ICIMOD

Habitat suitability modeling of landscape-scale umbrella species

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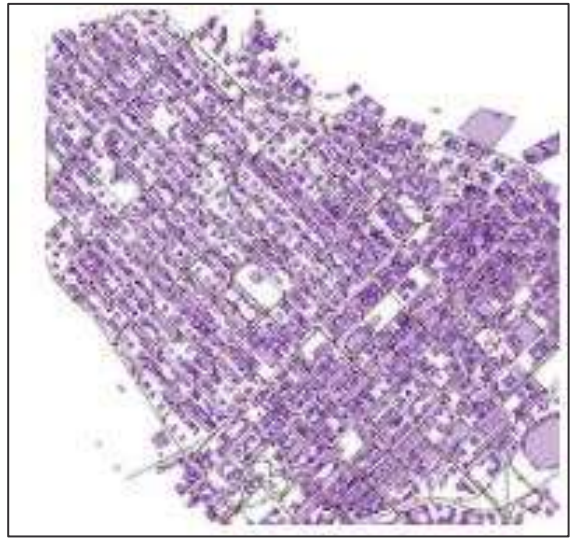
17-08-2021

Photo: DoFPS, Bhutan

What is spatial data

Data related to or containing information about a specific location on the Earth's surface



Vector

Raster

Components of Spatial Data

Attributes information

Projection system

Geographic and projected co-ordinate system

LATITUDE	LONGITUDE	WardNumber	DISTRICT	ZONE	VDC	PA	ELEVATION	SLOPE	LANDCOVER
26.6	87.911	5	Jhapa	Mechi	Dangibari		105	0.697233	Irrigated croplands
27.055	87.543	4	Terhathum	Koshi	Okhre		531	22.8728	Mosaic Croplands/Vegetation
27.056	87.553	4	Terhathum	Koshi	Okhre		361	12.1367	Mosaic Vegetation/Croplands
27.478	84.322	6	Chitawan	Narayani	Baghauda	Chitwan	170	0.413298	Irrigated croplands
28.41	84.875	3	Gorkha	Gandaki	Sirdibas	Manaslu	2729	33.3615	Mosaic Croplands/Vegetation
28.309	84.991	9	Gorkha	Gandaki	Kerauja		3867	32.3932	Closed needleleaved evergreen forest
28.312	85.005	9	Gorkha	Gandaki	Kerauja		3170	33.7899	Closed needleleaved evergreen forest
28.79	80.171	99	Kanchanpur	Mahakali	Shuklaphanta wildlife reserve	Shukla Phanta	181	0.413298	Mosaic Vegetation/Croplands
28.8	80.163	99	Kanchanpur	Mahakali	Shuklaphanta wildlife reserve	Shukla Phanta	181	0.945178	Rainfed croplands
28.808	80.197	99	Kanchanpur	Mahakali	Shuklaphanta wildlife reserve	Shukla Phanta	178	0.324219	Mosaic Vegetation/Croplands
27.561	84.472	99	Chitawan	Narayani	Chitwan national park	Chitwan	185	0.573131	Mosaic Vegetation/Croplands
27.561	84.479	99	Chitawan	Narayani	Chitwan national park	Chitwan	184	0.256319	Mosaic Vegetation/Croplands
27.128	84.86	6	Parsa	Narayani	Bageshwari titarauna		96	0.229259	Irrigated croplands
27.133	84.853	6	Parsa	Narayani	Bageshwari titarauna		96	0.687748	Irrigated croplands
27.537	84.077	99	Chitawan	Narayani	Chitwan national park	Chitwan	144	8.93321	Rainfed croplands
27.546	84.075	99	Chitawan	Narayani	Chitwan national park	Chitwan	132	0.895217	Rainfed croplands
27.548	84.086	99	Chitawan	Narayani	Chitwan national park	Chitwan	136	0.668372	Rainfed croplands

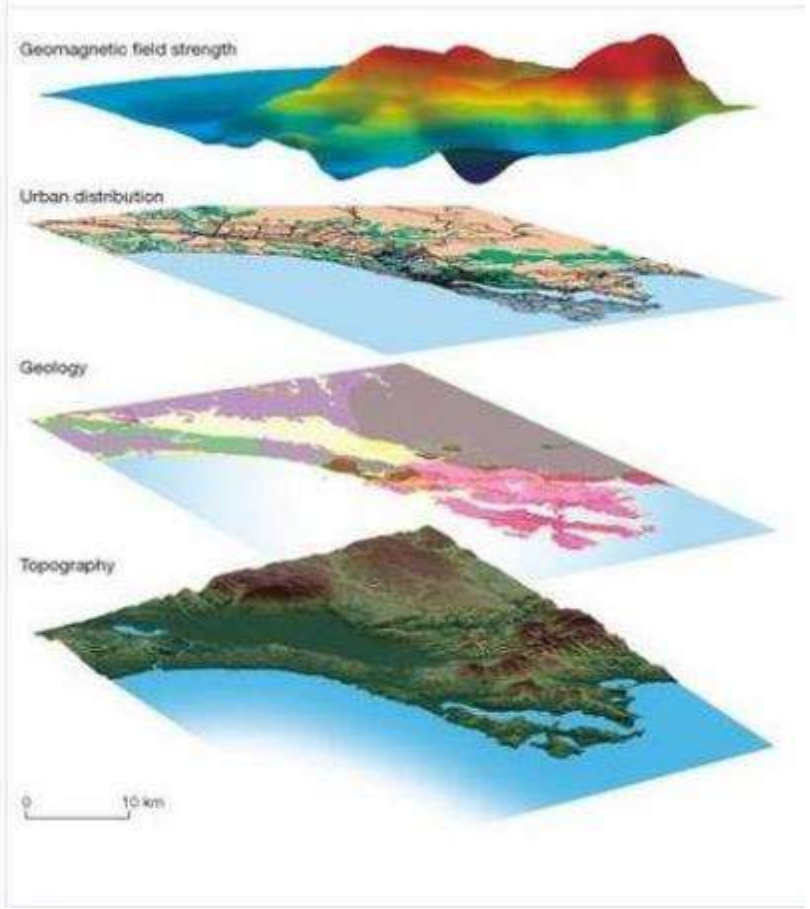
Geospatial modeling

To study and simulate spatial objects or phenomena that occur in the real world to facilitate problem solving and planning.

The Key elements are:

- Scale
- Pattern
- Noise

Accuracy and Precision



Hazard analysis using geospatial modelling

Habitat suitability modeling

Wildlife habitat models represent the presumed or known relationships between a species and the various environmental components that are needed for survival and reproduction (Cushman et 2013)

Important building block of connectivity models – A resistance raster

Habitat suitability modeling

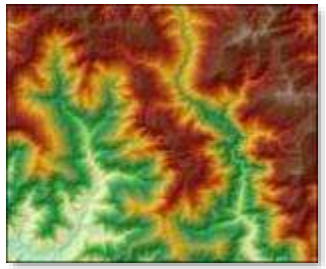
- Overlay analysis:

  Raster overlay
  Weighted overlay

- Species distribution model:

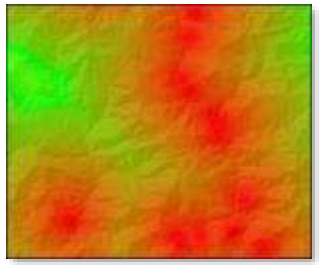
  includes species presence/absence data

  Regression Models
  Machine learning Models
  Ensemble model



DEM

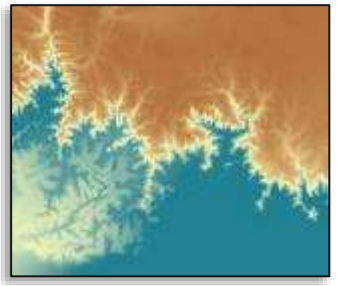
Distance from road



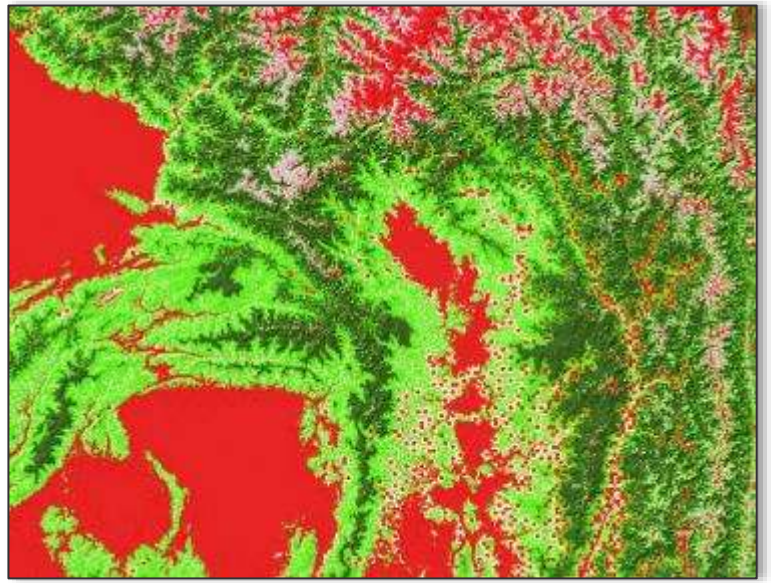
Distance from settlement

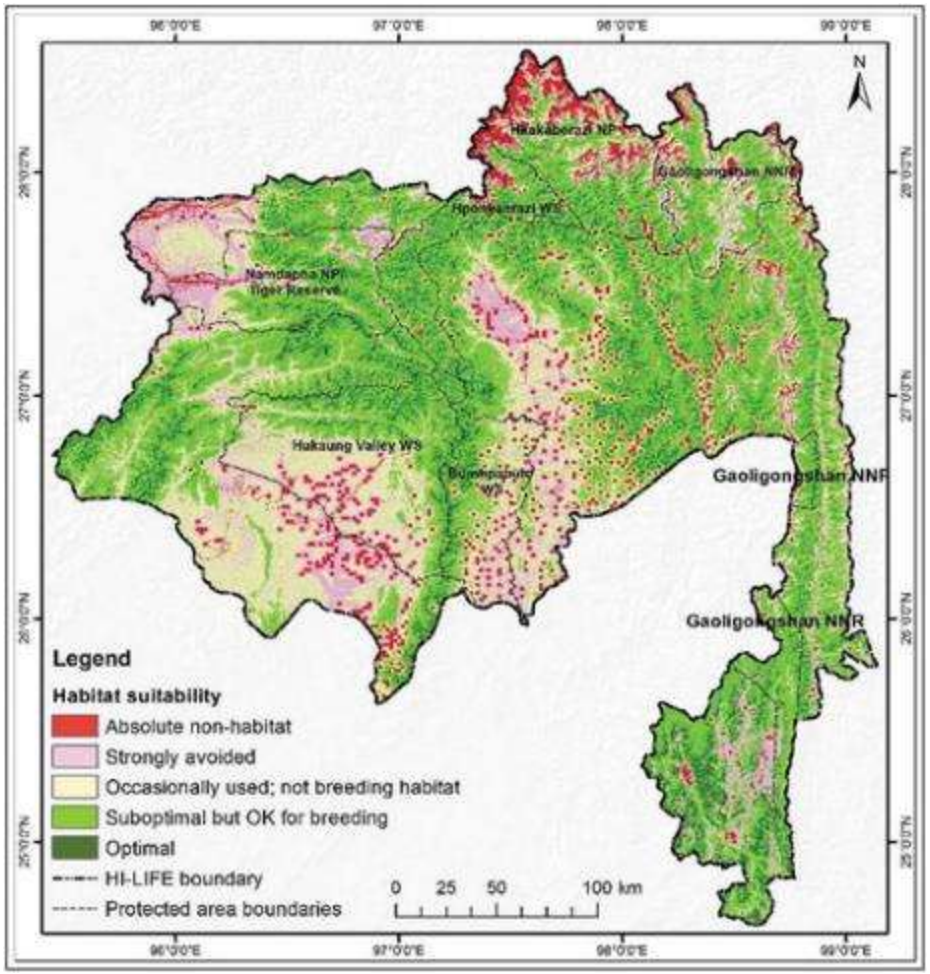
Land cover

Human-footprint index



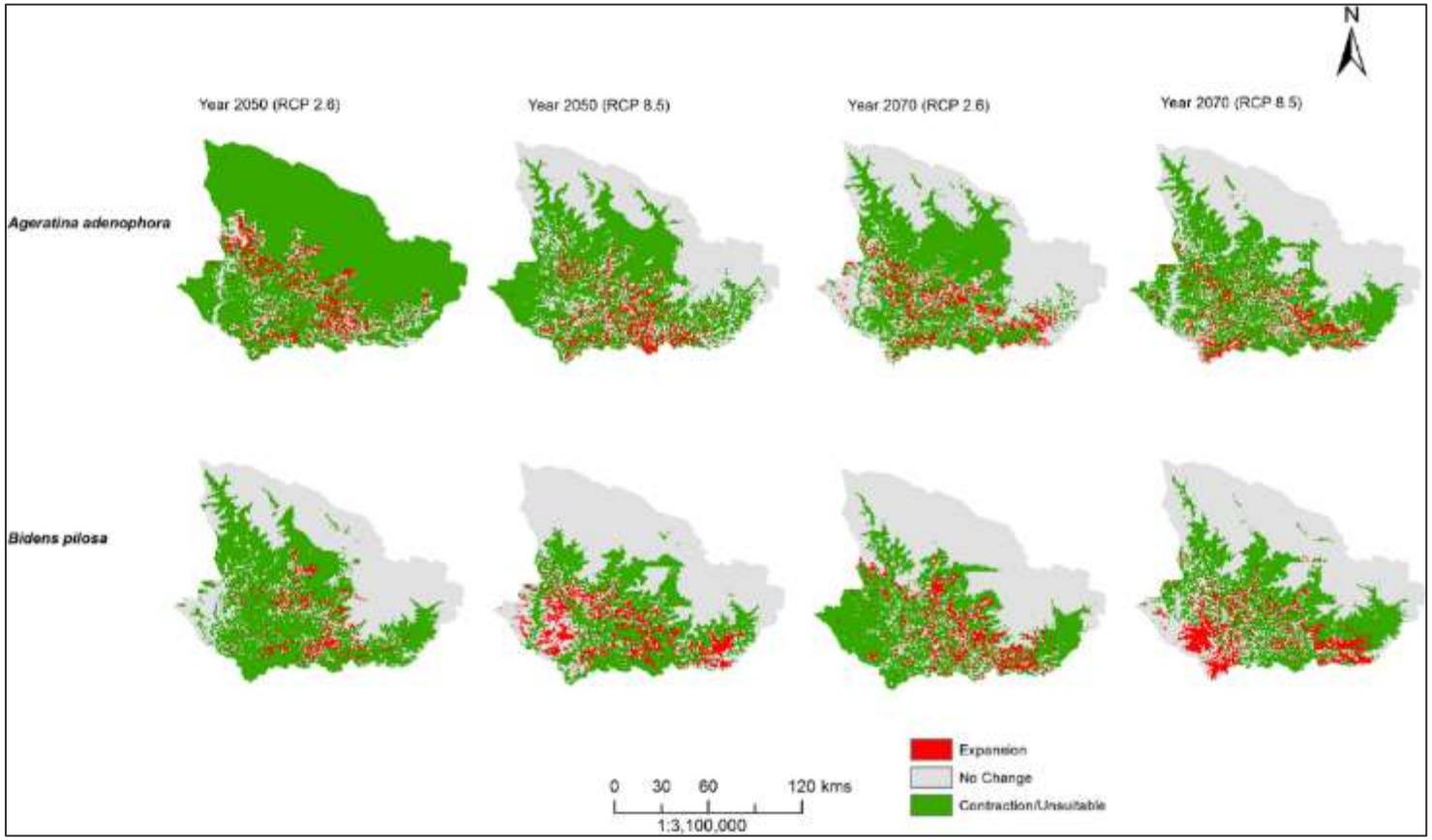
Bioclimatic





Habitat suitability of Leaf deer, Takin and Red panda in the eastern Himalayan landscape

Source: Uddin et al., 2019



Predicted range expansion of *Ageratina adenophora* and *Bidens pilosa* for year 2050 and 2070 at different climatic scenario

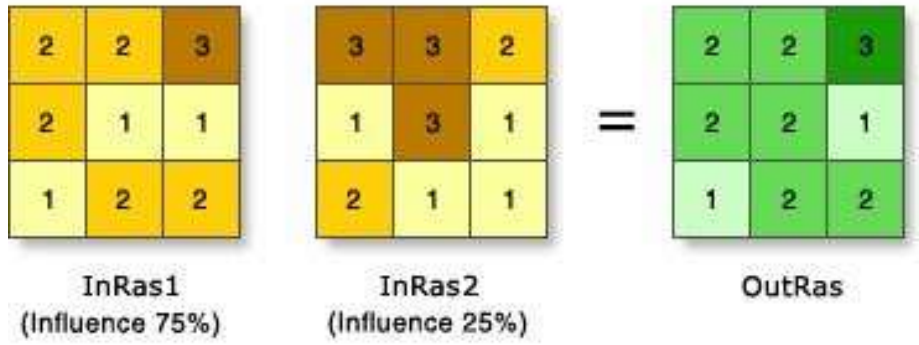
Source: Thapa et al., 2018

Weighted overlay analysis for habitat suitability

Overview of Weighted Overlay analysis

Liberal models

Types of overlay analysis:



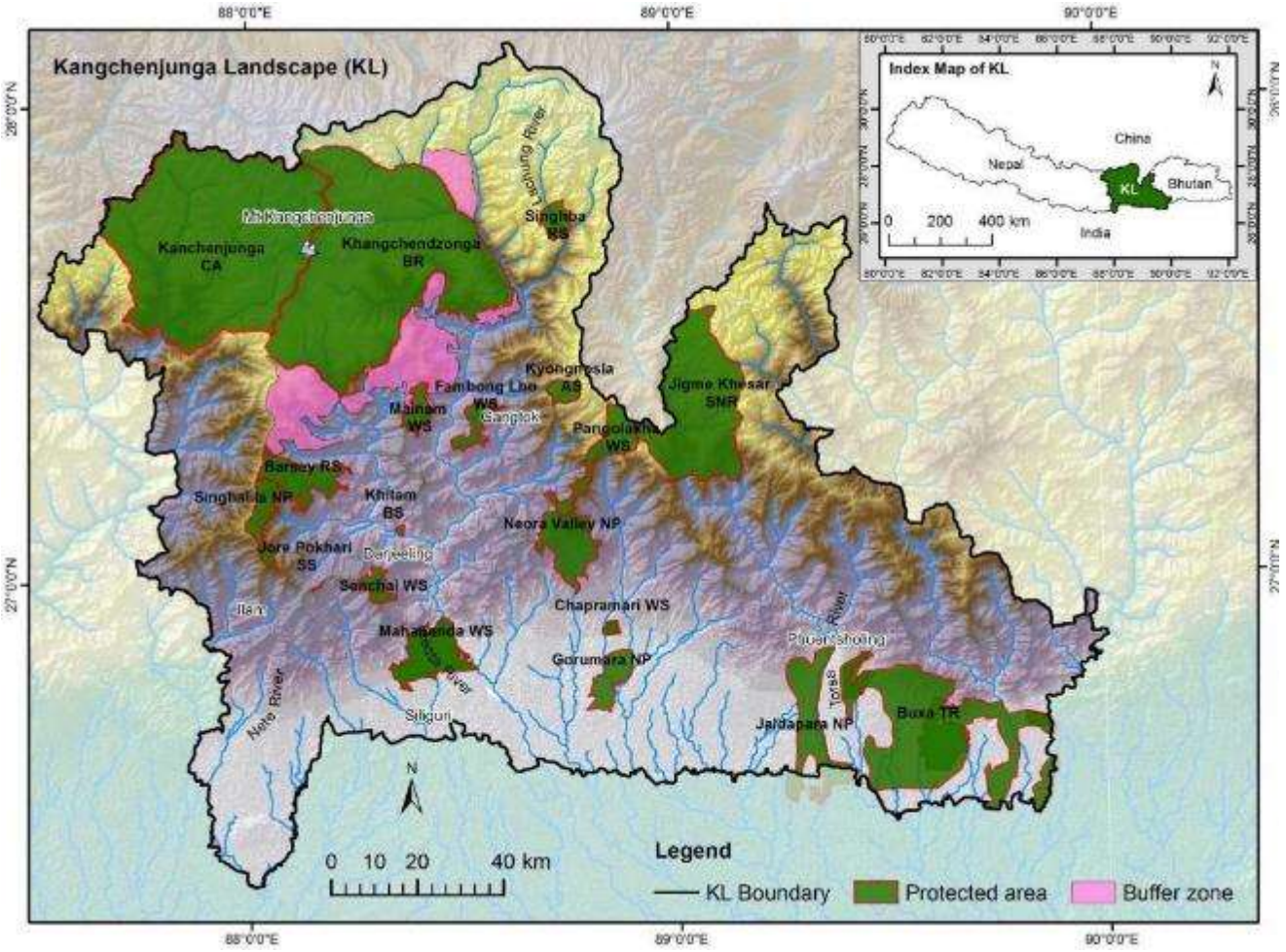
Source: Arc GIS

Additive mean – calculated using addition of data layers

Geometric mean - calculated using geometric mean of data layers

Steps in Weighted Overlay analysis

1. Define objective
2. Determine evaluation criteria
3. Acquire spatial datasets for criteria
4. Provide scores within criteria
5. Evaluate weights for each criteria
6. Perform overlay analysis
7. Evaluate and interpret results



Defining objective

To develop habitat suitability map for Kangchenjunga landscape for umbrella species

Determining criteria

- Land cover/ Land use pattern Surface
- Human infrastructure
  - Transportation network
  - Settlement
  - Utilities
- Terrain characteristics
  - Elevation
  - Topographic position
  - Slope
- Climate consideration
  - Temperature
  - Precipitation
- Surface hydrology
- Geology
- Soil characteristics

Criteria used in the study

Land cover – *ICIMOD Regional database system for HKH*

Distance to all road- Road line layer: *Open Street Map*

Distance to major settlement- Point layer- *Open Street Map (Cities and Towns)*

Topographic position- Raster layer: Derived from Elevation

Elevation- Raster layer: Shuttle Radar Topography Mission (SRTM)

Distance to river- Line vector layer: *ICIMOD Regional database system for HKH*

Acquiring spatial data

- Is it available in spatial format
- Source of the dataset
- Spatial resolution of dataset
- What is the latest available dataset

Some of the globally available data set for:

- Climate: World clim, NCAR CommunityClimate System Model (CCSM)
- Hydrology: HdroSHEDS, JRC Global Surface Water,
- Landover: Copernicus global land cover, USGS GLCC, SERVIR HKH RLCM (available shortly)

Defining scores

Provide scores based on suitability classes

Ranges or **discrete classes** are provided with score/rank to each categories based on suitability

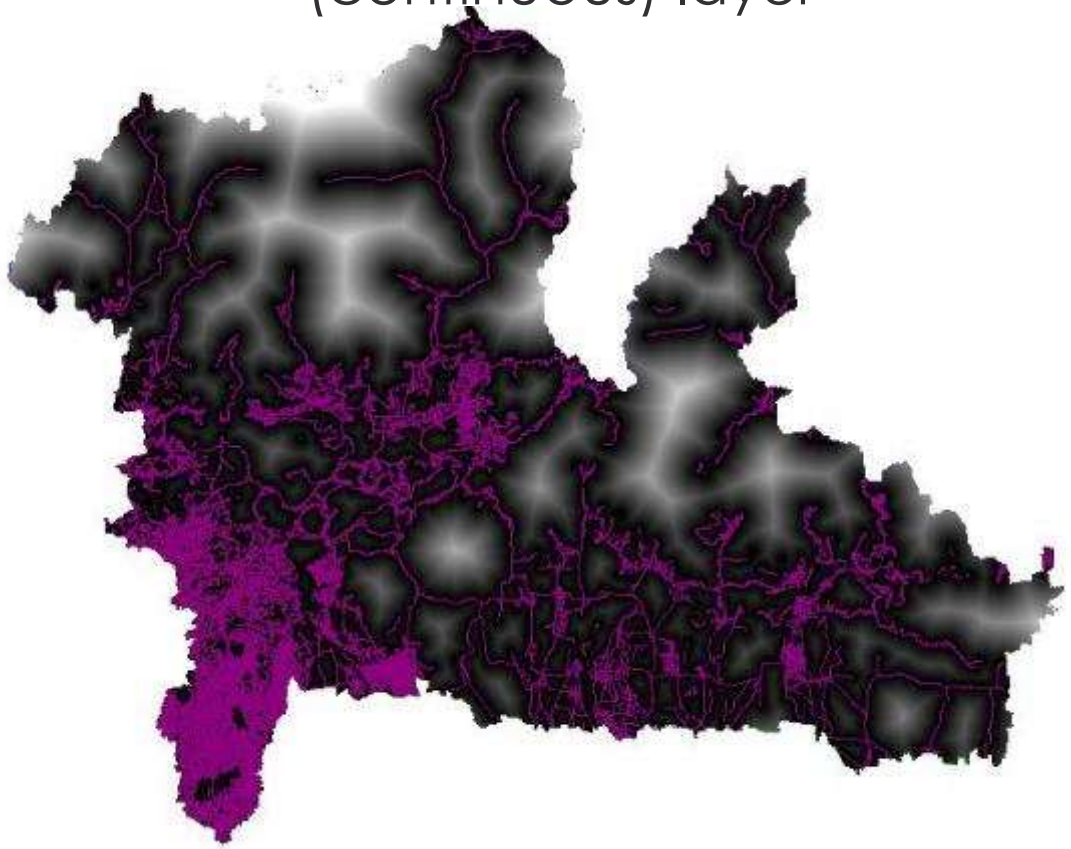
All criteria must be scored in the same scale

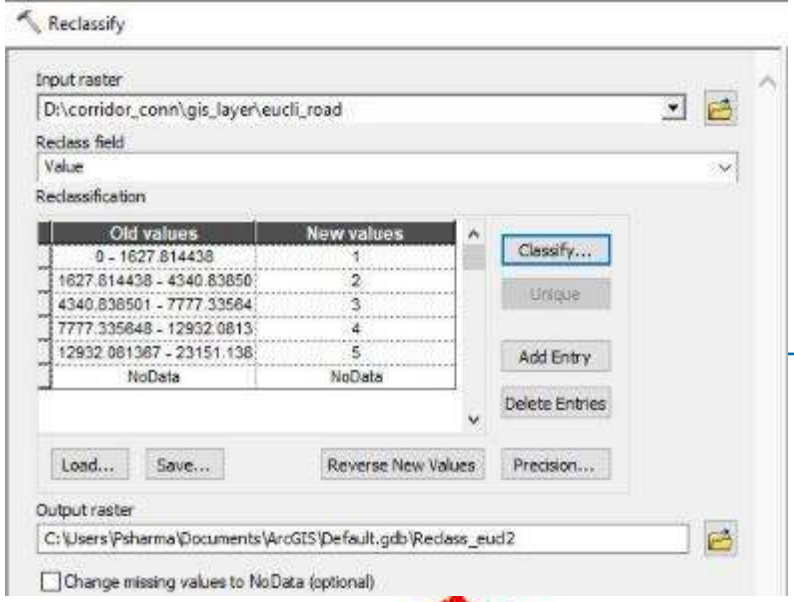
Mathematical function such as linear scaling are also used to provide scores and form continuous raster

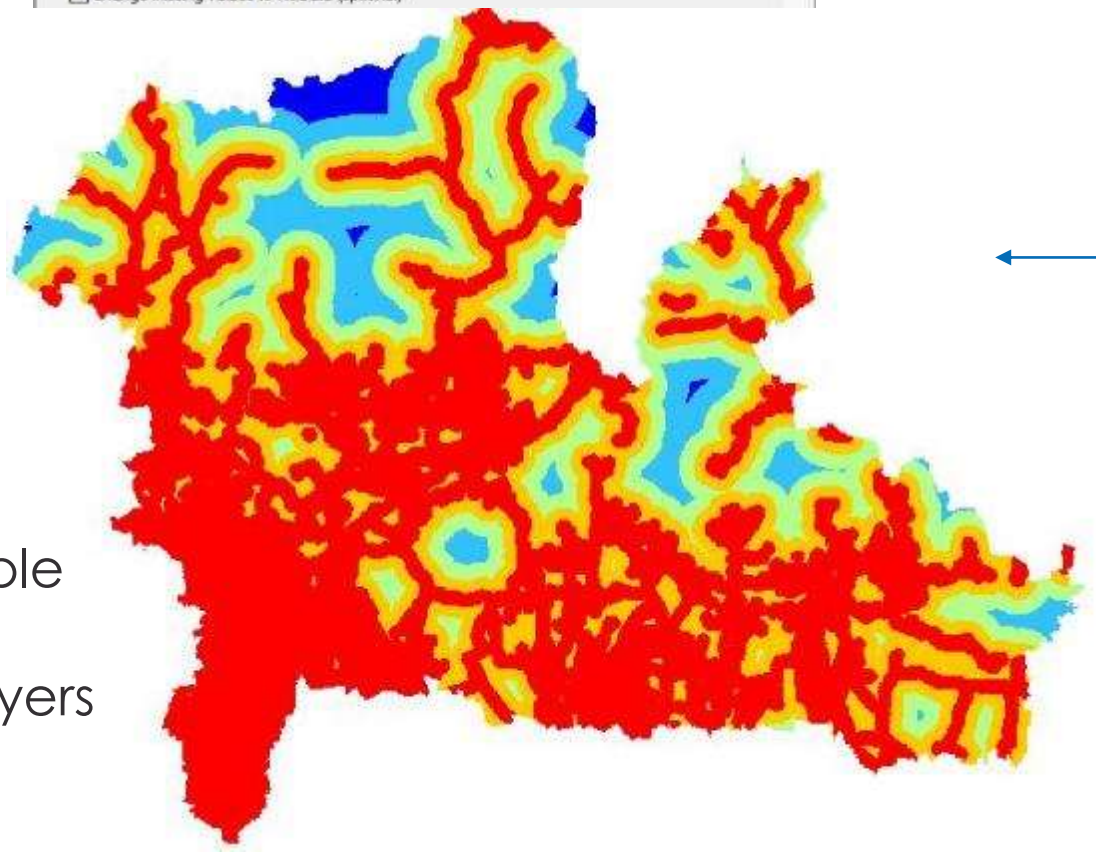
Distance to nearest road	
<0.5 km	4
0.5 km - 2 km	3
2 km - 8 km	2
>8 km	1

Forest cover type	
Needle leave forest	4
Broad leave forest	4
Mixed forest	2
Thorn forest	1

Example for reclassifying road (continuous) layer







- Reclassify tool to set scores
- Euclidean distance to road layer
- Reclassify road layer closet as least suitable and furthest as most suitable
- Carry out this steps for all raster criteria layers

Determining weights

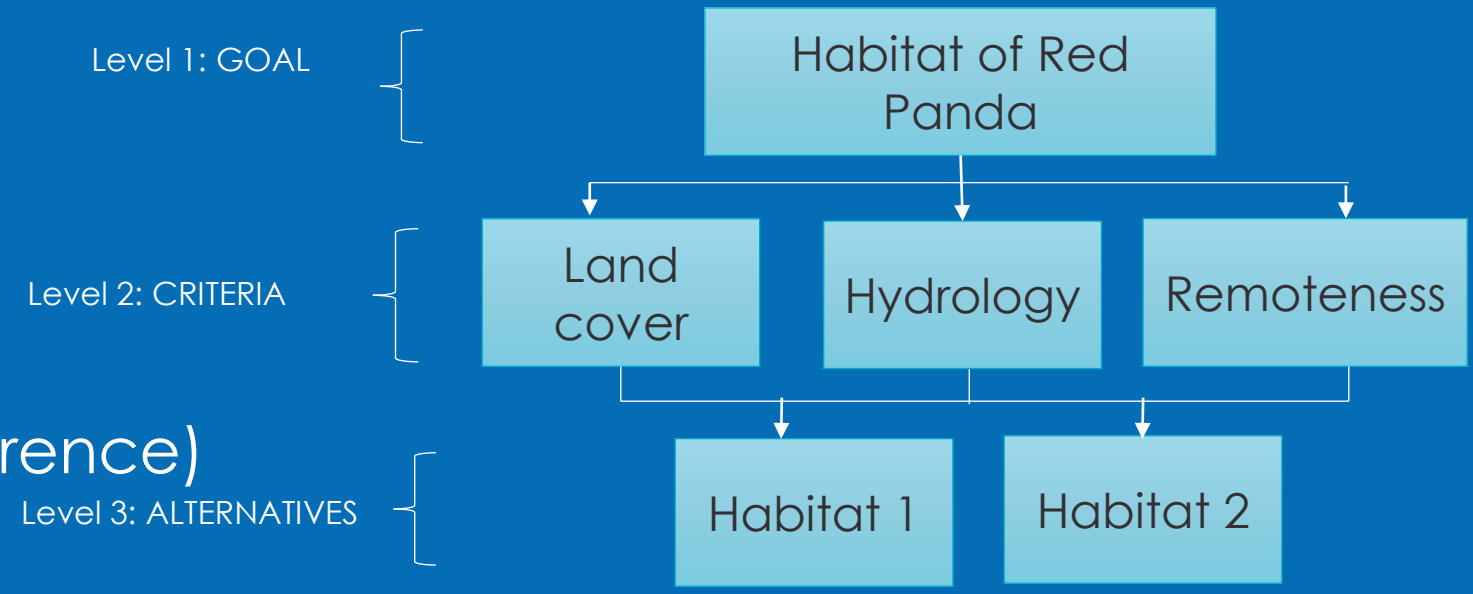
Most commonly used method:

Saaty's (2012) Analytical Hierarchy Process using pairwise comparison among criteria

Based on:

Best judgement
Expert knowledge
Literature

Stakeholder consultation(preference)



Saaty's Pairwise comparison scale	
Extremely important	9
	8
V. strongly more important	7
	6
Strongly more important	5
	4
Moderately more important	3
	2
Equally important	1

Criteria	Land cover	Dist to road	Dist to major settlement	Topographic position	Elevation	Dist to rivers
Landcover	1	4	4	4	3	4
Dist to road	1/4	1	1/2	1/3	1/3	1/2
Dist to major settlement	1/4	2	1	1/3	1/3	1/2
Topographic position	1/4	3	3	1	1/3	3
Elevation	1/3	3	3	3	1	3
Distance to rivers	1/4	2	2	1/3	1/3	1
SUM	2.333333	15	13.5	9	5.33333	12

Criteria	Land cover	Dist to road	Dist to major settlement	Topographic position	Elevation	Dist to rivers	AVERAGE	Weights	**Final Weights***
Land cover	0.43	0.267	0.29	0.44	0.56	0.3	0.38	38.86	39%
Dist to road	0.11	0.067	0.03	0.03	0.06	0.04	0.058	5.86	6%
Dist to major settlement	0.11	0.13	0.07	0.03	0.06	0.04	0.075	7.59	8%
Topographic position	0.11	0.2	0.22	0.1	0.06	0.25	0.158	15.88	16%
Elevation	0.14	0.2	0.22	0.3	0.18	0.25	0.22	22.1	22%
Dist to rivers	0.11	0.13	0.14	0.03	0.062	0.083	0.095	9.52	10%

*Weights should add up to 100

Overlay Analysis

- Weighted Overlay Analysis – Arc GIS tool

  Additive mean

Sum(creiteria1*Weight1+ creiteria2*Weight2+ criteria3*W3 +……)

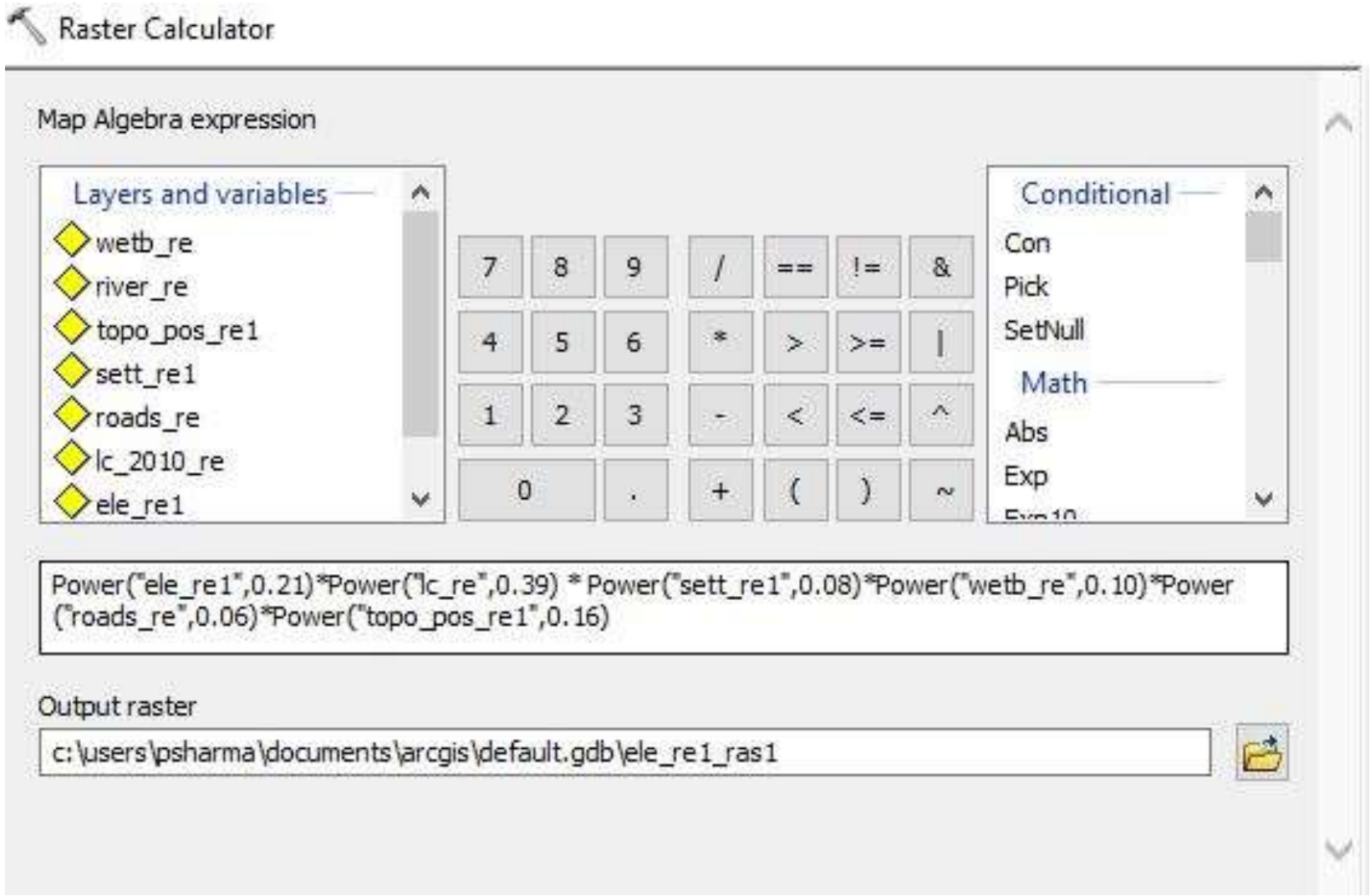
- Weighted Geometric mean

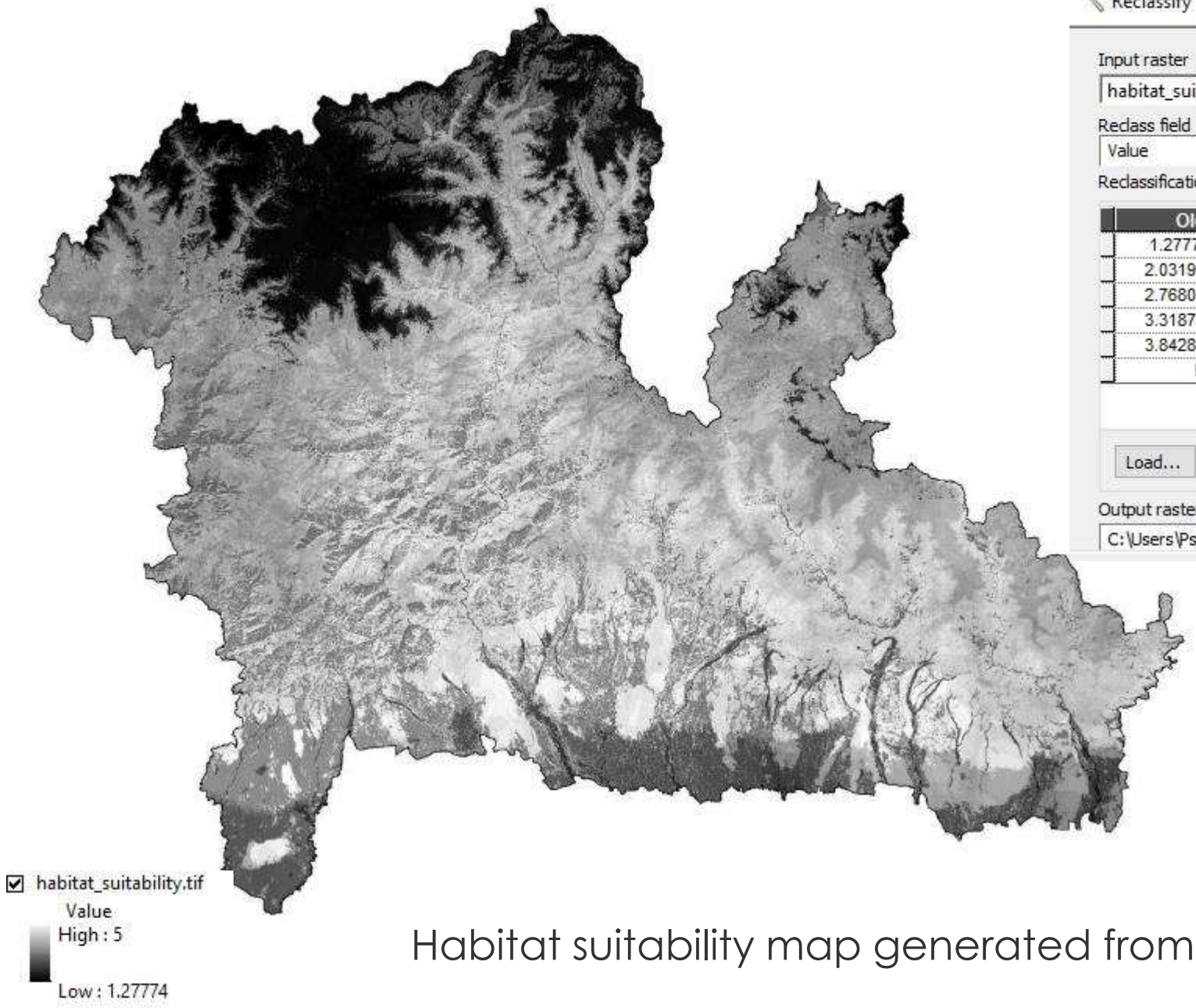
Formula:

$$\left(\prod_{i=1}^{n} x_i^{w_i}\right)^{1/\sum_{i=1}^{n} w_i}$$

HSI= Product((Criteria1^Weight1)*(Criteria2^Weight2)*(Criteria3^Weight3))^(1/ sumWn)

Formula for raster calculator





Reclassify

Input raster: habitat_suitability.tif

Reclass field: Value

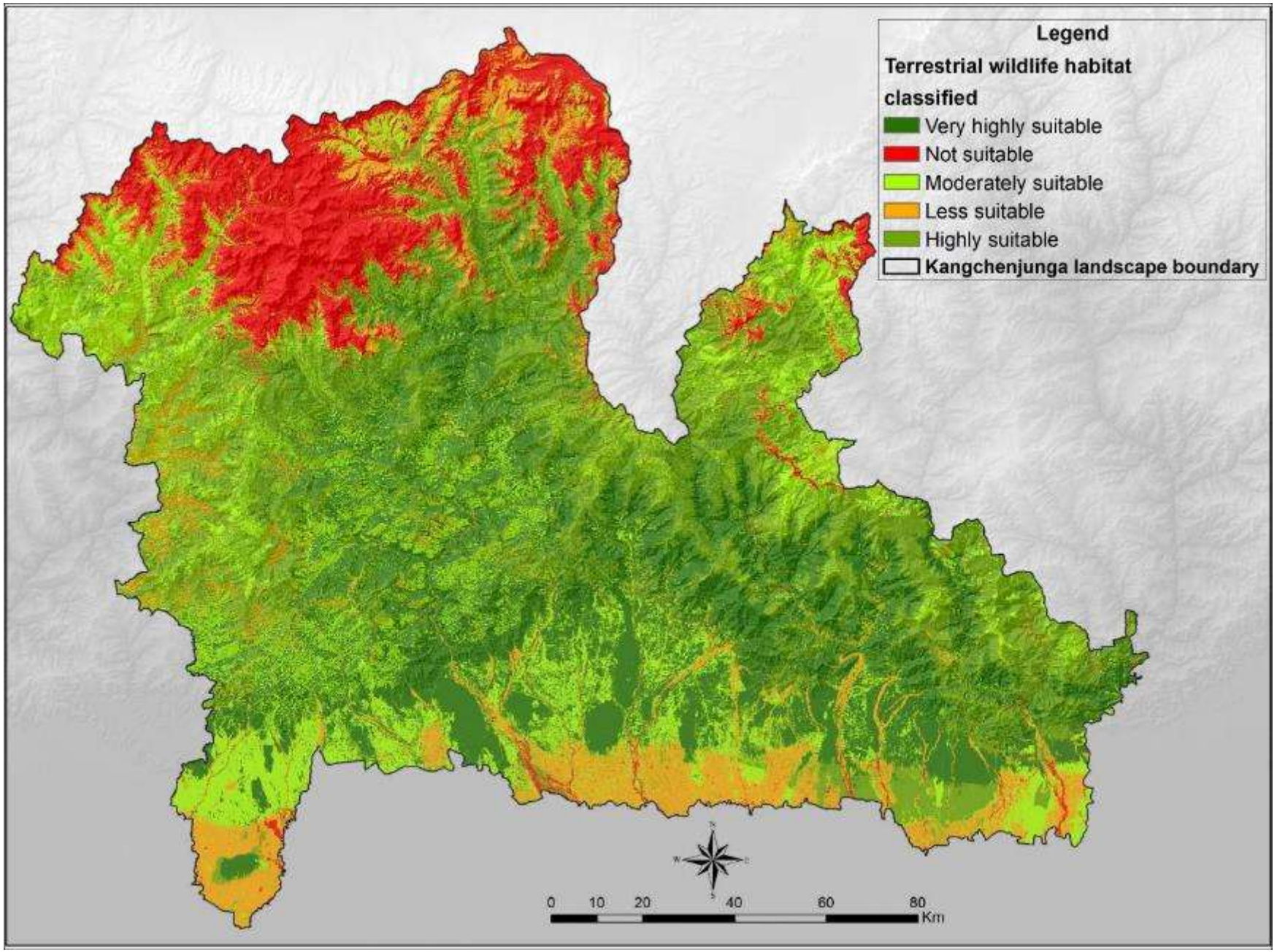
Reclassification

Old values	New values
1.27774 - 2.031925	1
2.031925 - 2.768083	2
2.768083 - 3.318783	3
3.318783 - 3.842801	4
3.842801 - 4.763282	5
NoData	NoData

Classify... | Unique | Add Entry | Delete Entries | Load... | Save... | Reverse New Values | Precision...

Output raster: C:\Users\Psharma\Documents\ArcGIS\Default.gdb\Reclass_tif1

Habitat suitability map generated from overlay analysis



Classified habitat suitability for terrestrial wildlife of the Kangchenjunga landscape

Conclusion

Weighted Overlay analysis can be used in areas of presence-absence data

Selection of and justification of weights could problematic.

Species distribution software like MaxEnt can be explored if data allows

Species level information is necessary to reach certain degree to accuracy and validation.

Reading materials

- Arc Map guide to Overlay analysis: https://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/how-weighted-overlay-works.htm

- Suitability analayis : Helmut Flitter et al., http://www.gitta.info/Suitability/en/text/Suitability.pdf

- GIS-Based Multicriteria Evaluation of Land Suitability for Grasslands Conservation in Chihuahua, Mexico: Vázquez-Quintero et al.,

- A GIS-based habitat suitability model for commercial yield estimation of Tapes philippinarum in a Mediterranean coastal lagoon (Sacca di Goro, Italy)

Thank you

Protect the pulse.