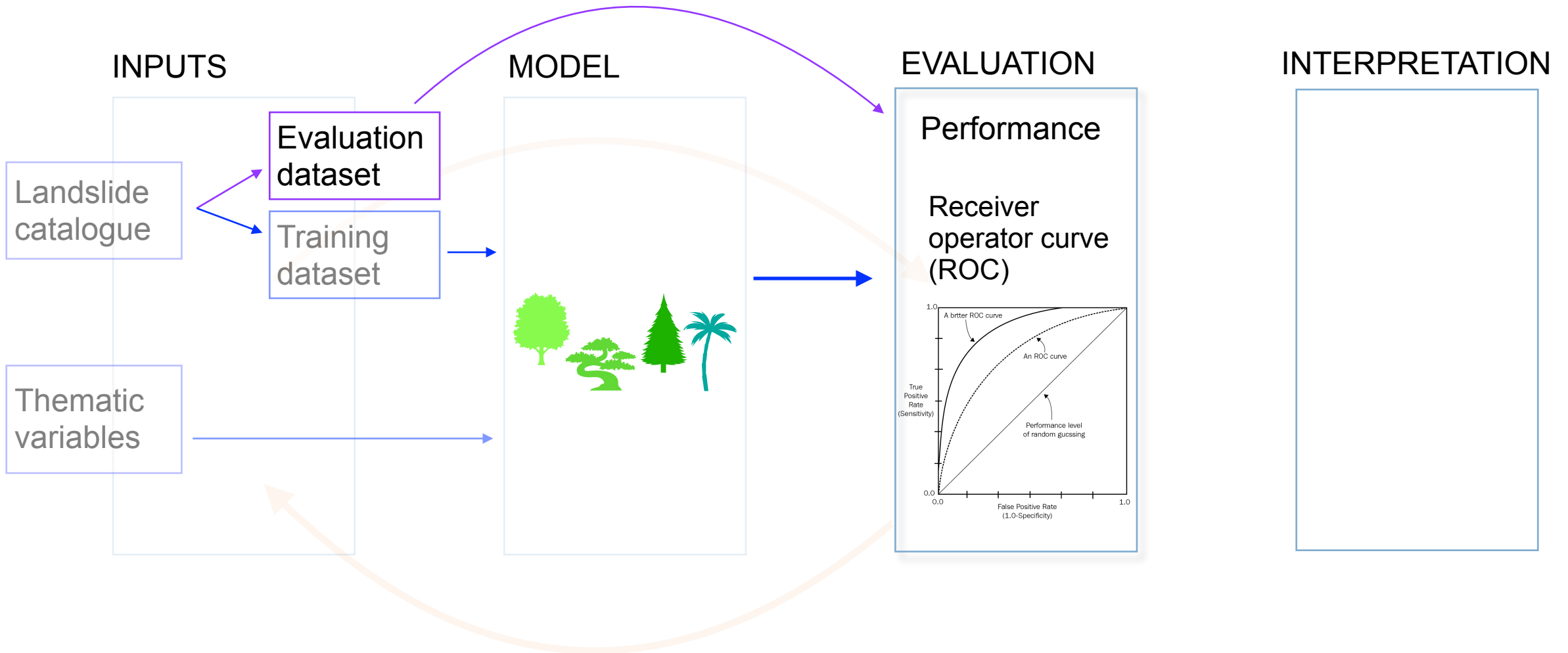
RANDOM FOREST FOR LANDSLIDE SUSCEPTIBILITY

Study case: South Tien Shan



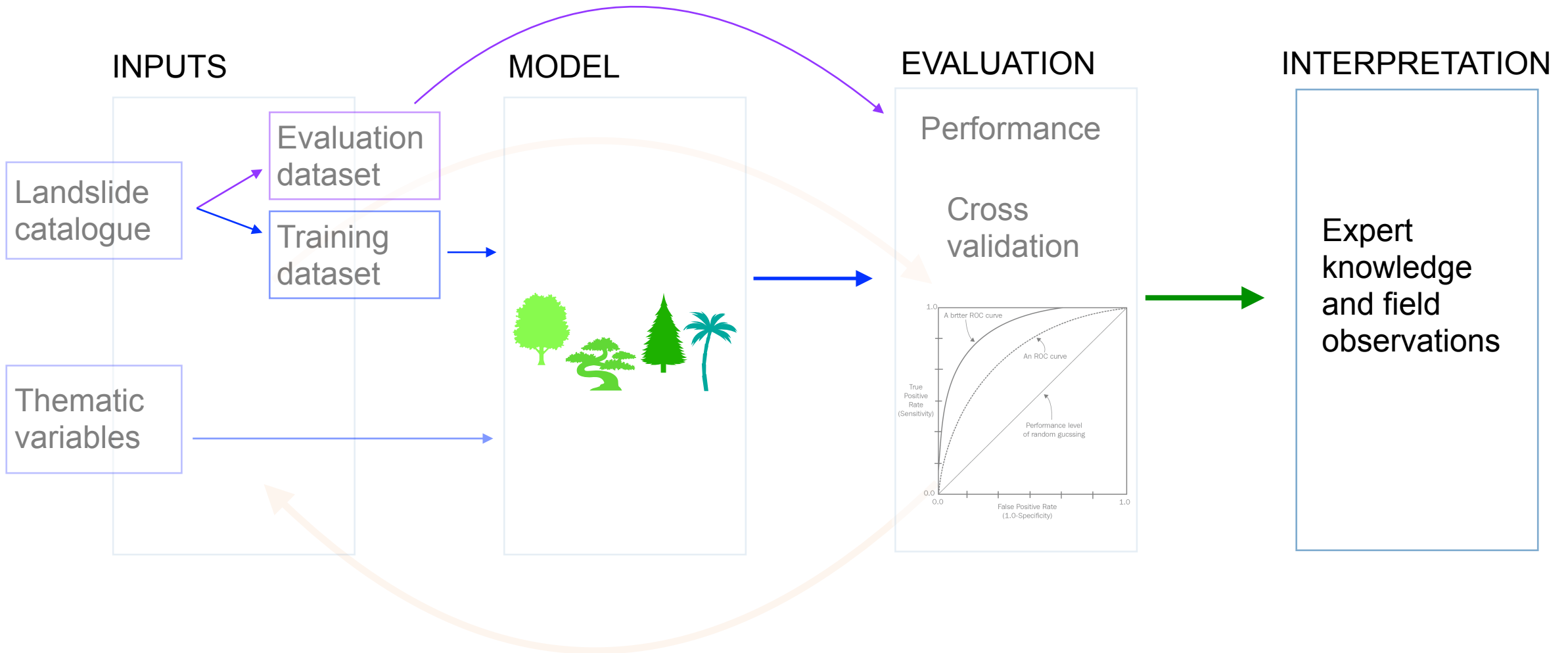
RANDOM FOREST FOR LANDSLIDE SUSCEPTIBILITY

Study case: South Tien Shan



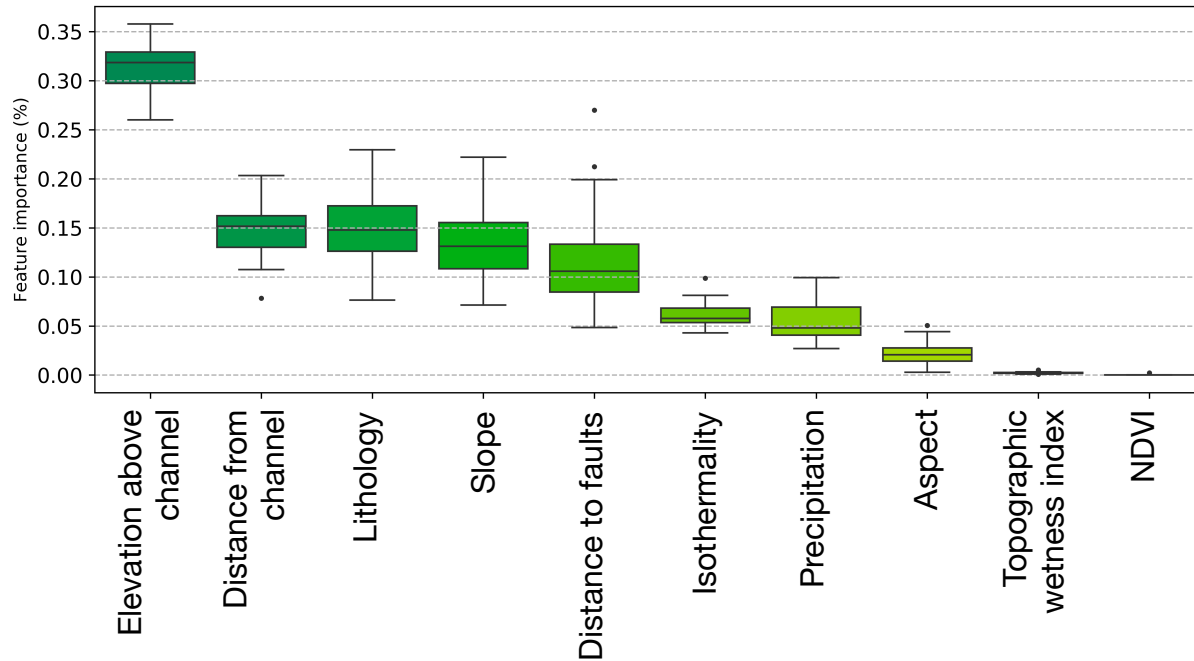
RANDOM FOREST FOR LANDSLIDE SUSCEPTIBILITY

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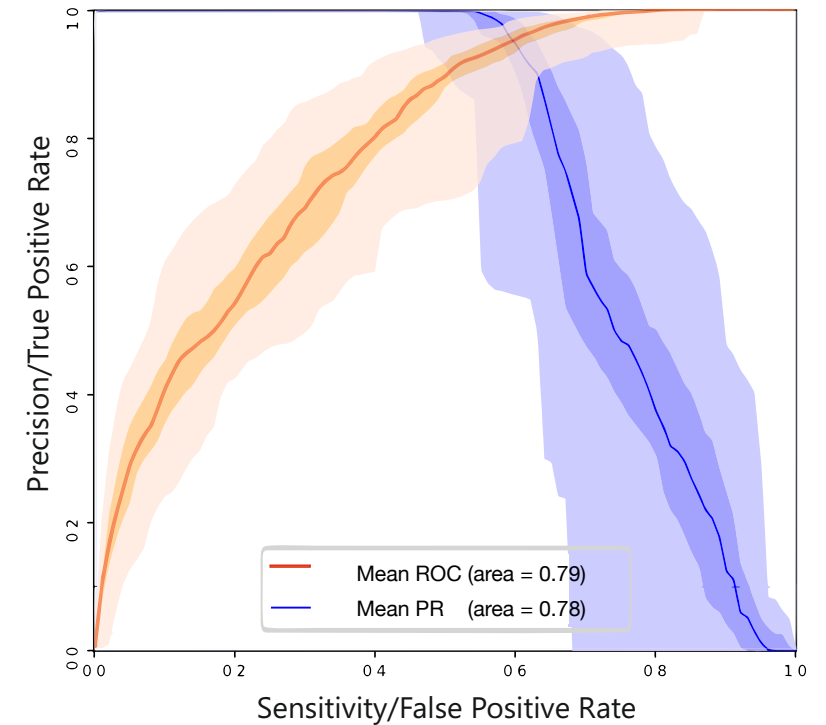


LANDSLIDE SUSCEPTIBILITY MODEL

Ranking of importance of the thematic variables

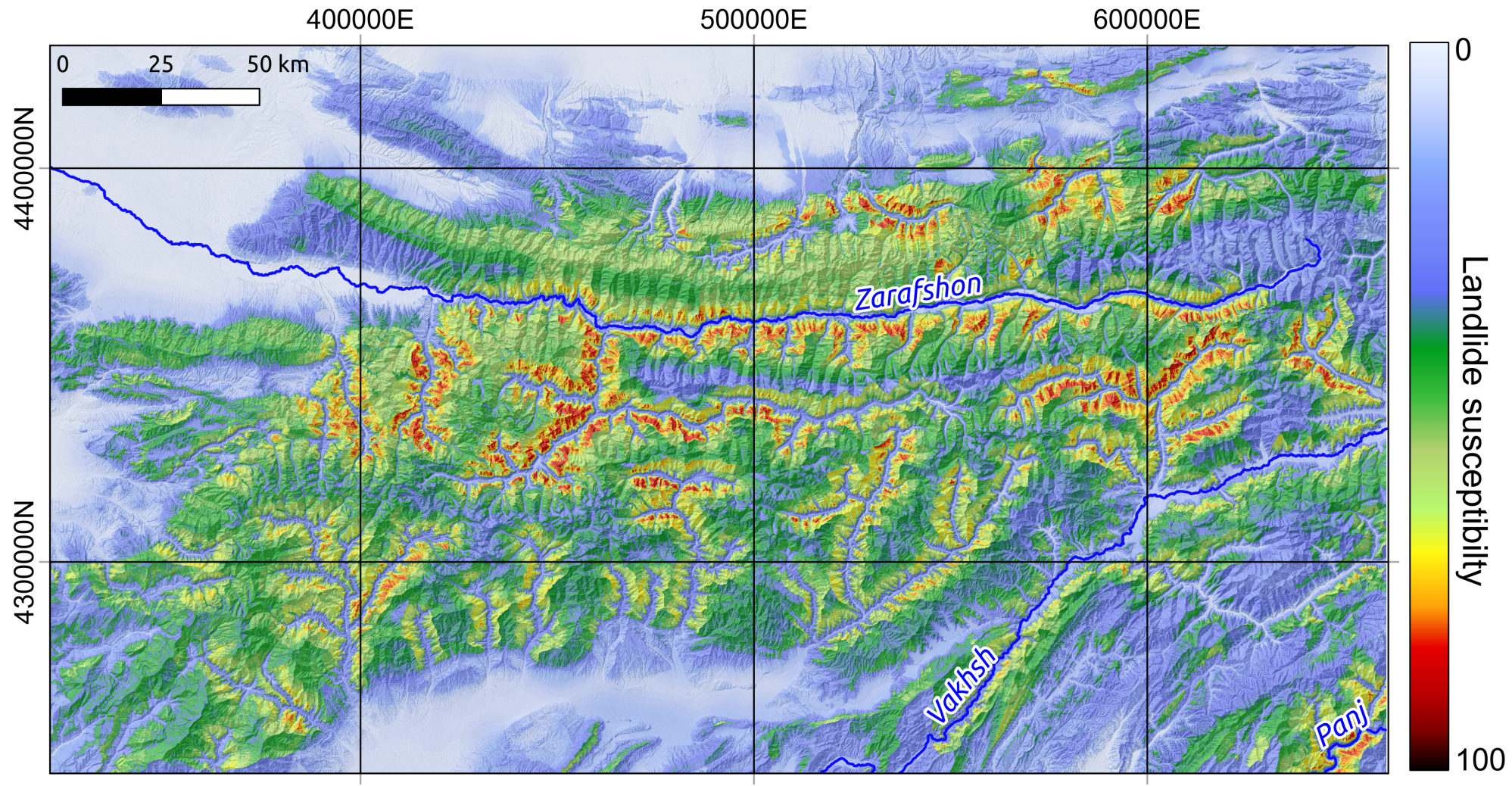


Evaluation — how good the model identified “new landslides”



Source: Barbosa et al, 2019

LANDSLIDE SUSCEPTIBILITY MAP



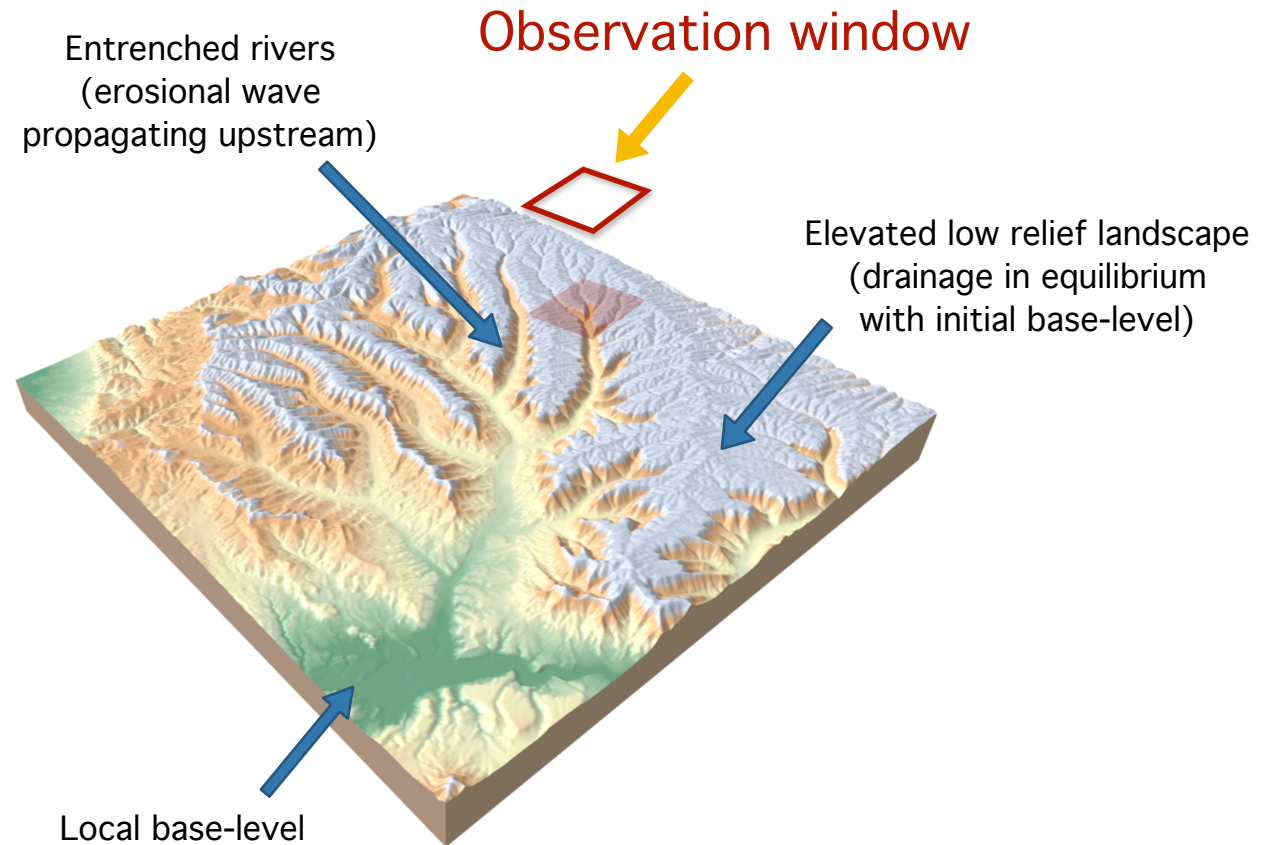
CREATE MORE MODELS

Collect more and/or better thematic variables

Morphometric indices

Mathematical modification of the elevations storage in a digital elevation model.

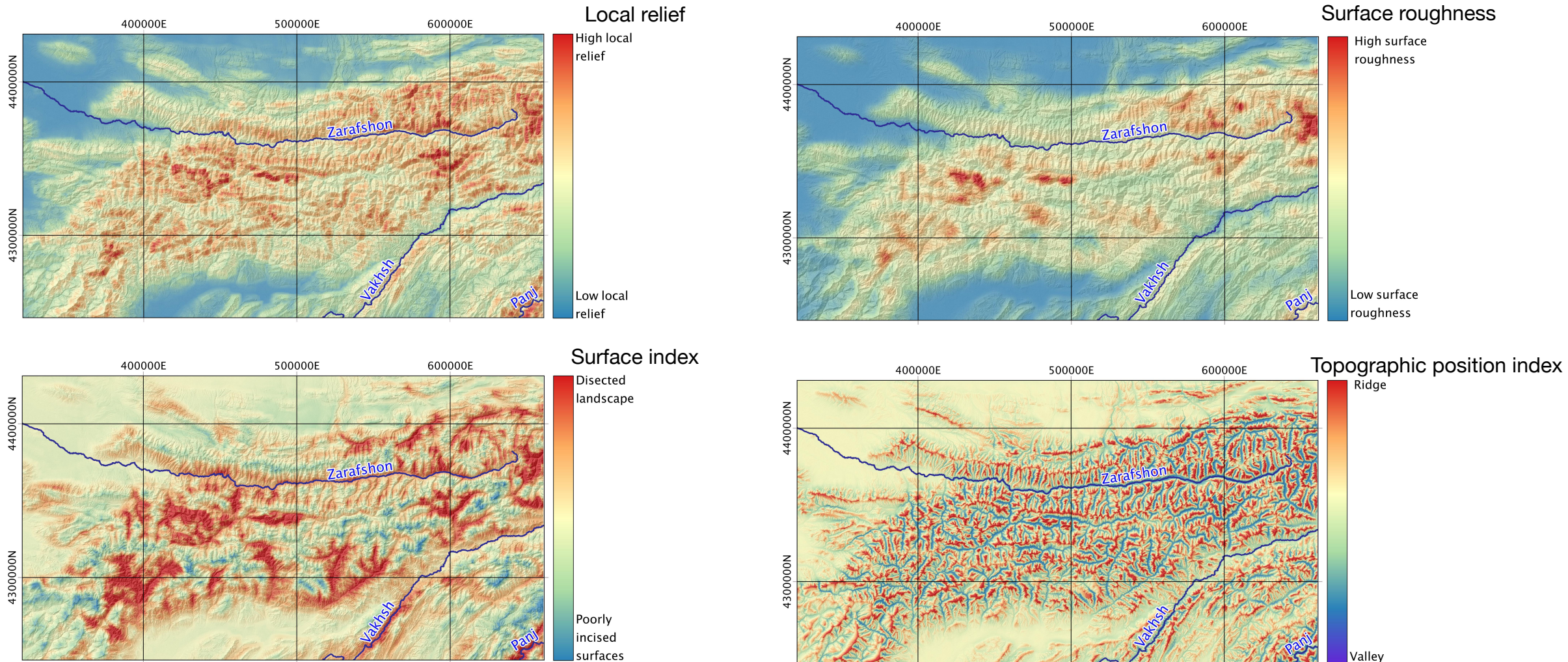
Morphometric indices enhance different landscape characteristics based on the definition of an observation window.



Source: Andreani et al, 2014

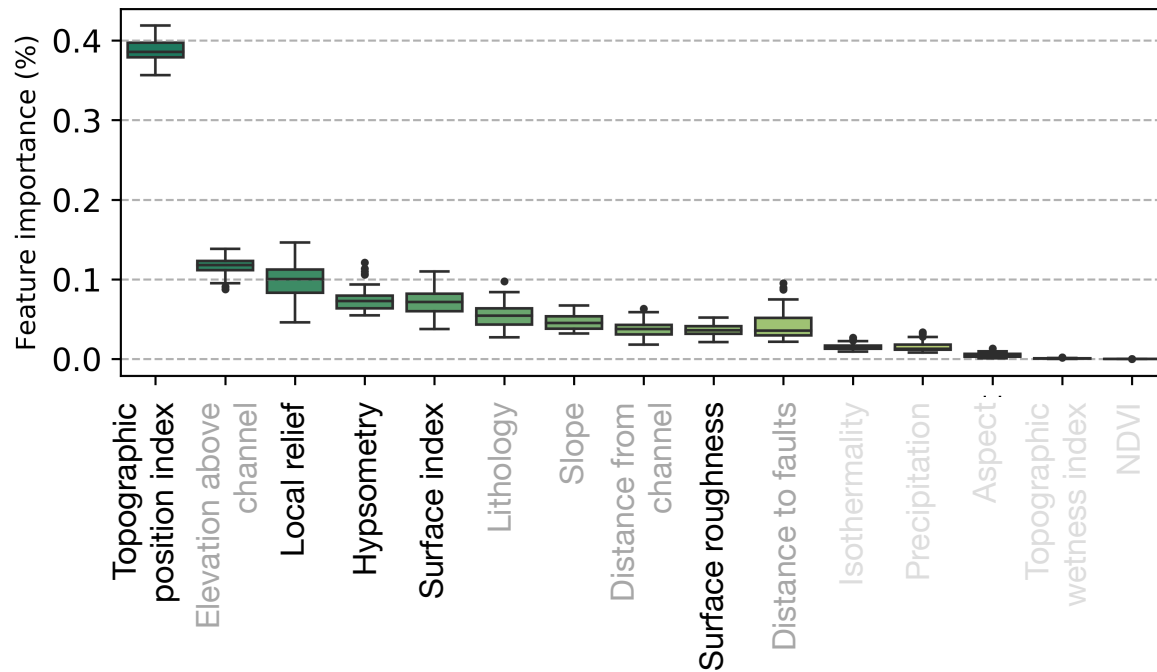
ADDITIONAL THEMATIC VARIABLES

Regional morphometric indices (Window-based morphometric indices)

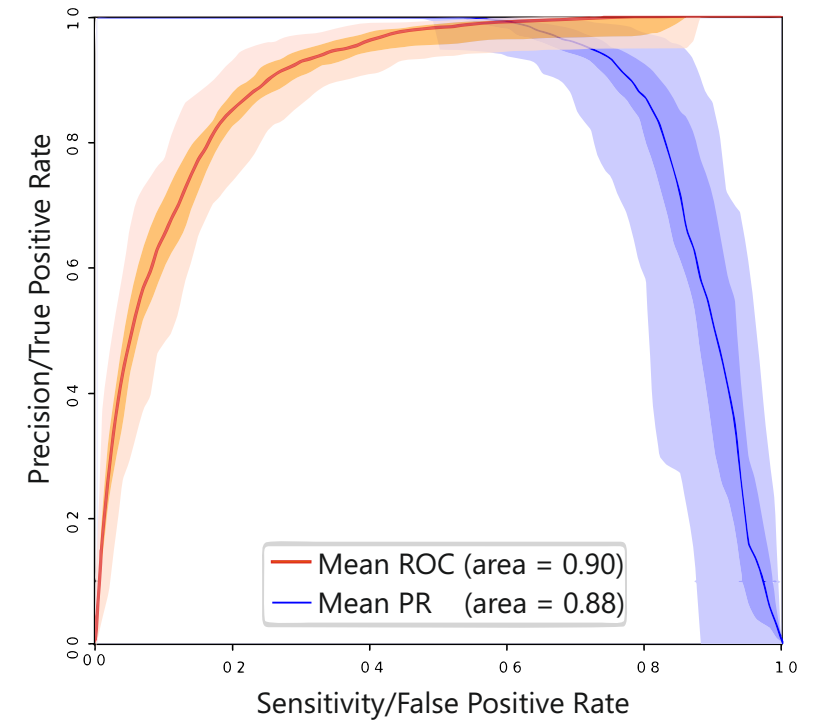


CREATE MORE MODELS

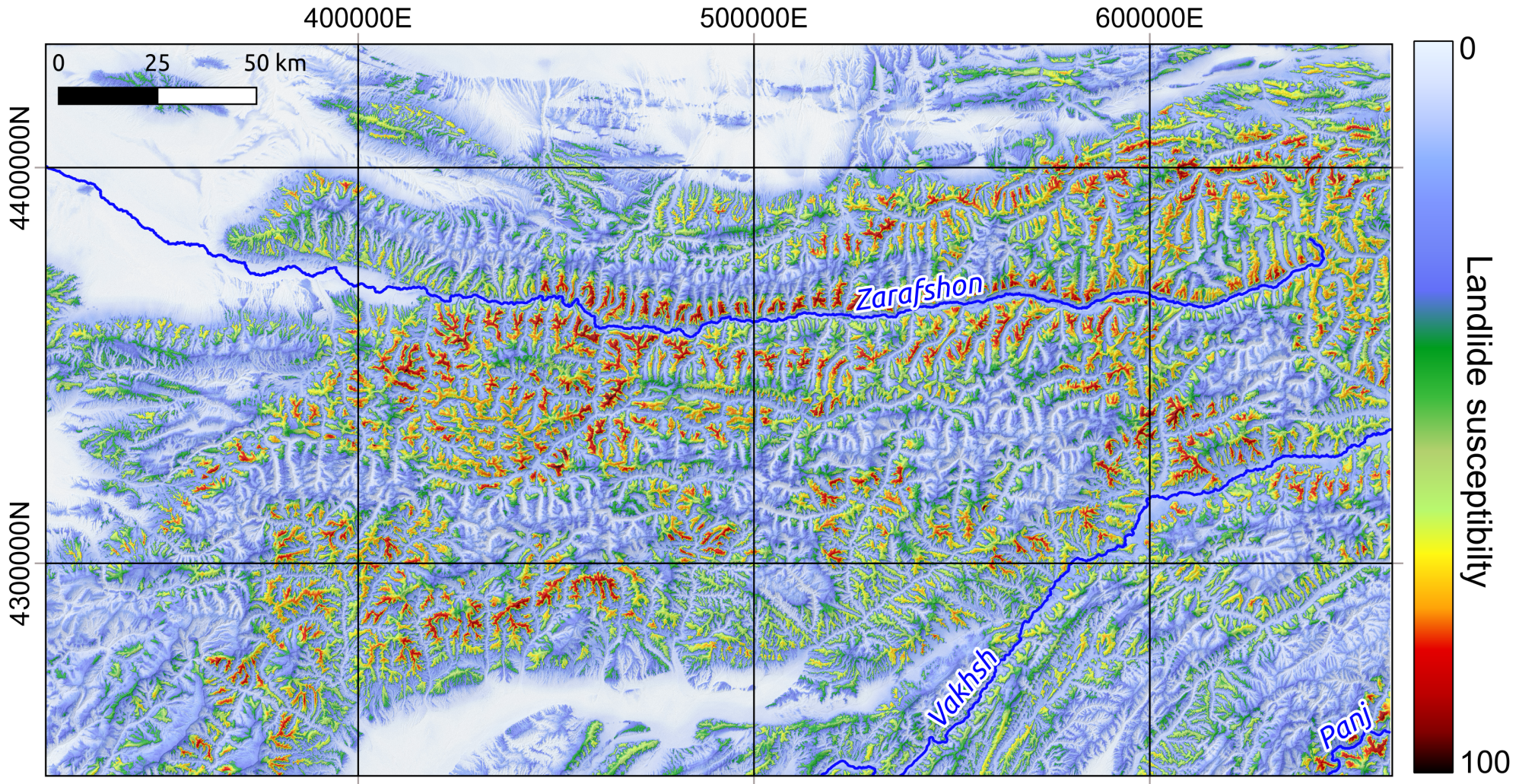
Ranking of importance of the thematic variables



Evaluation — how good the model identified “new landslides”



CREATE MORE MODELS



Source: Barbosa et al, 2020

NEXT STEPS

Field validation



Improvement of the landslide catalogue and thematic variables

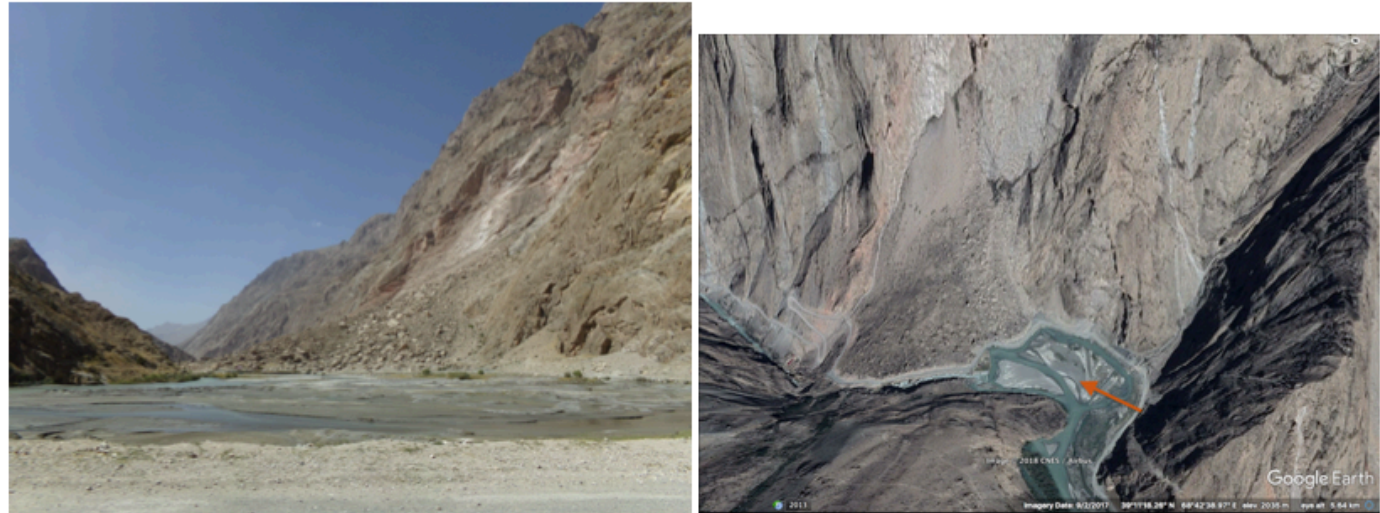


Figure 2.21: Rockfall damming the Yagnob River. Left: Field picture. Right: Google Earth view. The red arrow indicates the direction from which the photo was taken.

TAKE AWAY

Landslide susceptibility models identify **where** landslides may occur based on relationships between thematic variables and the landslide catalogue. The identified relationships may differ with the method selected.

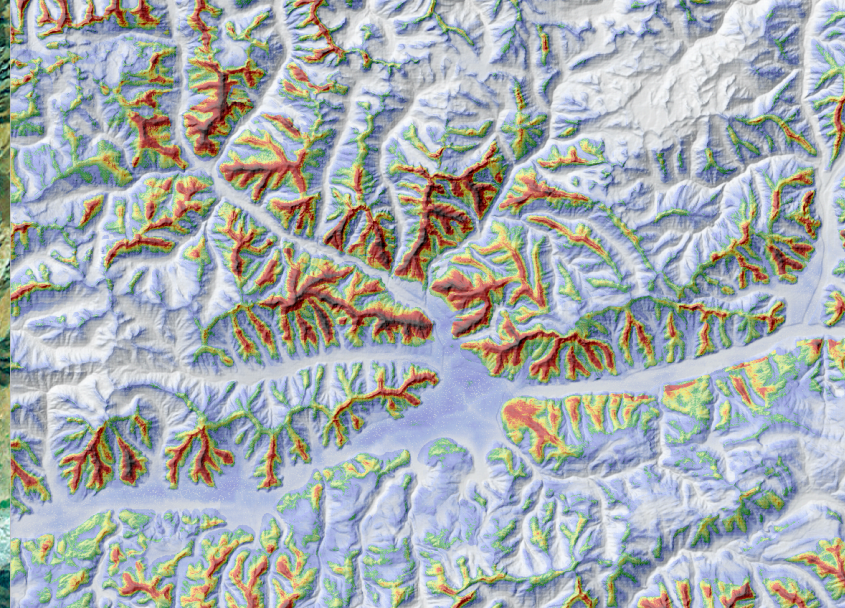
Quality of the thematic variables and landslide catalogue strongly influence the results. Poor thematic variables lead to unreliable results.

The use of morphometric indices can improve the landslide susceptibility model for areas with data-scarcity. Different indices should be tried as well as observation windows.

Random forest among other machine learning and statistically based approach proved as a high-performance method to assess landslide susceptibility when representative datasets are used.

Evaluation is a required step to measure the performance of the model and support the discussion towards improvements.

QUESTIONS



Federal Ministry
of Education
and Research

CLIENT II

International Partnerships
for Sustainable Innovations



GEFÖRDERT VOM



Bundesministerium
für Bildung
und Forschung

References

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Andreani, Louis, et al. "DEM-based analysis of interactions between tectonics and landscapes in the Ore Mountains and Eger Rift (East Germany and NW Czech Republic)." *Remote Sensing* 6.9 (2014): 7971-8001.