ICIMOD

Risk assessment of cultural ecosystem services in the Kailash Sacred Landscape

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Kailash- a cultural landscape

PROVISIONING SERVICES
Products obtained from ecosystems
- Energy
- Seafood
- Biomedial
- Transportation
- National defense

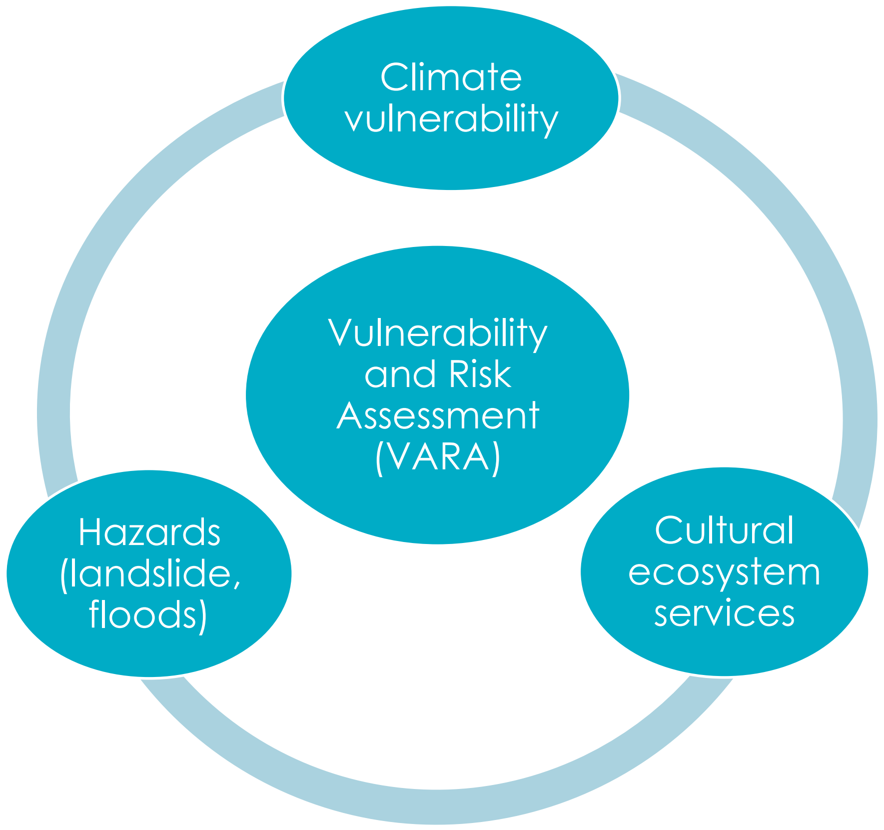
REGULATING SERVICES
Benefits obtained from the regulation of ecosystem processes
- Flood prevention
- Climate regulation
- Erosion control
- Control of pests and pathogens

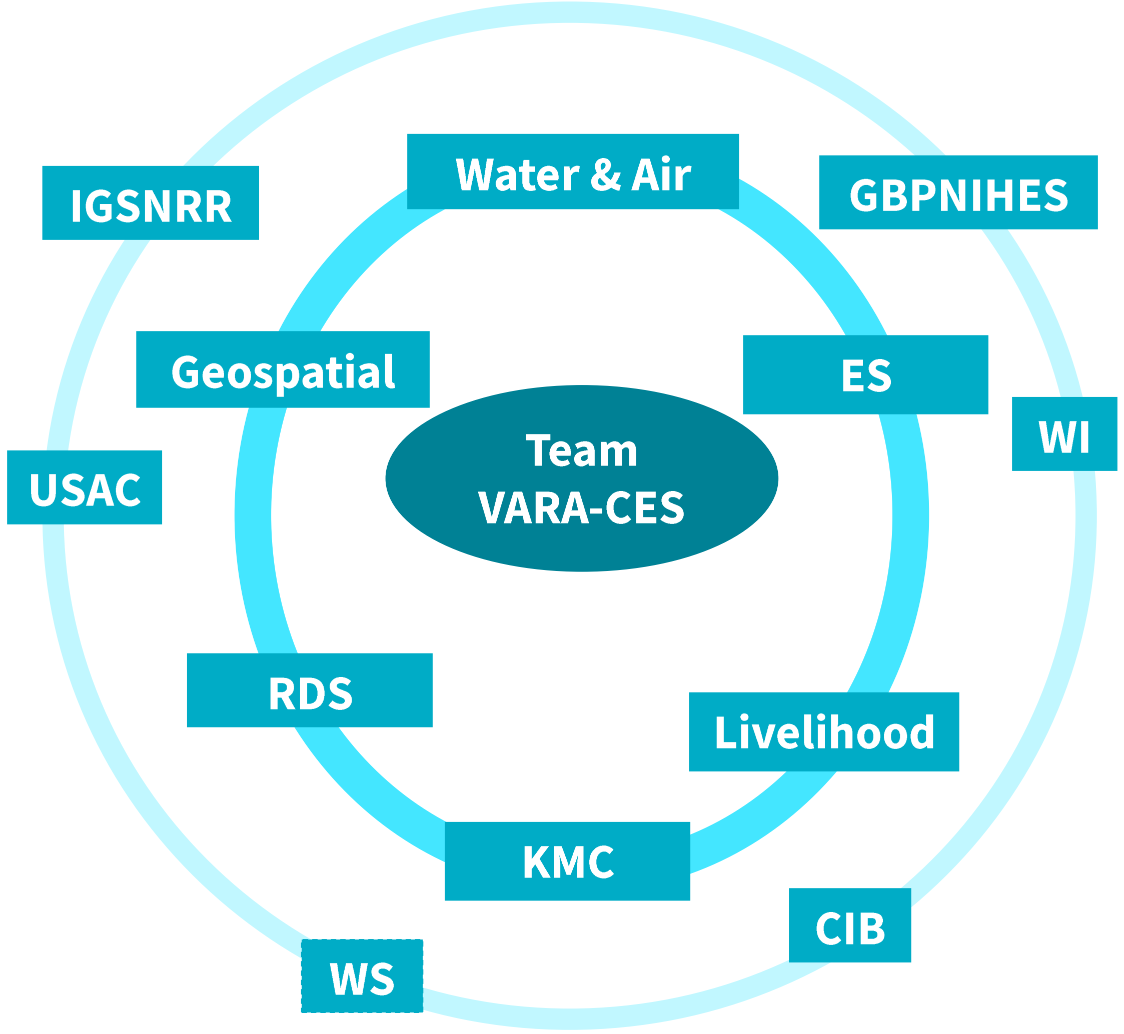
CULTURAL SERVICES
Nonmaterial benefits obtained from ecosystems
- Educational
- Recreational
- Heritage
- Spiritual

SUPPORTING SERVICES
Services necessary for the production of all other ecosystem services
- Biological diversity maintenance
- Nutrient recycling
- Primary productivity

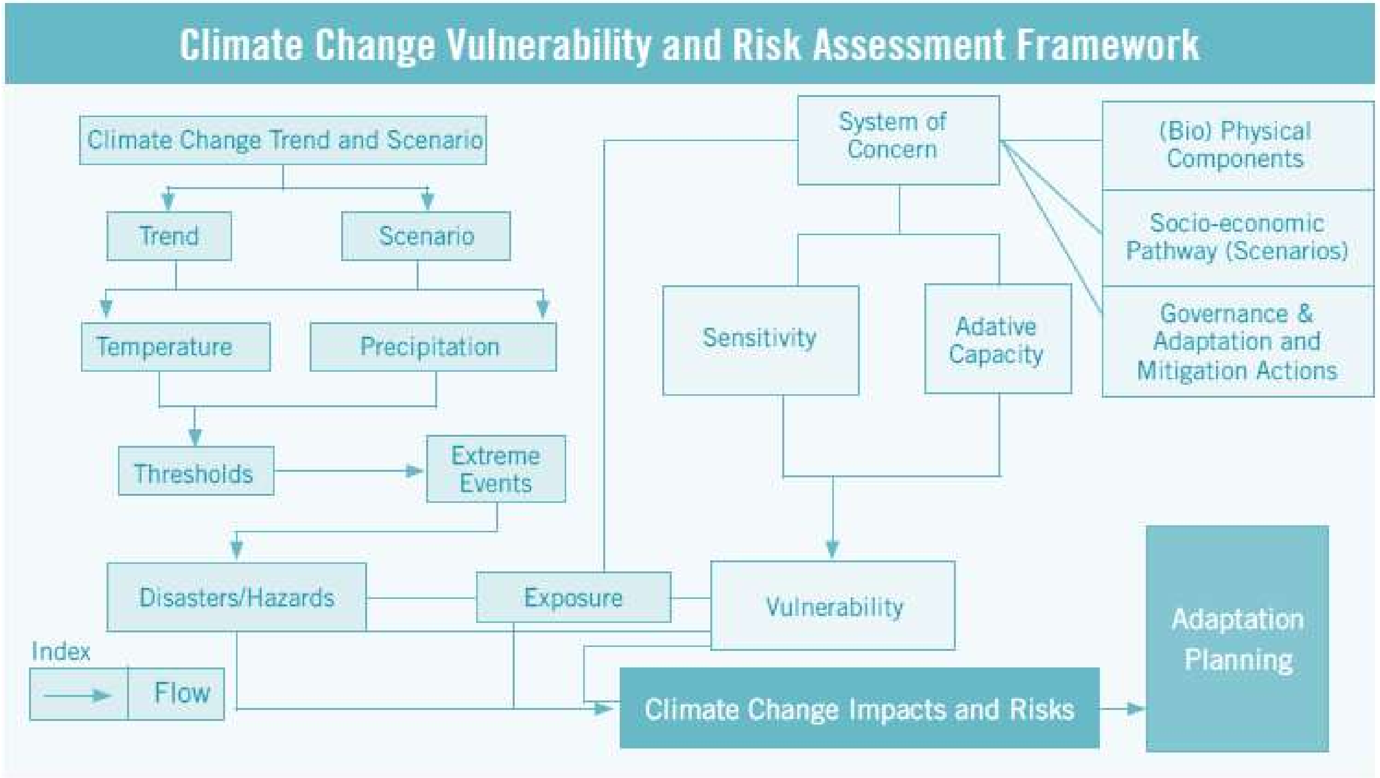
source: *Final Recommendations of the Interagency Ocean Policy Taskforce, 2010*

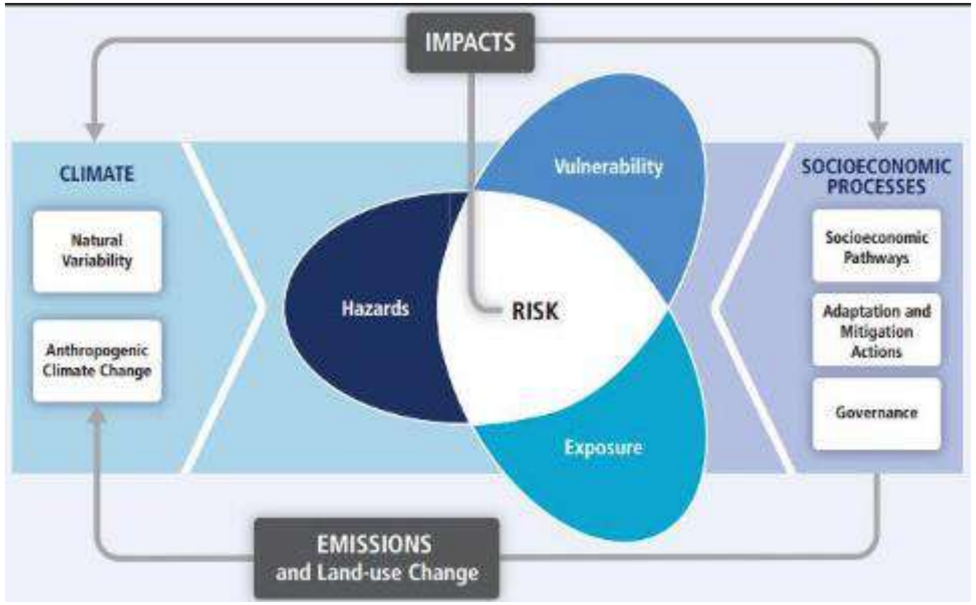
A trans-disciplinary approach





VARA assessment framework





IPCC, 2013

Risk assessment

- Identifying and selecting indicators
- Data collection
- Normalisation of indicators
- Weighting and aggregating of indicators
- Final risk assessment

Risk = Hazard * Vulnerability * Exposure

Vulnerability = Sensitivity * adaptive capacity

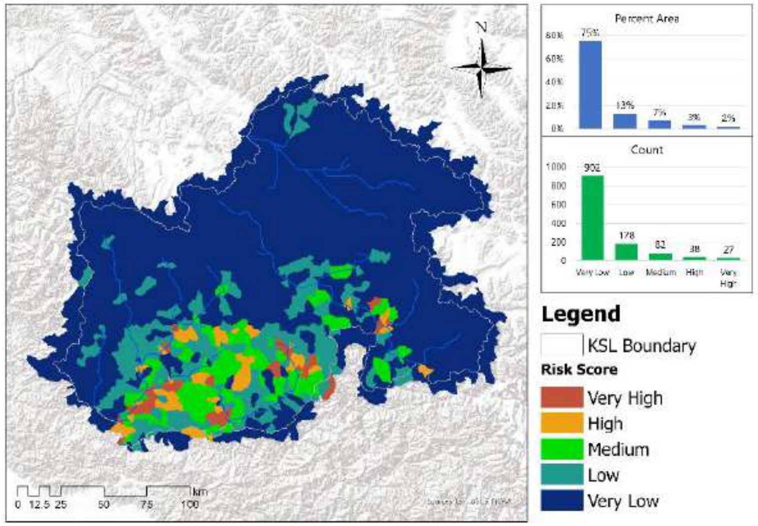
Sensitivity = sensitivity of CES to the hazards (based on the survey from experts)

Adaptive capacity = socio-economic (income, education, infrastructure, school)

Exposure = number of CSs in a watershed unit (higher sensitive with higher number)

Risk assessment

Risk = Function of (Hazard, vulnerability and exposure)



Hazards

(Landslides, Floods, GLOF, Climate Change, Inter/Intra annual Variability in precipitation, snow cover/snowline change)

Vulnerability

(Sensitivity, Adaptive Capacity)

Exposure

(Cultural Ecosystem Services, Communities)

Indicators

(Landslide Hazard Mapping, Flood Frequency and Magnitude, Extreme Indices)

Normalization

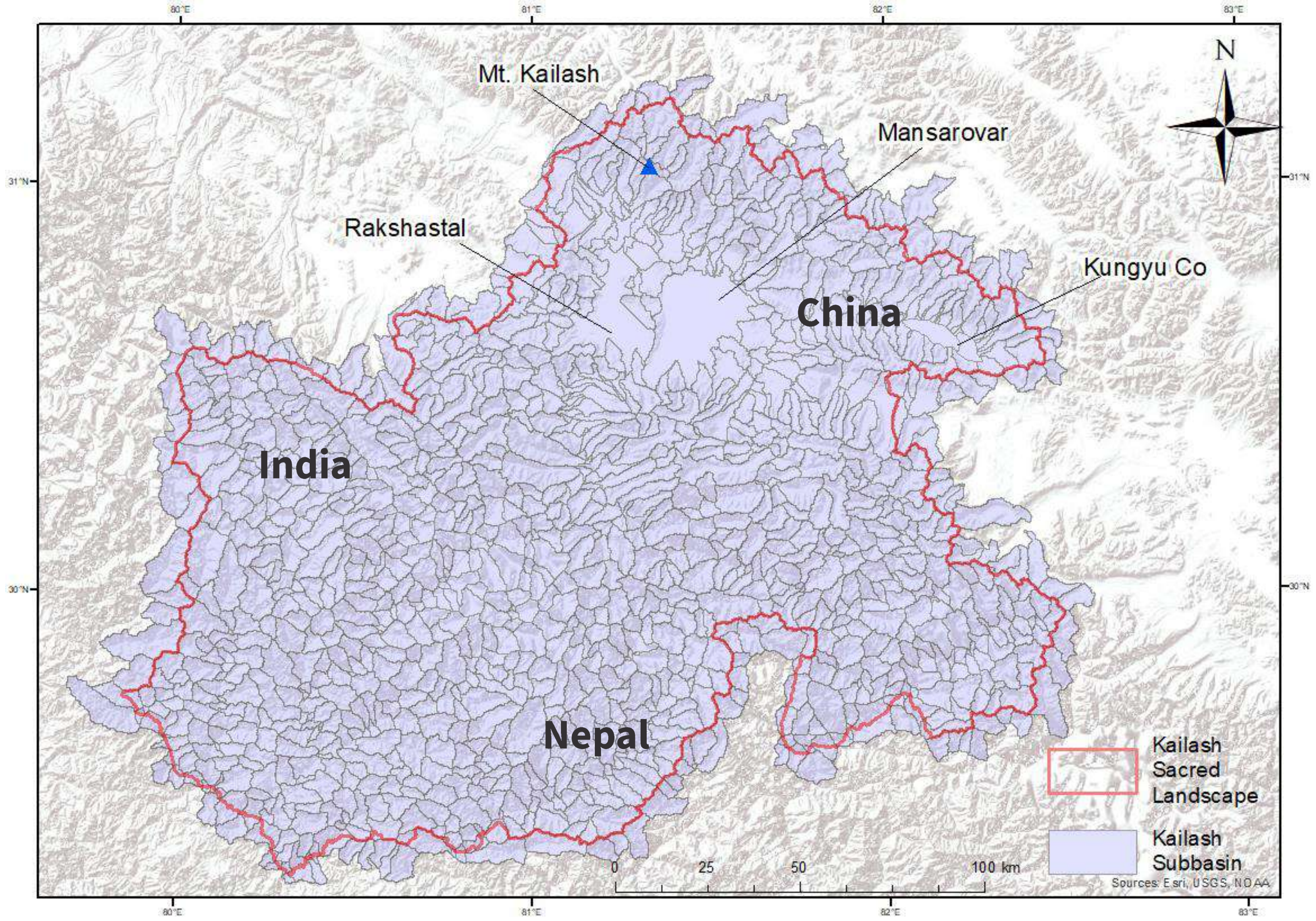
0 - 1

Risk Prioritization for all subbasins

Risk Score

0 – 0.2		Very low
0.2 – 0.4		Low
0.4 – 0.6		Medium
0.6 – 0.8		High
0.8 – 1		Very high

Spatial entity for risk assessment



1227 sub-watersheds ($10\text{-}20\ km^2$)

Every entity will have quantified indicators to calculate risk assessment

Information to hazard→Risk

Climate hazard hazard (rainfall, temperature)

Intra-annual variability –: CoV within year i.e. monthly. E.g. Jan, Feb… Dec

Inter annual variability –: CoV among year i.e. 1981, 1982…. 2010

Trend –: Sen slope and significance

Equation

- Co-efficient of variation (CoV) $= \frac{Standard\ deviation}{Mean}$
- CoV is measure of how large the standard of deviation is relative to the mean
- A higher value of CoV is the indicator of larger variability, and vice versa

Variability as an indicator of hazard

Rainfall variability has the potential to undermine sustainable development, increase poverty, and delay or prevent the realization of the Millennium Development Goals (IPCC, 2007).

The variability of each entity is calculated

1) Temporal variability for each climatic variable: average of all three variabilities

a) Interannual variability (considering variability of last 30 years) (1981-2010)

b) Intra-annual variability (considering monthly variability) (Jan-Dec)

c) Trend (Increase or Decrease in the climatic variables in last 30 years)

Combined variability: product of climatic variables → Normalization

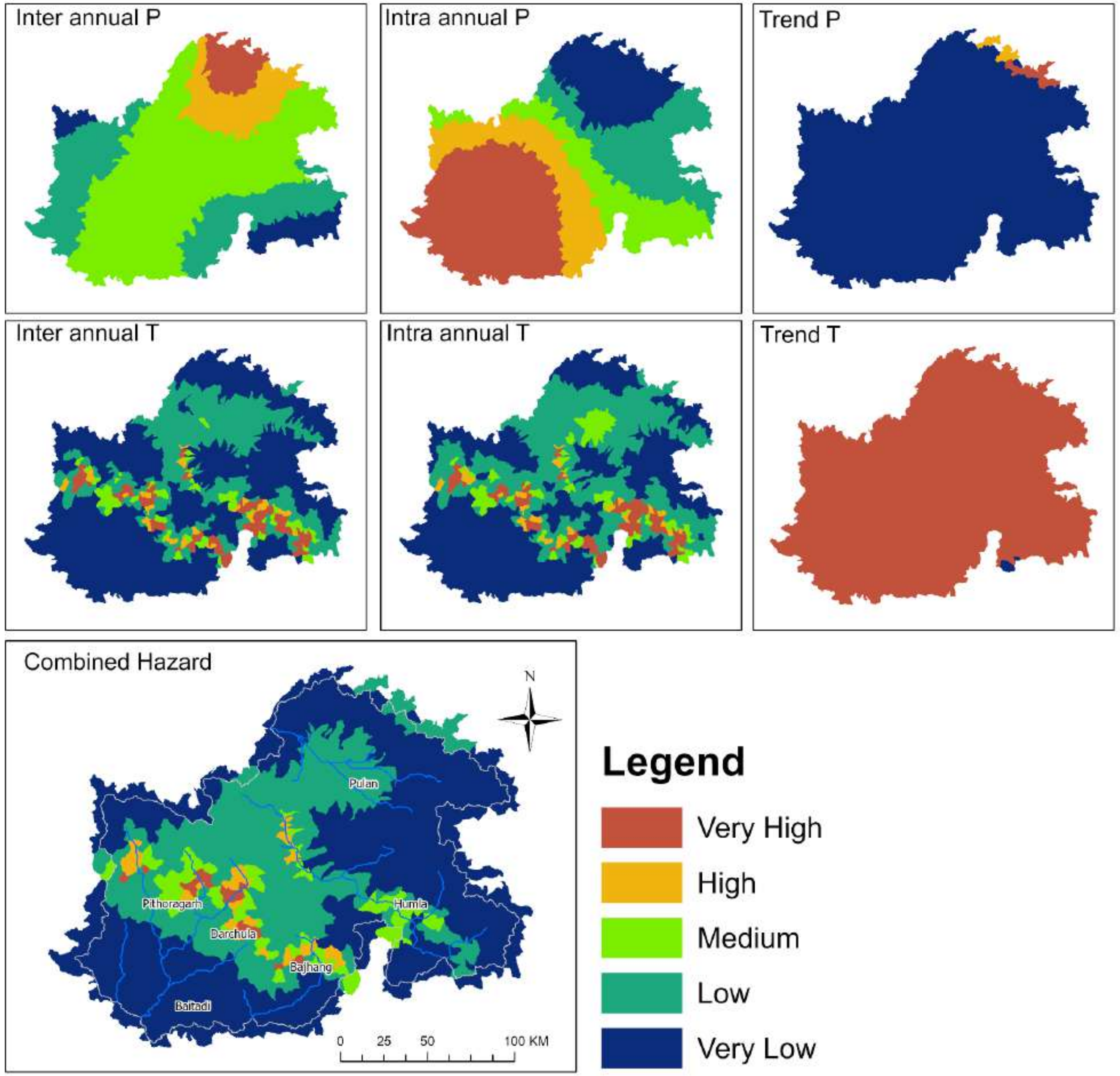
Similar approach of rainfall variability is applied in agriculture (Ibrahim Omer, 2017), Global watershed vulnerability (Immerzeel, 2019)

Present climate hazard map of KSL

Hazard= rainfall variability , temperature variability ,rainfall and temperature trend

Normalization method:

$$X_{i,\,0\ to\ 1} = \frac{X_i - X_{min}}{X_{\max} - X_{min}}$$

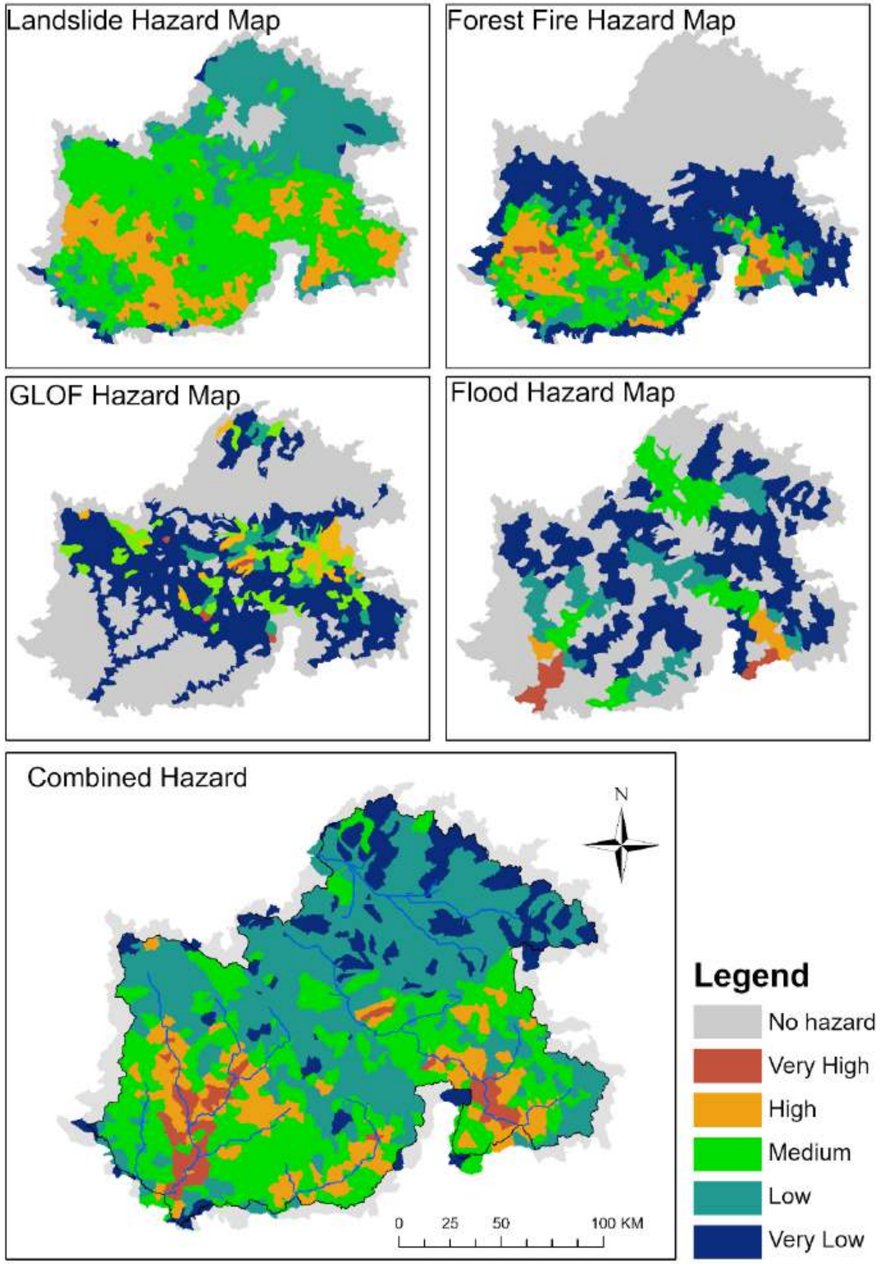


Present geogenic hazard map of KSL

Hazard= Landslides, Forest fire, GLOF and Flood

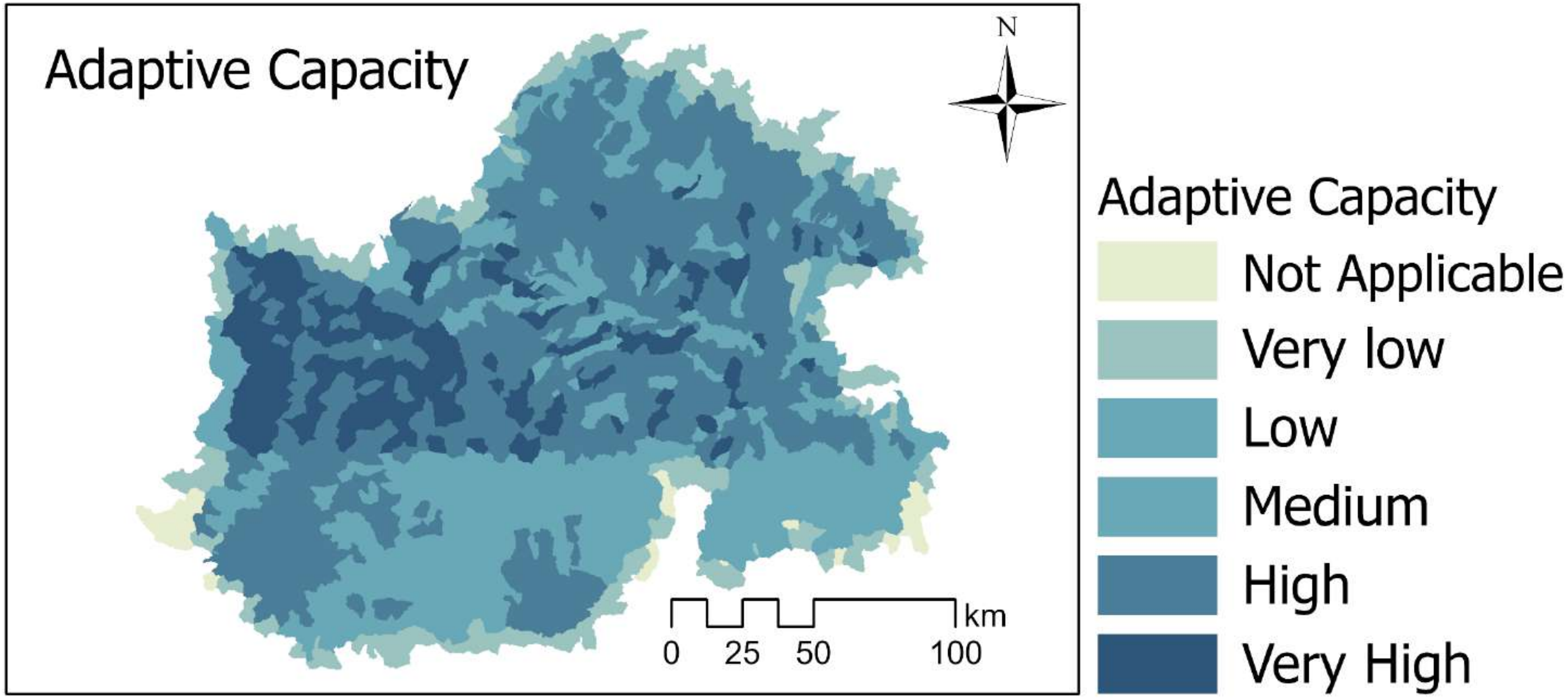
Normalization method:

$$X_{i,\,0\ to\ 1} = \frac{X_i - X_{min}}{X_{\max} - X_{min}}$$



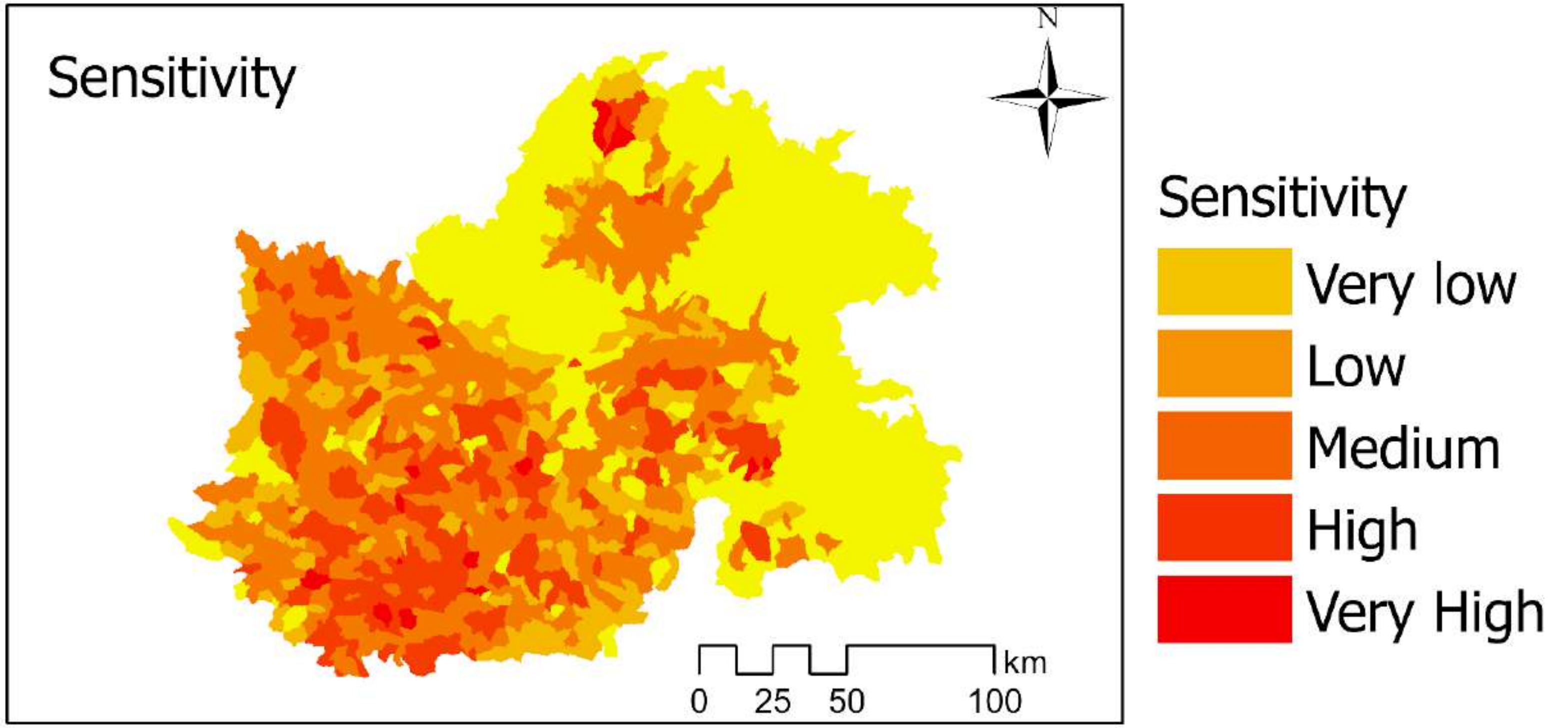
Present adaptive capacity of KSL

- Human capital
- Natural capital
- Physical capital
- Social capital
- Financial capital



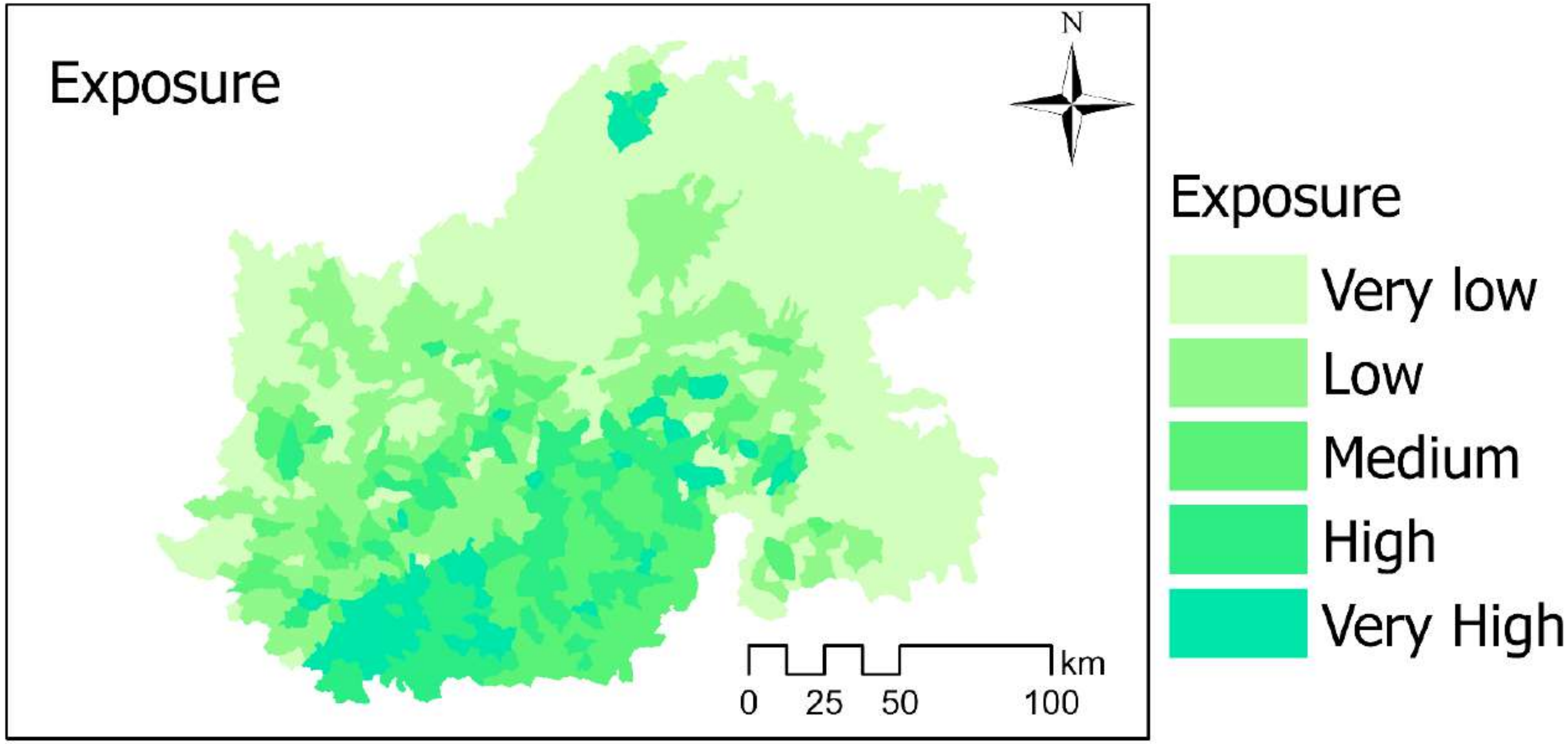
Present sensitivity of KSL

- 50 different types of CES are identified in the KSL
- Sensitivity of each subbasin is calculated based on no. of CES in each subbasin, their type and the weightage score for each CES developed based on survey from the experts in the region

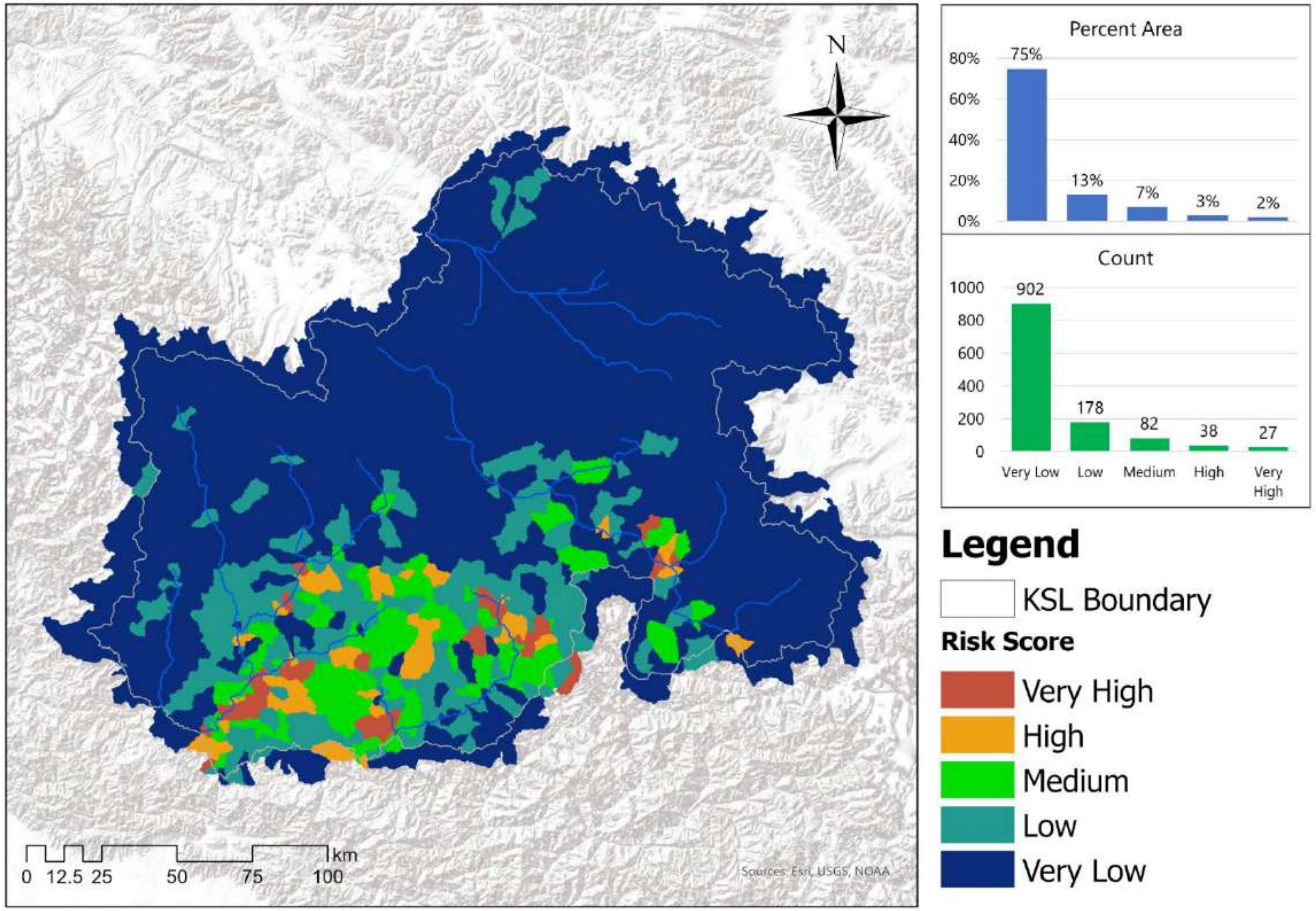


Present exposure of KSL

- Exposure of each subbasin is calculated based on no. of CES in each subbasin. If the number of subbasin has higher no. of CES then it is exposed more to the hazards



Present risk map of KSL



Thank you

Protect the pulse.