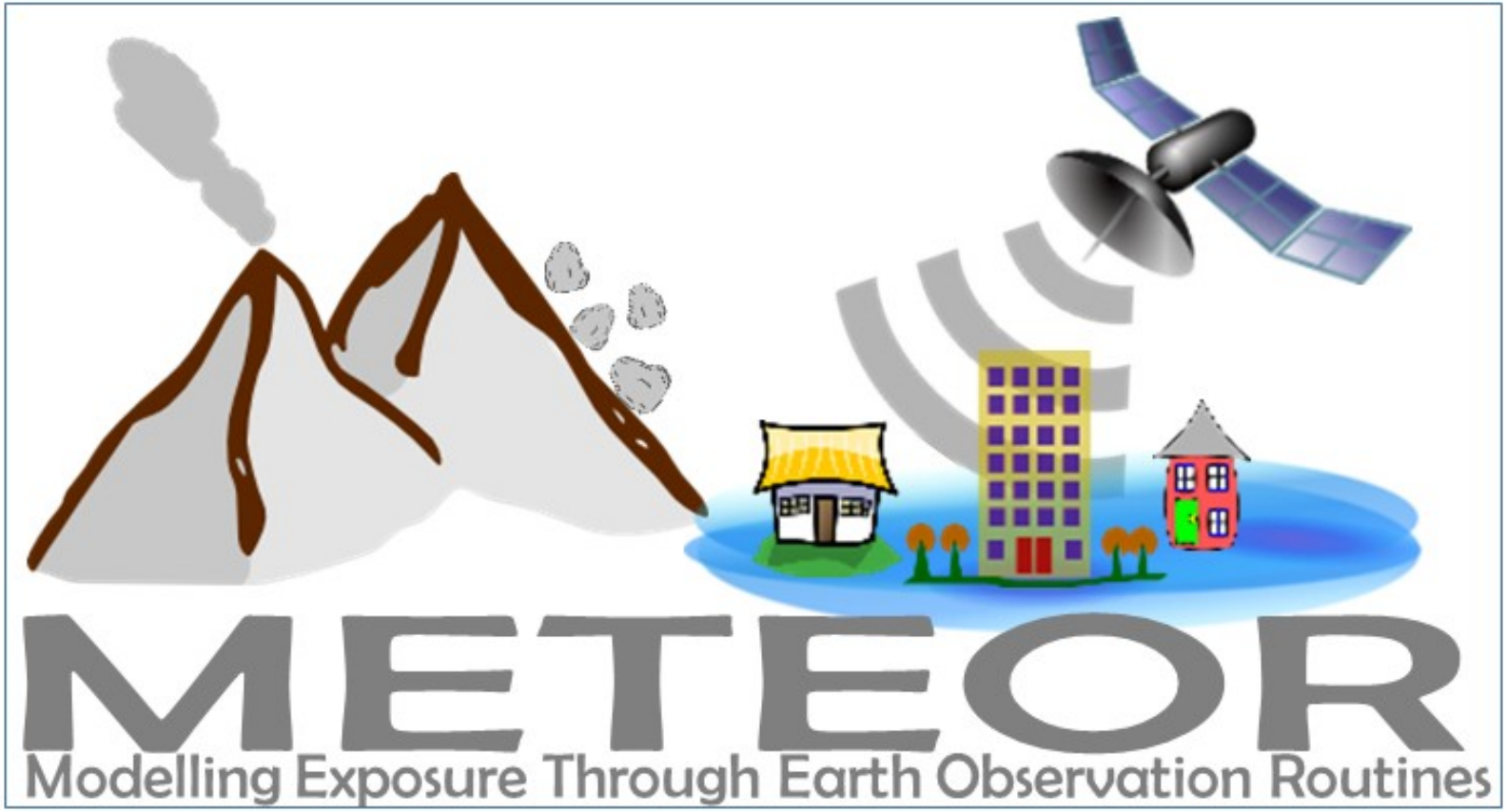
METEOR
Modelling Exposure Through Earth Observation Routines

METEOR TRAINING

Implementation of the model in GIS

(illustrated for rainfall-induced landslides)

METEOR project

Modeling Exposure Through Earth Observation Routines

- Three-year project
- Funded by UK Space Agency
- Aims to develop innovative application of Earth Observation (EO) technologies to improve understanding of exposure
- Specific focus on pilot countries Nepal and Tanzania
- Consortium of eight organizations

funded by:

UK SPACE AGENCY

project consortium:

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Contents

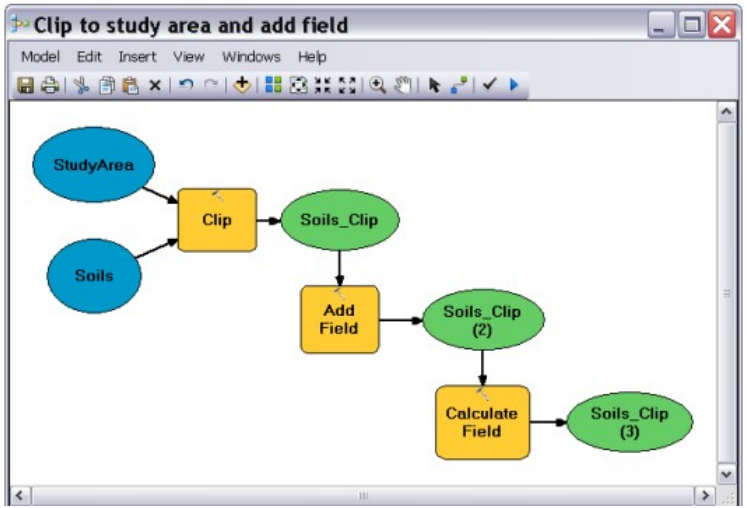
- Introduction to modelling tool
- Input data workflow
- Example A: fuzzy membership function for continuous-scaled variables
- Example B: fuzzy membership function for categorical variables
- Model and resulting susceptibility and hazard maps

Modelling tool

ArcGIS v.10.3 ☾ ArcMap ☾ ModelBuilder

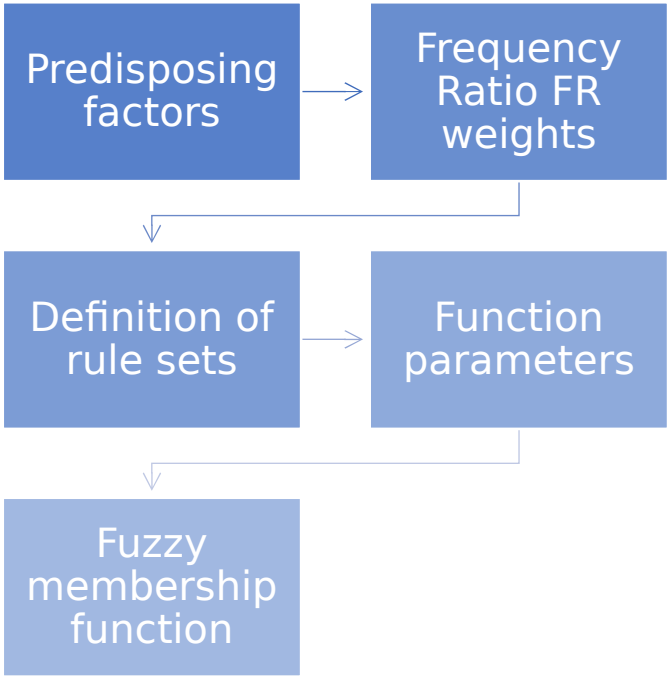
ModelBuilder ☾ application used to create, edit, and manage models

+ easy-to-use for creating and running workflows containing a sequence of tools
+ can be used to create new tools
+ tools created with ModelBuilder can be used in Python scripting and other models
+ integration of ArcGIS with other applications using ModelBuilder and scripting



ArcMap10.3 Help

ModelBuilder input data workflow



A. Function for continuous-scaled variables:

$$fv(eij,v) = exp\left[-\left(\frac{|eij,v - ev| \times 0.8326}{w}\right)^2\right]$$

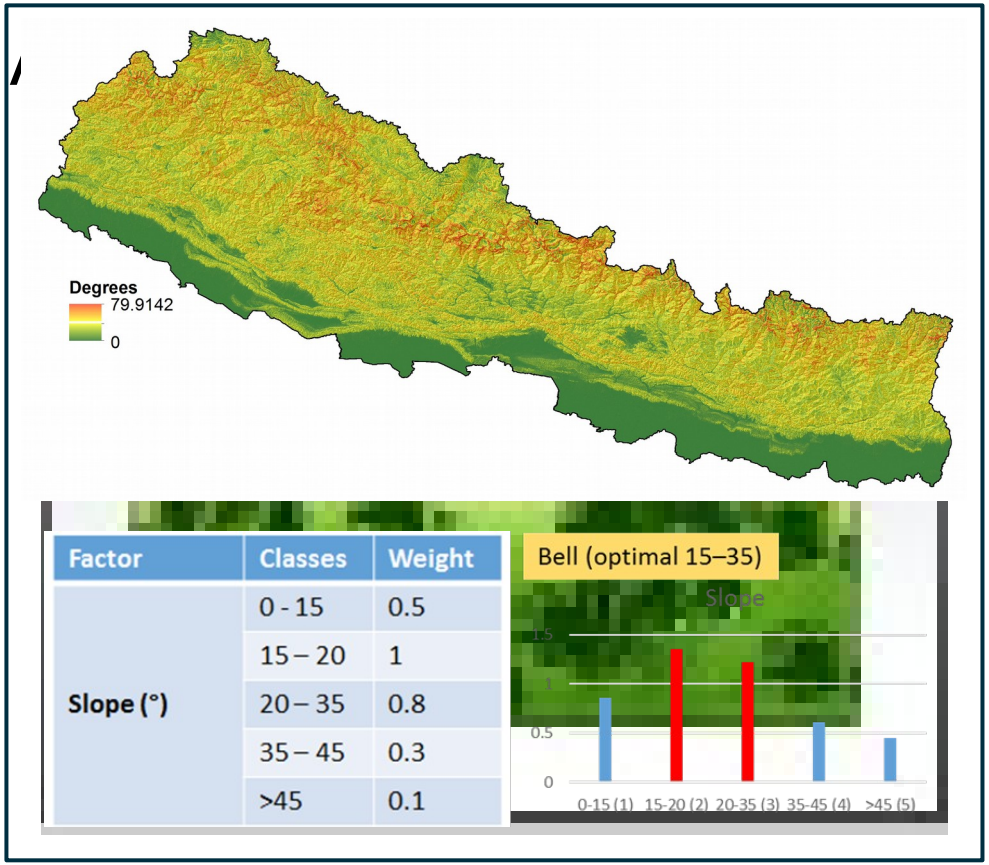
w = parameter that controls the shape of the curve;
$w = e_{LS=1} - e_{LS=0.5}$

B. Function for categorical variables:

$$f_v\left(e_{ij,v}\right) = \begin{cases} w_{1,v} & if\ e_{ij,v} = c_{1,v} \\ w_{2,v} & f\ e_{ij,v} = c_{2,v} \\ \ldots & \\ w_{m,v} & f\ e_{ij,v} = c_{m,v} \end{cases}$$

Zhu et al., 2008, 2014

Example A: Fuzzy membership function for slope gradient

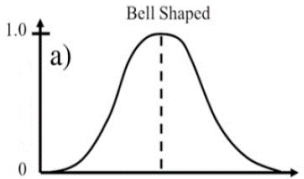


Rule set definition:

Susceptibility is at maximum for slopes btw 15° and 35°; as the slope decreases below 15° and increases above 35°, respectively, susceptibility decreases at different rates

Function type:

Bell-shaped



Example A: Fuzzy membership function for slope gradient

Function parameters

- Right side: w = 25 – 45
- Left side: w = 25 – 15

- S = 1 when Sg = 15° - 35°
- S = 0.5 when Sg ≥ 45° (for right side of curve)
- S = 0.5 when Sg ≤ 15° (for left side of curve)

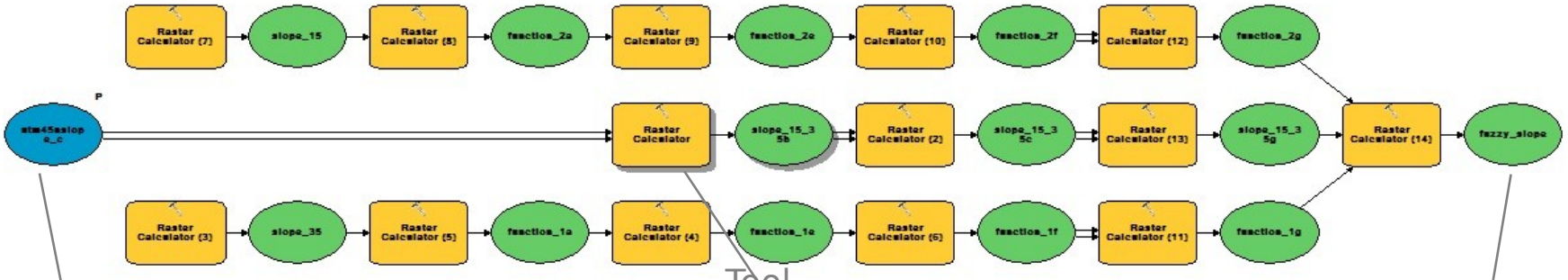
Function (split in two)

$$S = \begin{cases} 1, & Sg = 25 \\ \exp\left(-\frac{|Sg - 25| \times 0.8326}{-20}\right)^2 & \end{cases}$$

$$S = \begin{cases} 1, & Sg = 25 \\ \exp\left(-\frac{|Sg - 25| \times 0.8326}{10}\right)^2 & \end{cases}$$

Example A: Model diagram and elements

Model processes n = 14

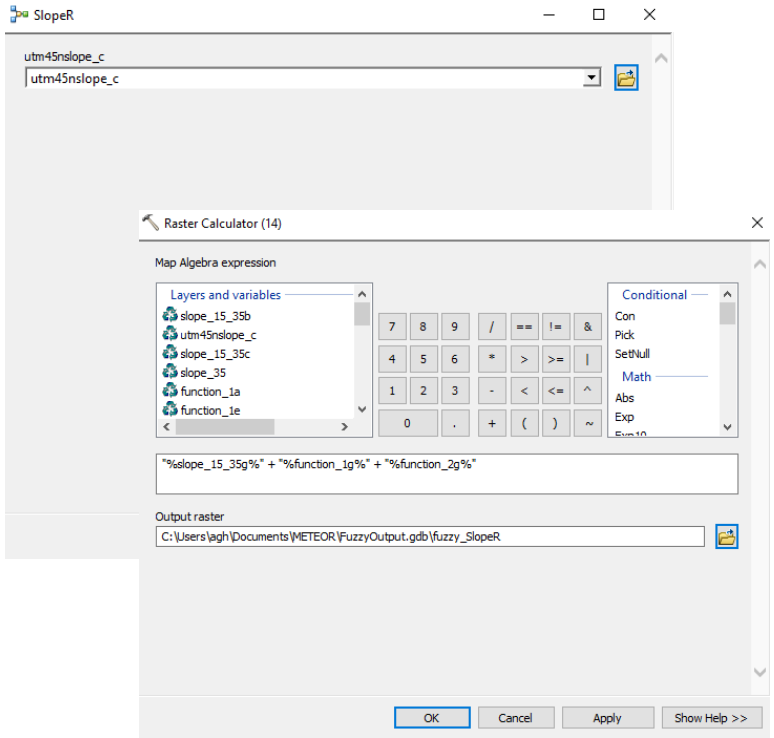


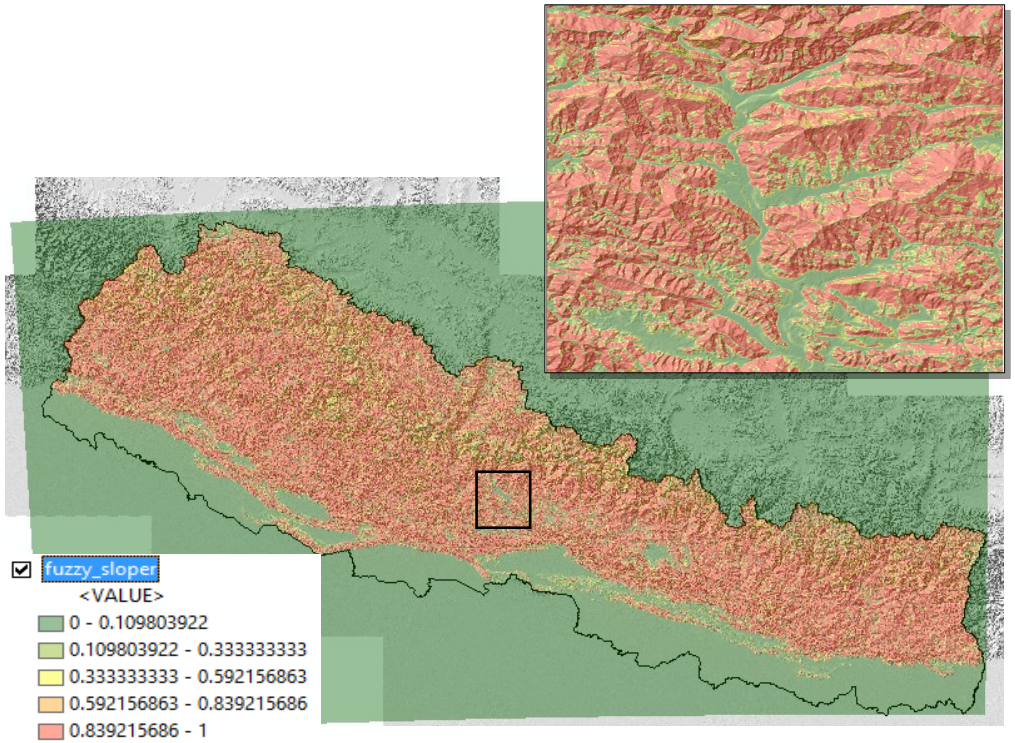
Input 1 Parameter

Tool (Raster Calculator)

Output n (final)

Example A: Model Tool Dialog and Fuzzy slope map





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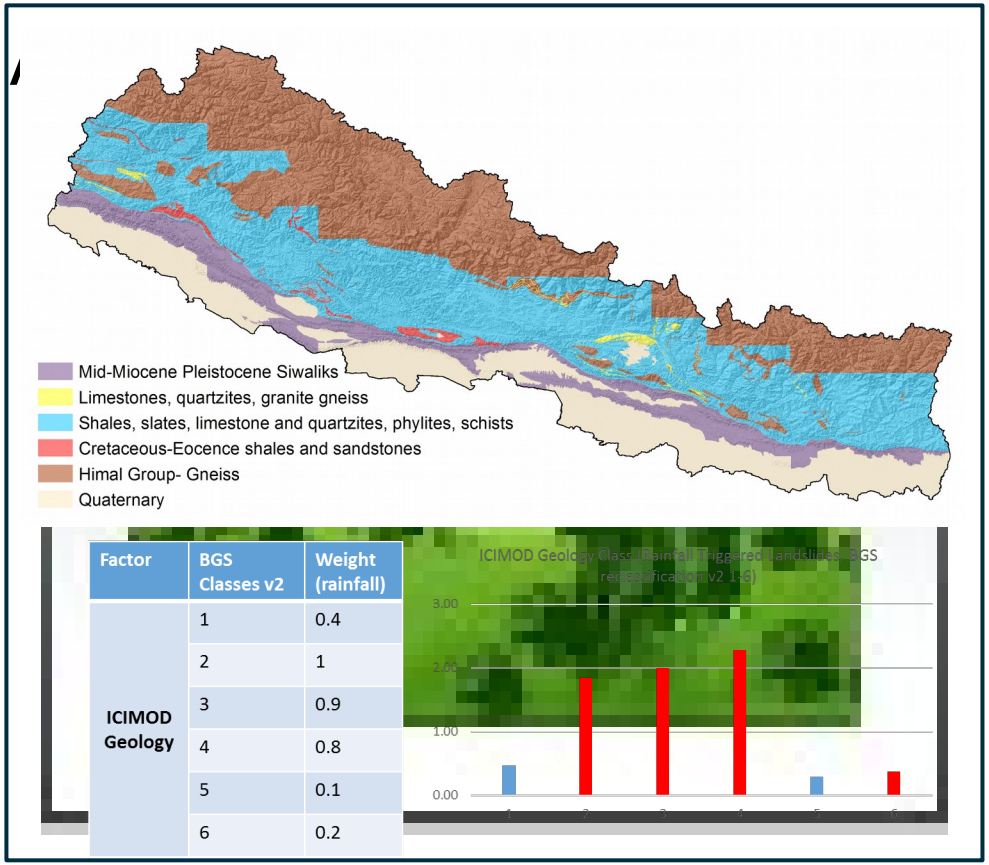
Example B: Fuzzy membership function for lithology



Factor	BGS Classes v2	Weight (rainfall)
ICIMOD Geology	1	0.4
	2	1
	3	0.9
	4	0.8
	5	0.1
	6	0.2

Rule set definition:

The competent fractured/tectonised rocks and mixed lithologies typically foliated, bedded and prone to weathering are most susceptible; Mid-Miocene Pleistocene Siwalik group is moderately susceptible; the Himal Group – Gneiss and Quaternary are least susceptible

Function type: n/a (categorical variable)

Example B: Fuzzy membership function for lithology

Function parameters

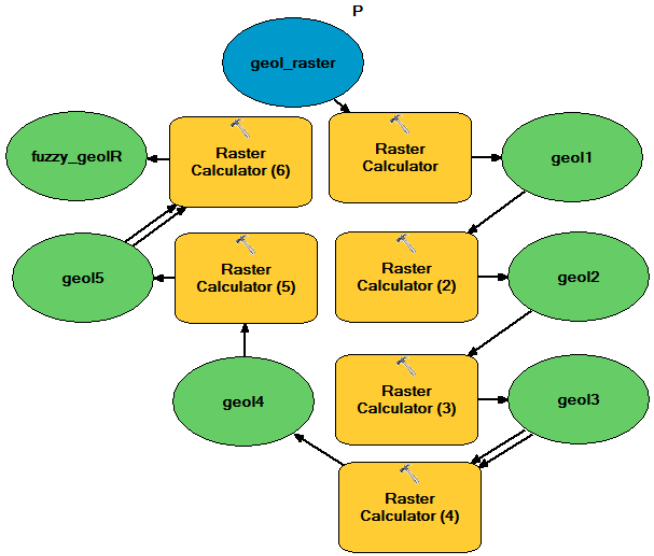
- S = 1, when G class = 2
- S = 0.9, when G class = 3
- S = 0.8, when G class = 4
- S = 0.4, when G class = 1
- S = 0.2, when G class = 6
- S = 0.1, when G class = 5

Function

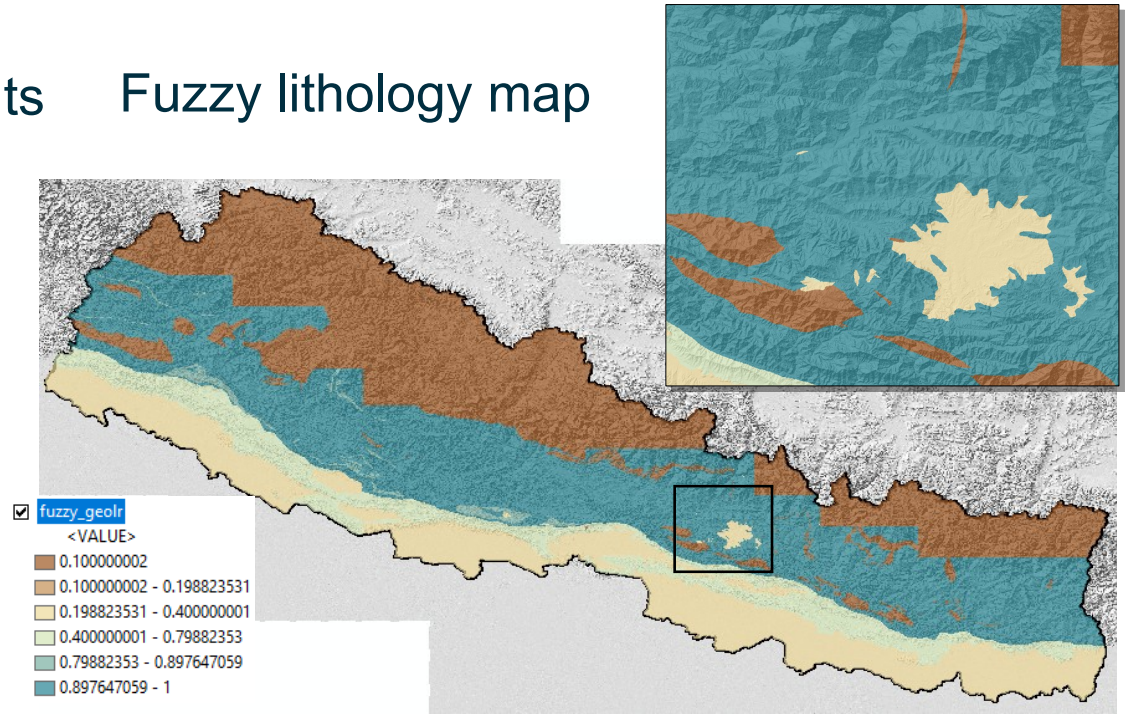
$$fG(G_i) = \begin{cases} 1, & G = \text{limestones, quartzites, granite gneiss} \\ 0.9, & G = \text{Weathered, fdicated, bedded mixed lithologies} \\ 0.8, & G = \text{K-EO shales and sandstones} \\ 0.4, & G = \text{Mid MI-PS Sivaliks} \\ 0.2, & G = \text{Recent} \\ 0.1, & G = \text{Himal Group - Gneiss} \end{cases}$$

Example B:

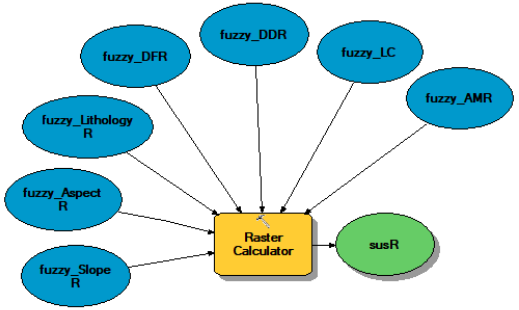
Model diagram and elements

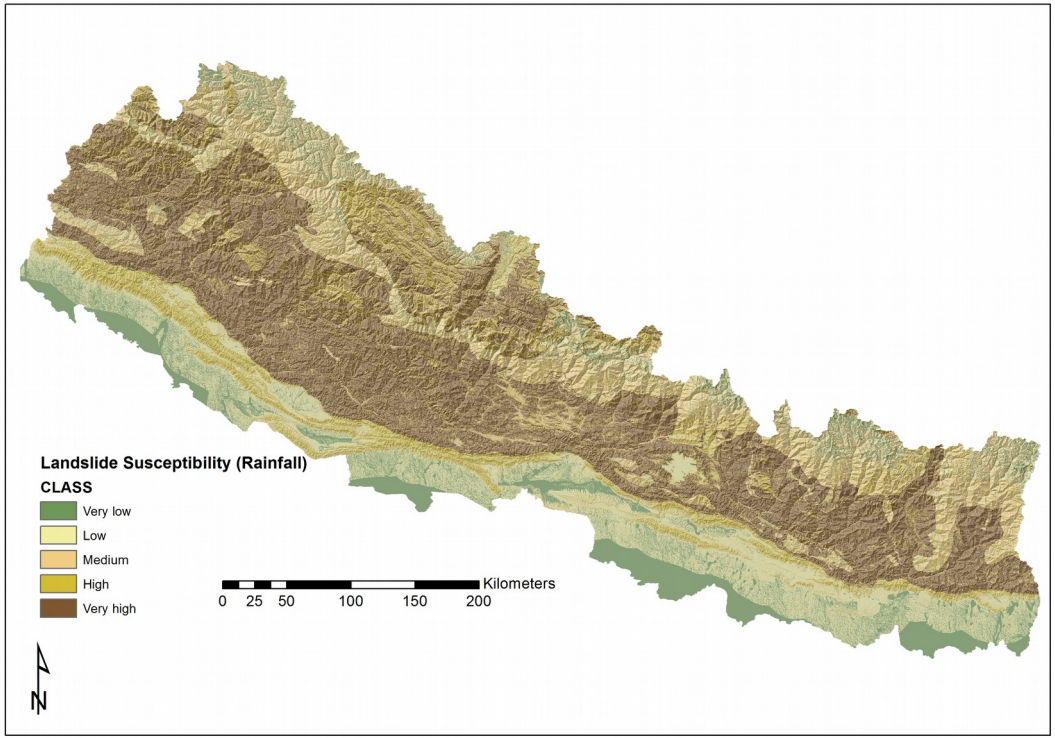


Fuzzy lithology map



Model diagram and resulting susceptibility map





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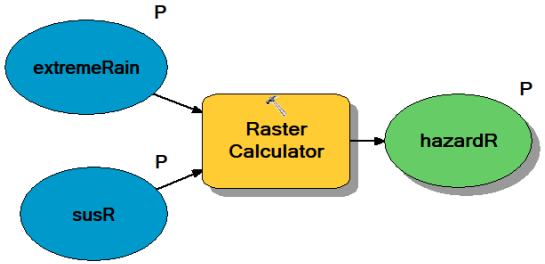
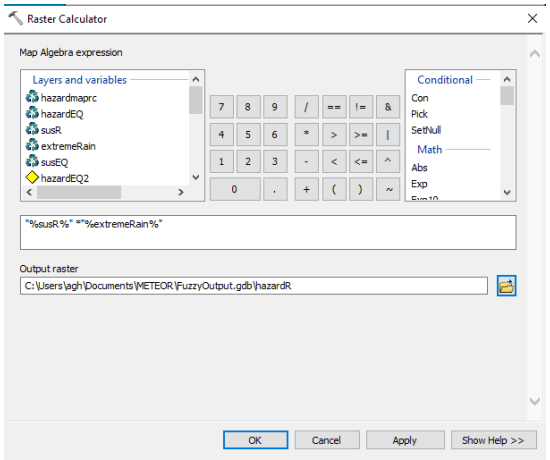
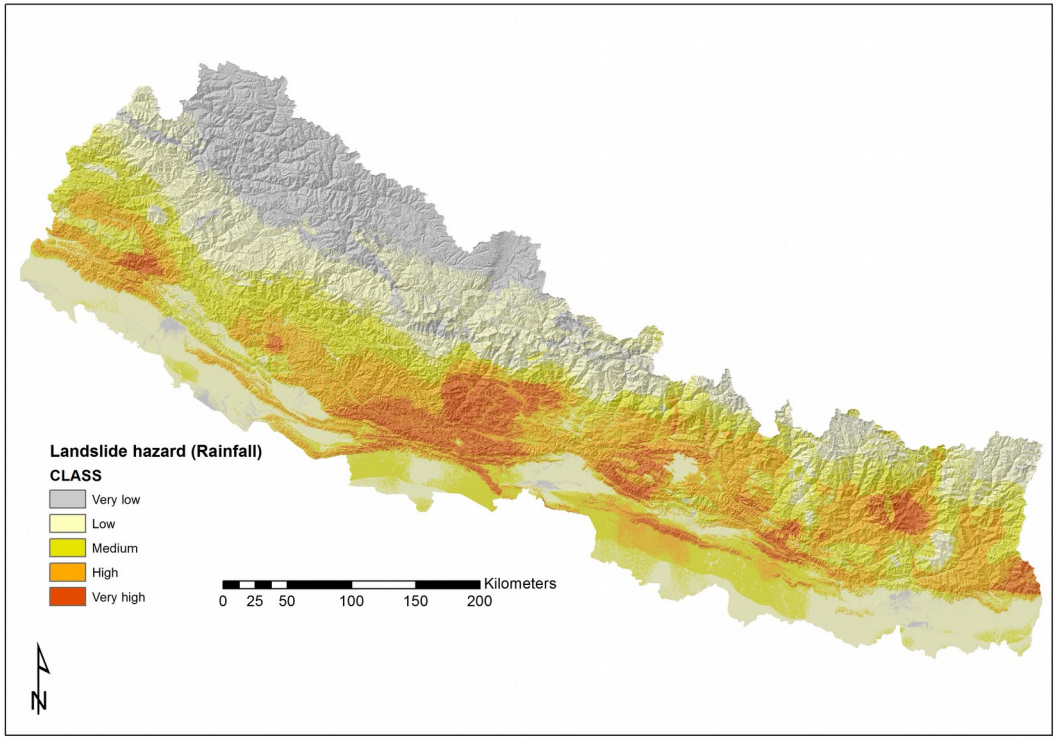
Model diagram and resulting hazard map







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Zhu, A.X., Wang, R., Qiao, J., Qin, C. Z., Chen, Y., Liu, J., Du, F., Lin, Y. & Zhu, T. (2014) An expert knowledge-based approach to landslide susceptibility mapping using GIS and fuzzy logic. Geomorphology (214), pp 128-138

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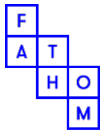

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