Digital land resource mapping to inform location-specific soil management advice

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Land resources in Central Dry Zone are under pressure

To provide agricultural livelihoods especially to smallholder farmers

- Need for sustainable agricultural intensification
  - Improve farmer livelihoods
  - Improve food security

To conserve land resources

- Maintenance of soil fertility
- Maintenance of water infiltration
- Prevention of erosion
- Prevention of salinity

ACIAR project on land evaluation of upland catchments in Philippines

Like CDZ uplands are under pressure

To provide agricultural livelihoods

To provide ecosystem services to downstream communities

- Year round supply of water for:
  - Domestic and industrial uses
  - Irrigation
  - Hydroelectric power
- Prevention of flash flooding
- Prevention of landslides

Land resource information required to underpin evidence-based land use planning

- Ensures agricultural investments are targeted at appropriate parts of the landscape
- Choice of alternative crops or cropping systems
  - More productive
  - More nutritious
  - Less risky
- Choice of land management practices to overcoming limitations
- Identification of areas prone to degradation

Land resource information required to underpin evidence-based land use planning

Planning requires spatial land resource information at sufficiently detailed scale

- To reduce risk/uncertainty in decision-making
- Planning required at both catchment and farm scales

Challenges for evidence-based land use planning

- Shortage of capability to survey land resources
  - Digital land resource mapping offers a new way of providing information
    - More efficient use of expert soil surveyors and laboratories
- Difficulties in achieving change
  - Participatory land use planning offers a way of using land resource information
    - Empowers communities to make land use change that are
      - technically feasible and
      - match community aspirations

Digital Land Resource Mapping (DLRM)

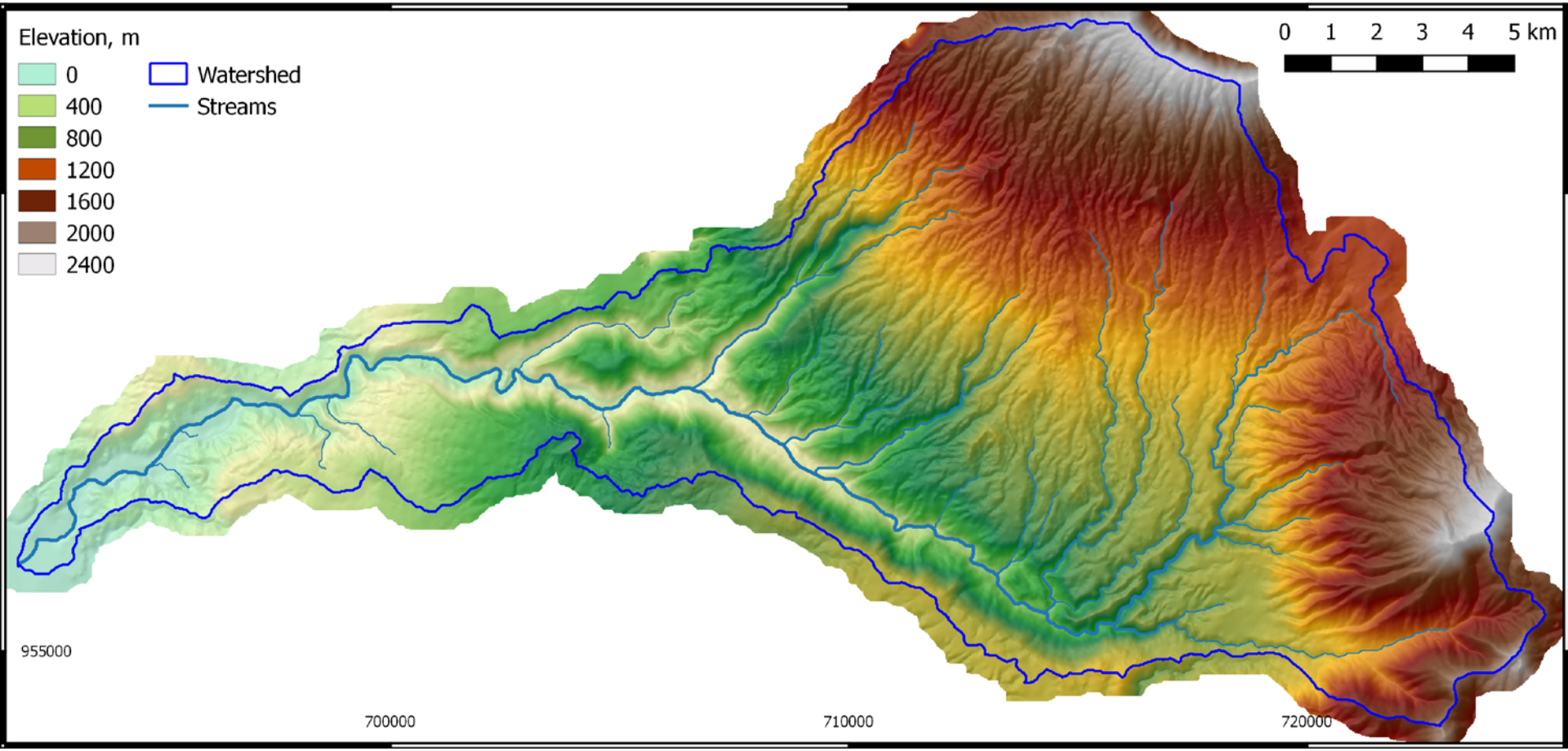
including Digital Soil Mapping (DSM)

Based on 4 pillars:

1. Statistically-based sampling strategy

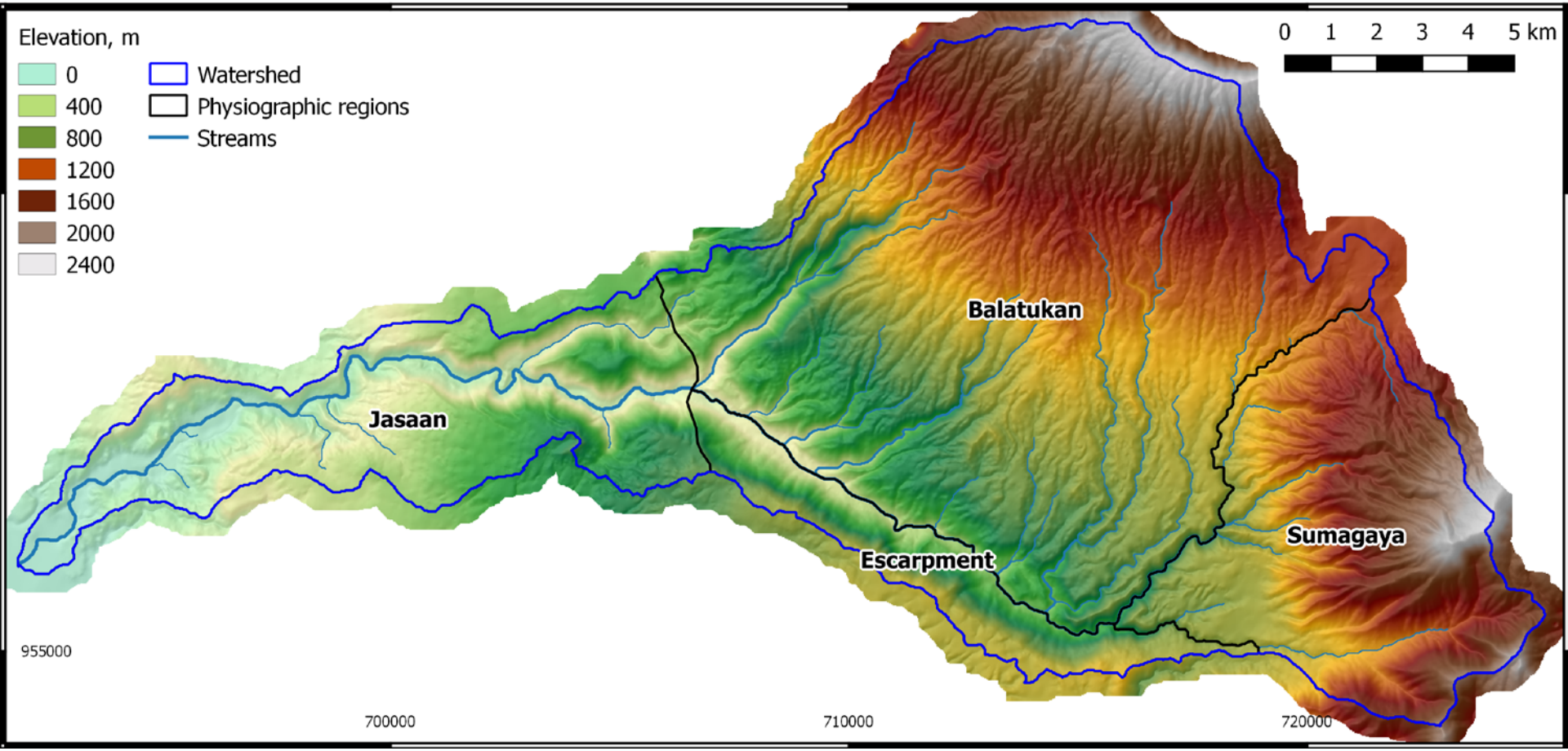
Cabulig River Catchment, N Mindanao, Philippines

20 m digital elevation model – 220 km^2



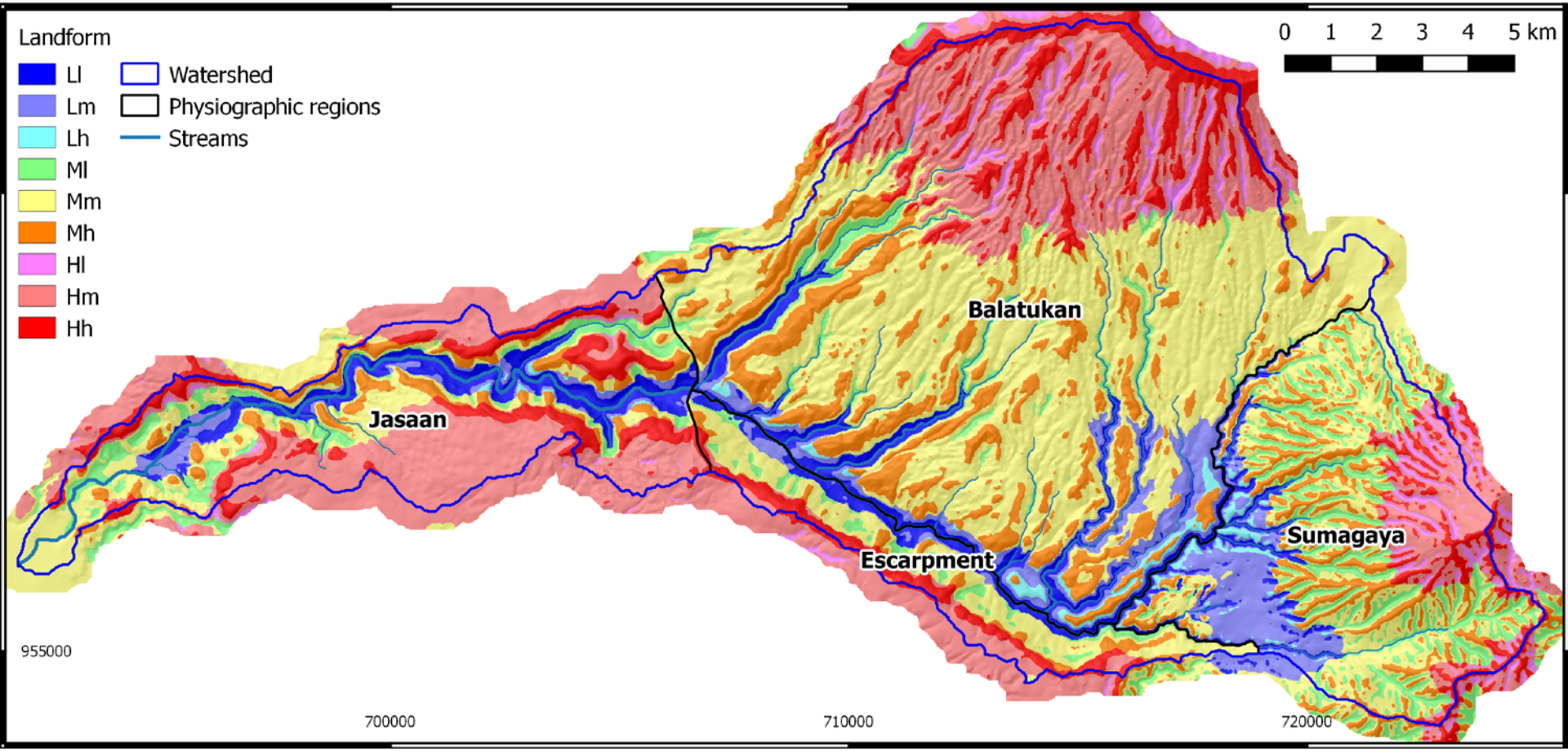
Cabulig River Catchment, Northern Mindanao

Stratification into physiographic regions



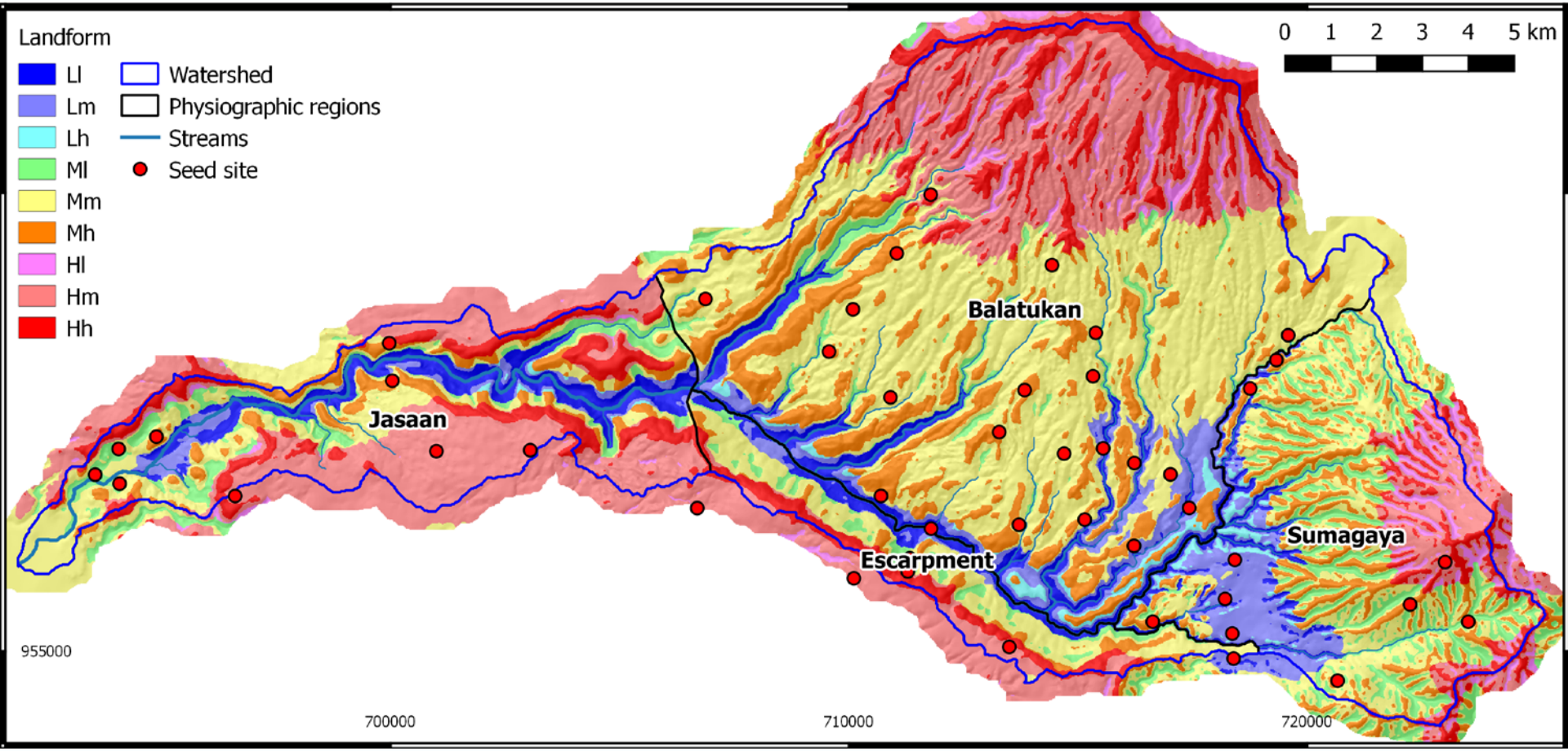
Cabulig River Catchment, Northern Mindanao

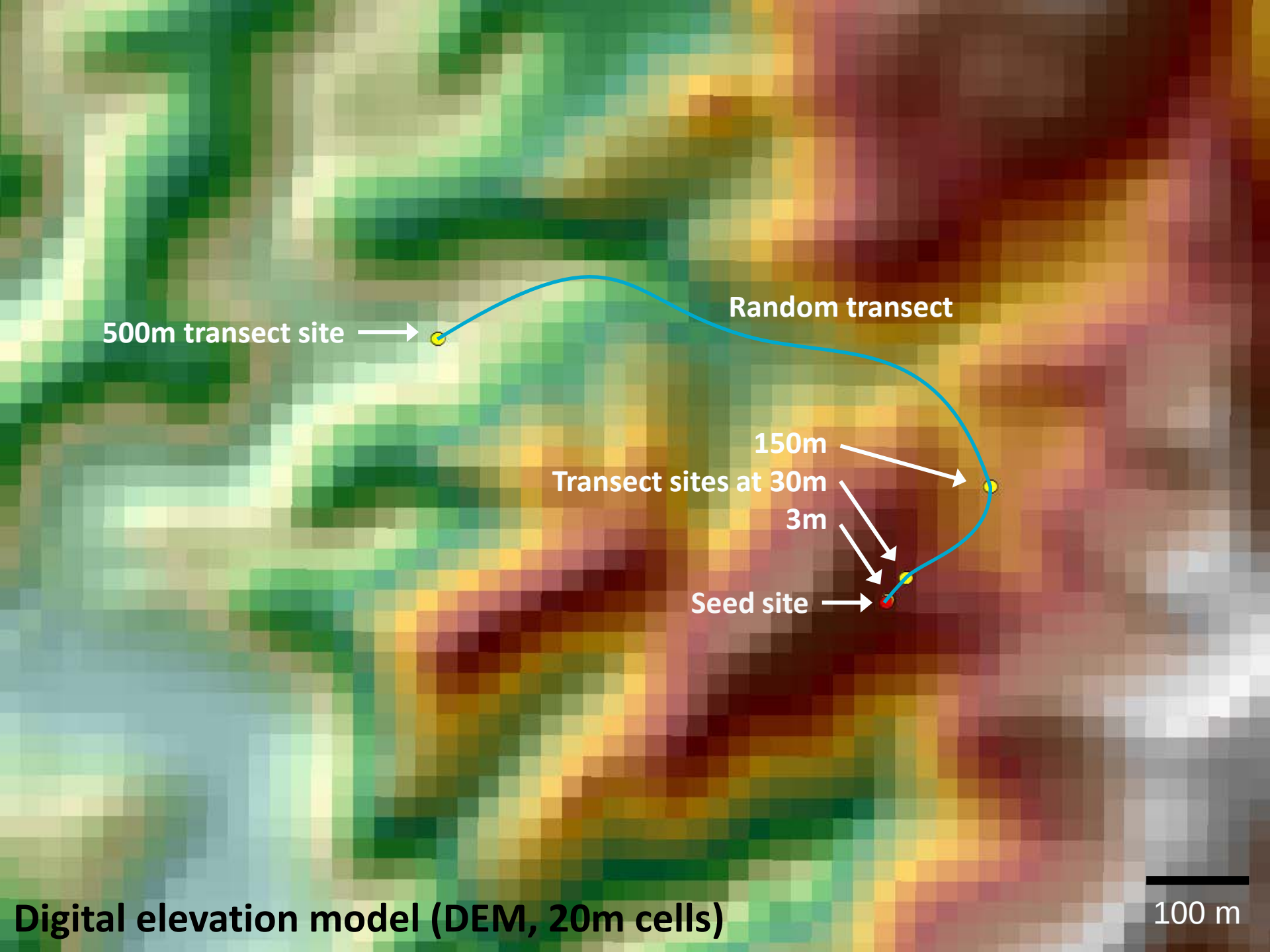
Stratification into landform units



Cabulig River Catchment, Northern Mindanao

Stratified random selection of “seed” sites

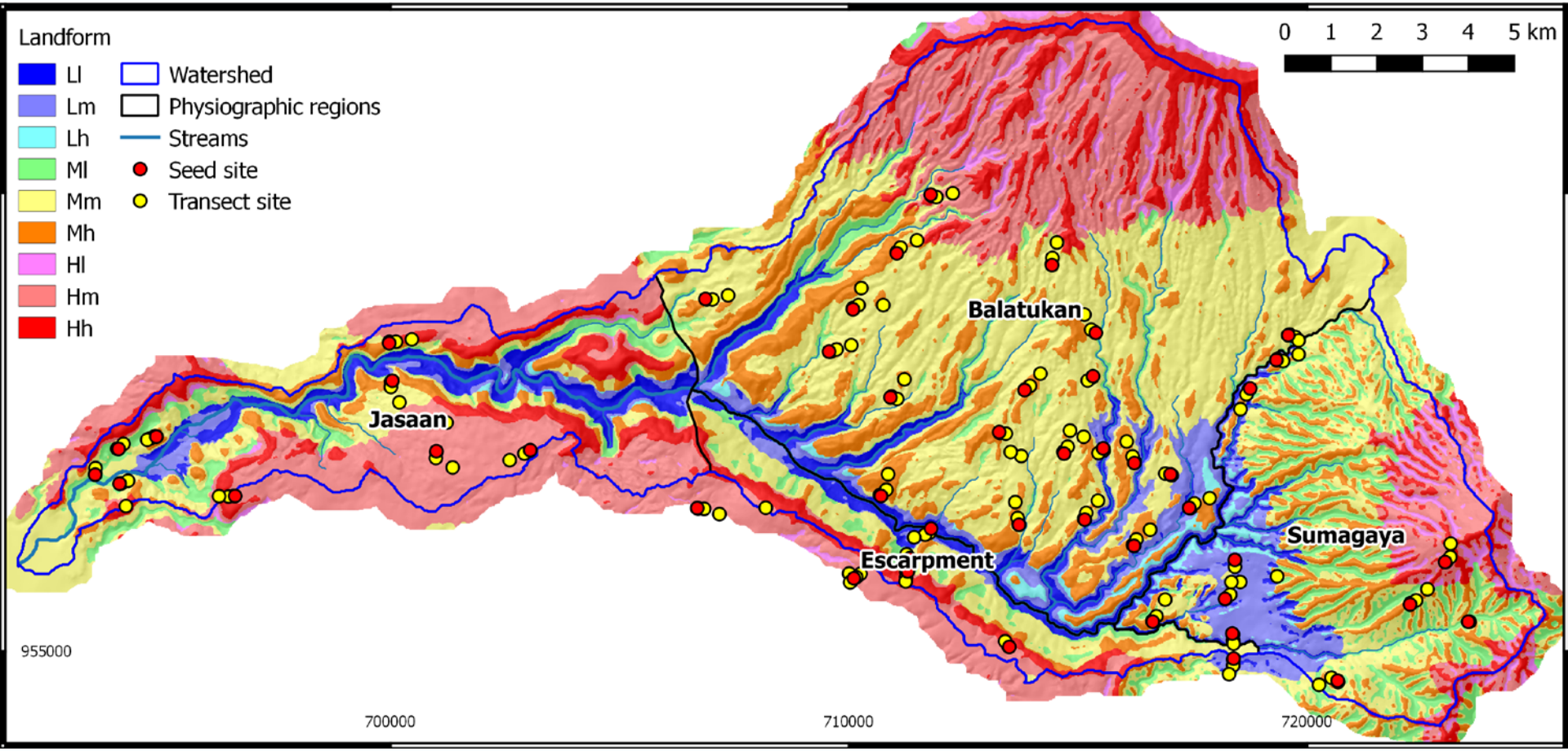




Digital elevation model (DEM, 20m cells)

Cabulig River Catchment, Northern Mindanao

Stratified random selection of “seed” sites + transect sites



1. Statistically based sampling strategy

Stratified random sampling

- Statistically valid
- Sites located by field teams using GPS
  - No need for pedologist to choose ‘representative’ sites in the field
- Landscape understanding improved by
  - Strata that are recognisable to pedologist
  - Transects along toposequences

Digital Land Resource Mapping (DLRM)

including Digital Soil Mapping (DSM)

Based on 4 pillars:

1. Statistically-based sampling strategy
2. Simplified site and soil profile methods

2. Site and soil profile methods

DLRM – Simplified site and soil profile methods

- Emphasis on taking soil samples at every site
- Simplified description at each sample site
  - Can be done by non-expert
  - Chip trays and photographs allow checking by expert

Digital Land Resource Mapping (DLRM)

including Digital Soil Mapping (DSM)

Based on 4 pillars:

1. Statistically-based sampling strategy
2. Simplified site and soil profile methods
3. Rapid soil analysis

3. Soil analysis using MIR spectroscopy

Some MIR calibration results from Cabulig catchment

SOIL PROPERTY	r^2	
Organic carbon	0.90	Analytical
pH ($CaCl_2$)	0.87	Good
Clay content	0.80	Good
CEC	0.78	Good
Exchangeable K	0.57	Indicator
Olsen P	0.38	Poor

- Local calibration using conventional analyses of samples from seed sites
- Having soil measurements at all sites reduces reliance on inferring soil properties from 'soil type'
  - Less need for pedologist in field for soil classification

Digital Land Resource Mapping (DLRM)

including Digital Soil Mapping (DSM)

Based on 4 pillars:

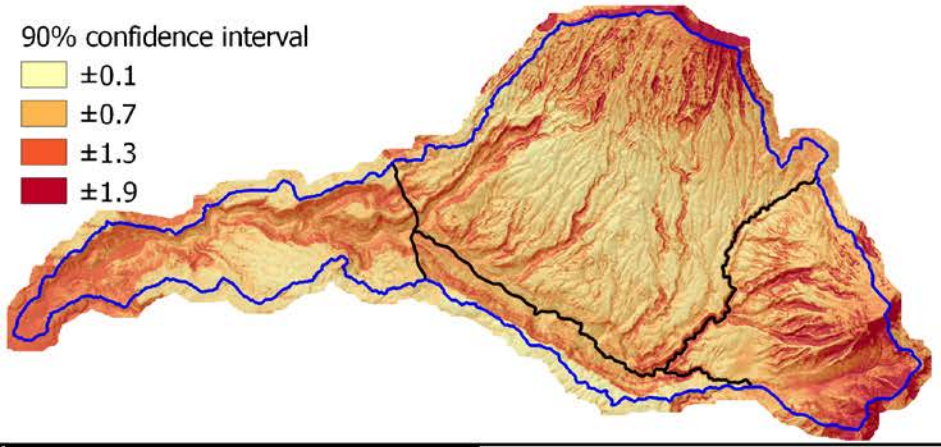
1. Statistically-based sampling strategy
2. Simplified site and soil profile methods
3. Rapid soil analysis
4. Mapping of soil and land properties using statistical models

4. Mapping of soil and land properties

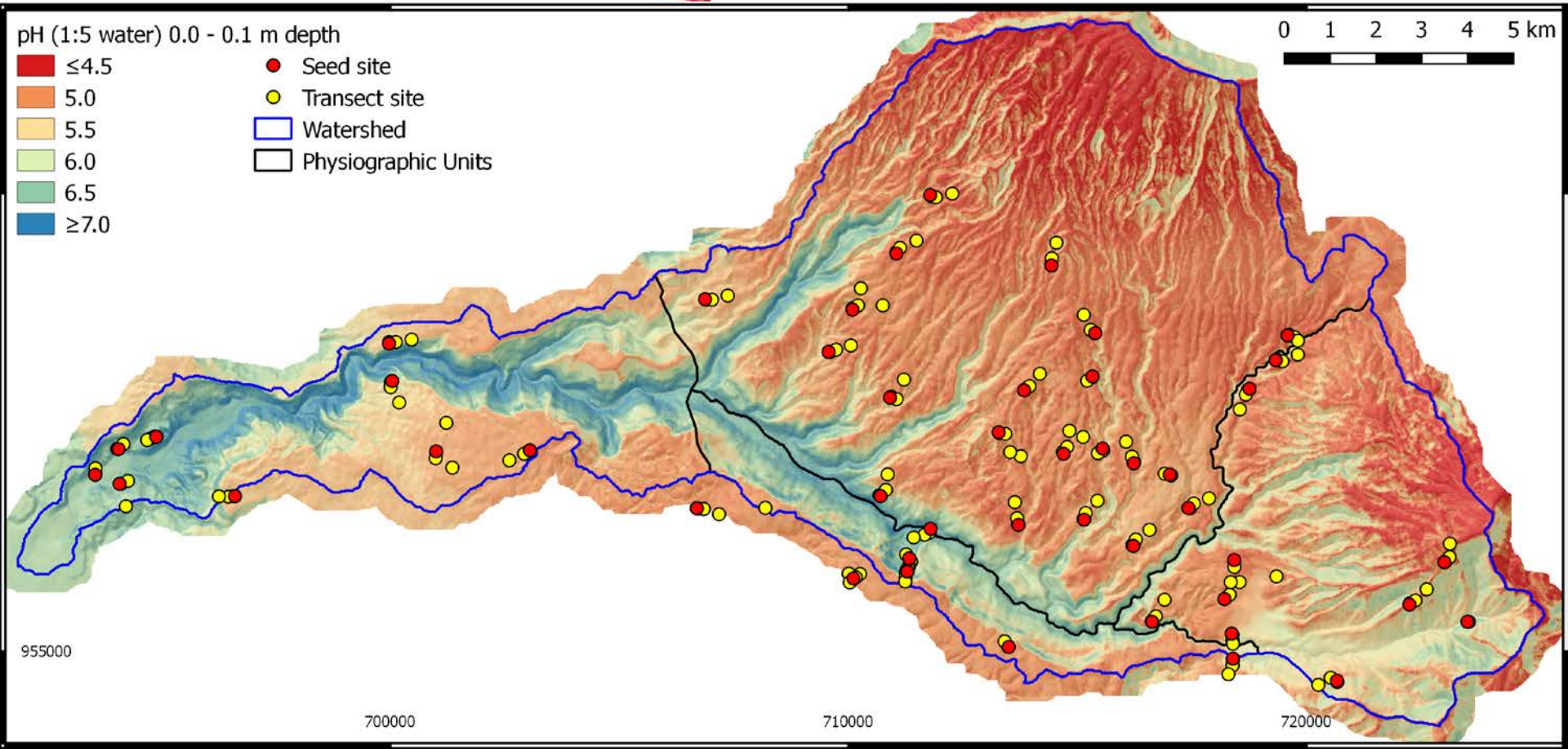
Digital soil maps of each soil property

- Soil properties predicted using **environmental correlation**
- Terrain attributes (from 20 m DEM) used as spatial covariates
  - Elevation
  - Slope
  - Topographic wetness index
  - Aspect
- Use machine learning to construct predictive relationship between
  - Soil properties measured at each sample site
  - Spatial covariates
- Use relationship + spatial covariates to predict soil properties over survey area

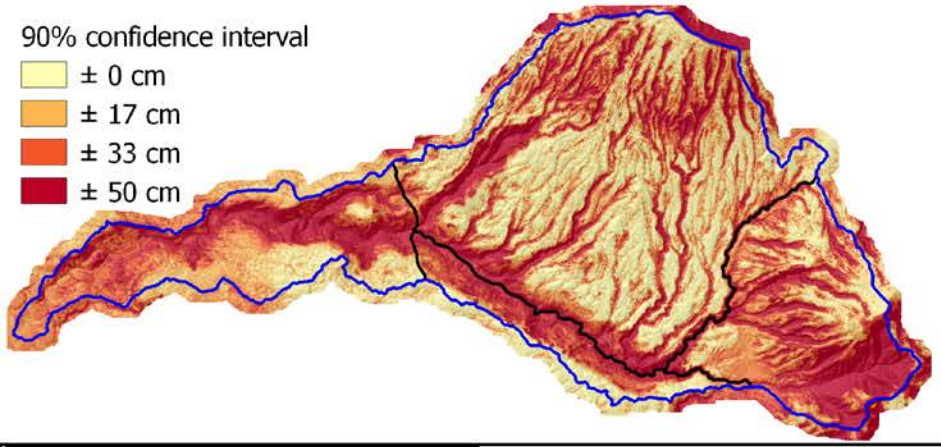
Cabulig River catchment
Northern Mindanao



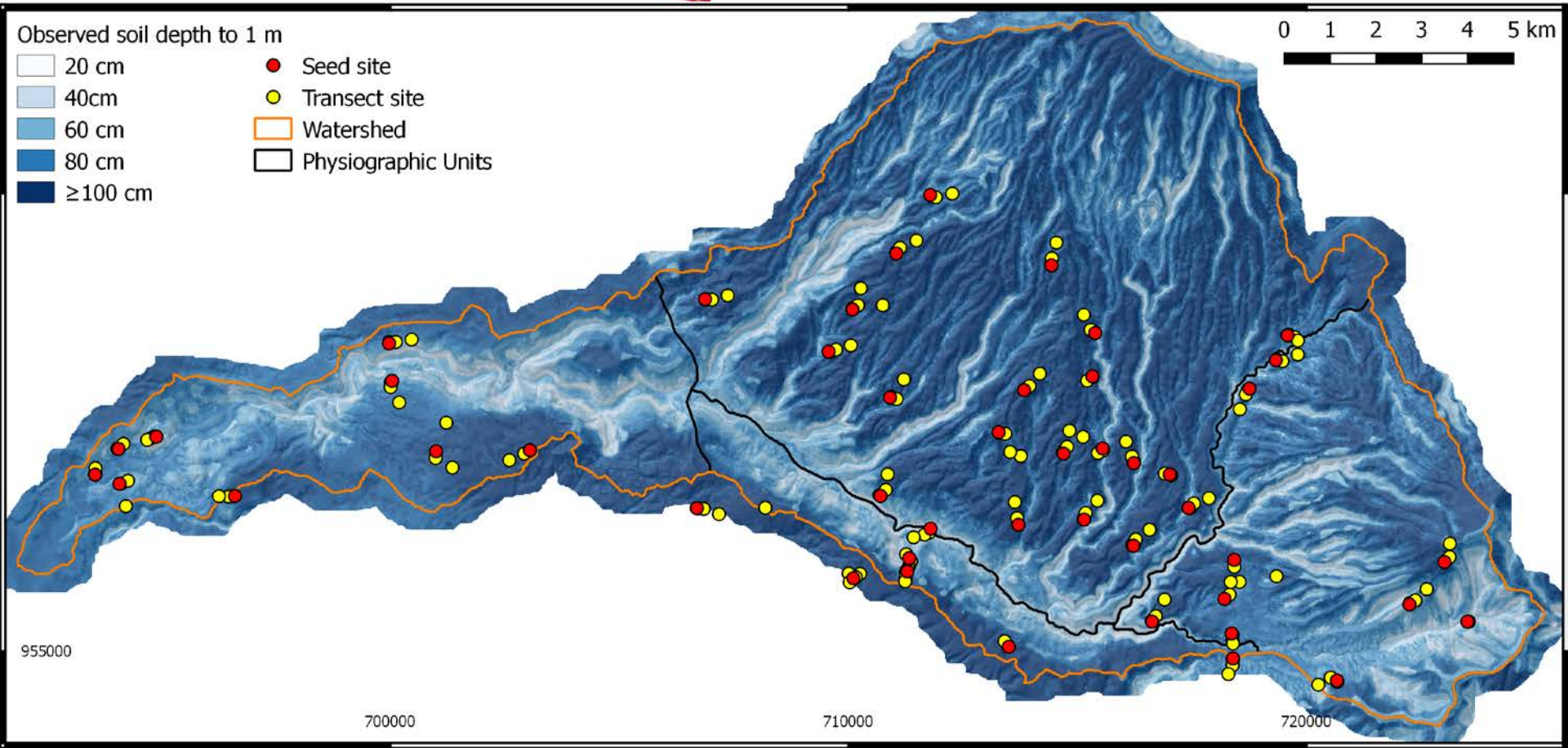
- pH ($CaCl_2$) 0-10 cm
  - External correlation 0.76
  - External concordance 0.86



Cabulig River catchment
Northern Mindanao



- Soil depth
  - External correlation 0.37
  - External concordance 0.59



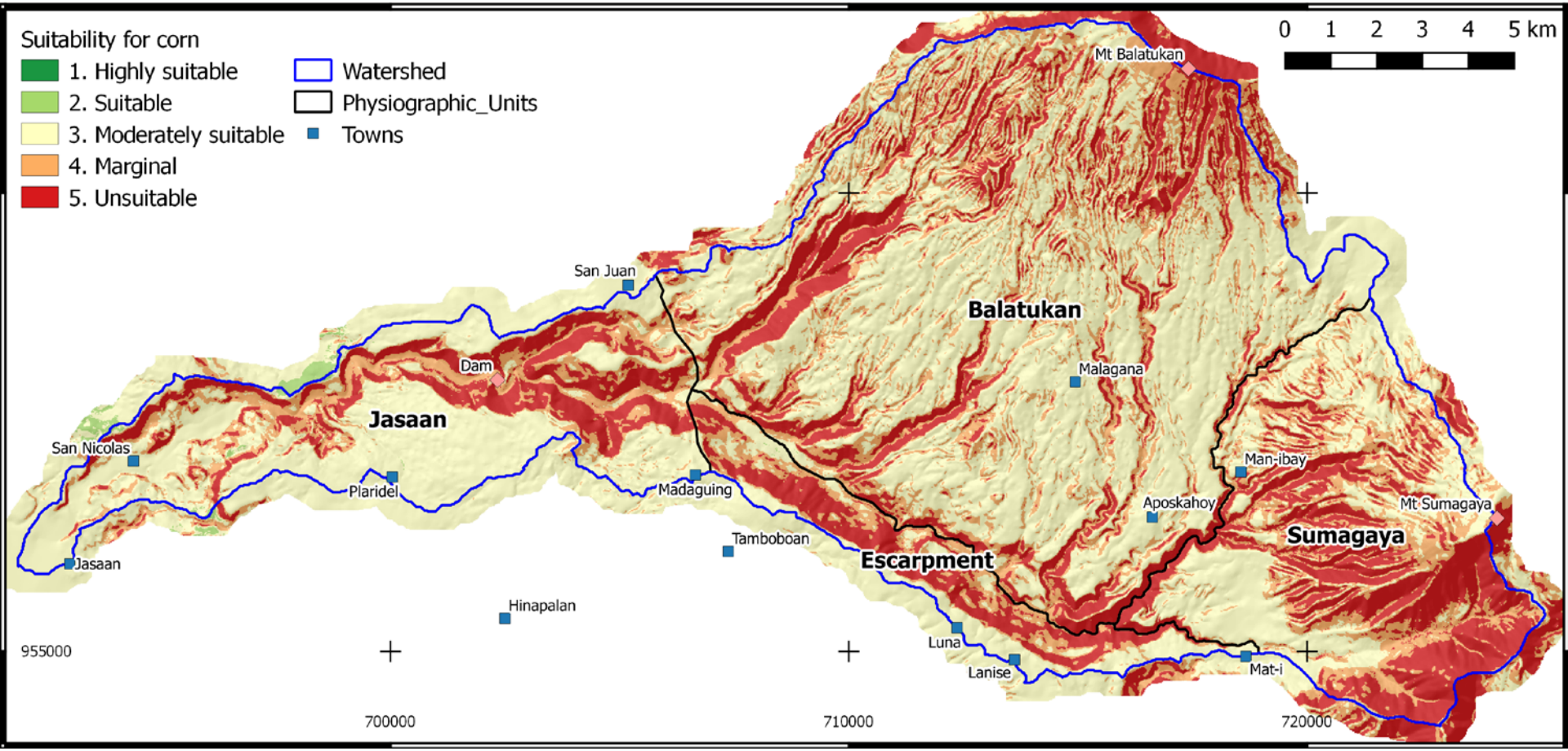
Land suitability assessment

FAO 1976

- A way to interpret land resource data
- Effect that each soil and land property has on a chosen land use is scored from 1 (no effect) to 5 (severe limitation)
- Overall suitability = most limiting property

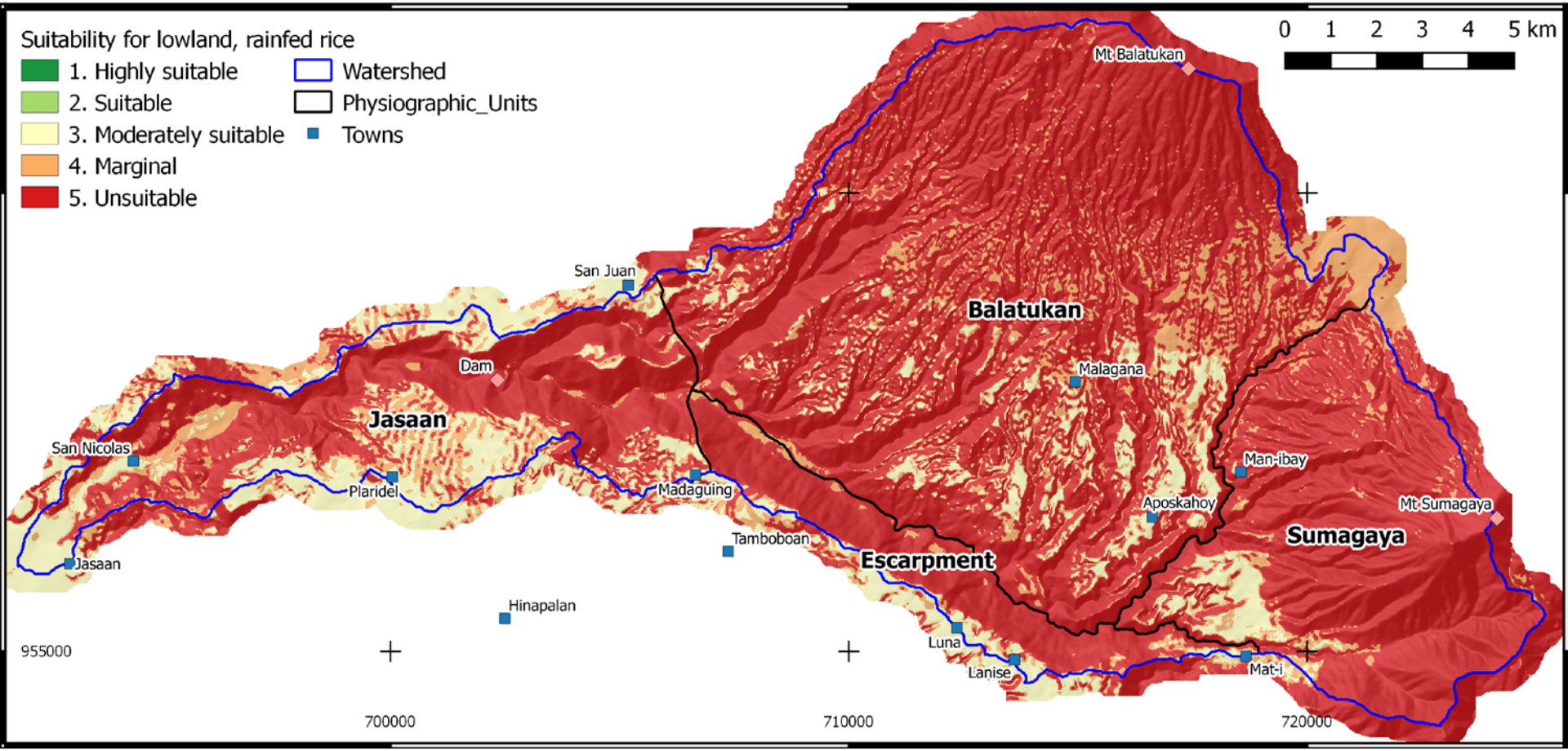
Cabulig River Catchment, Northern Mindanao

Suitability for maize



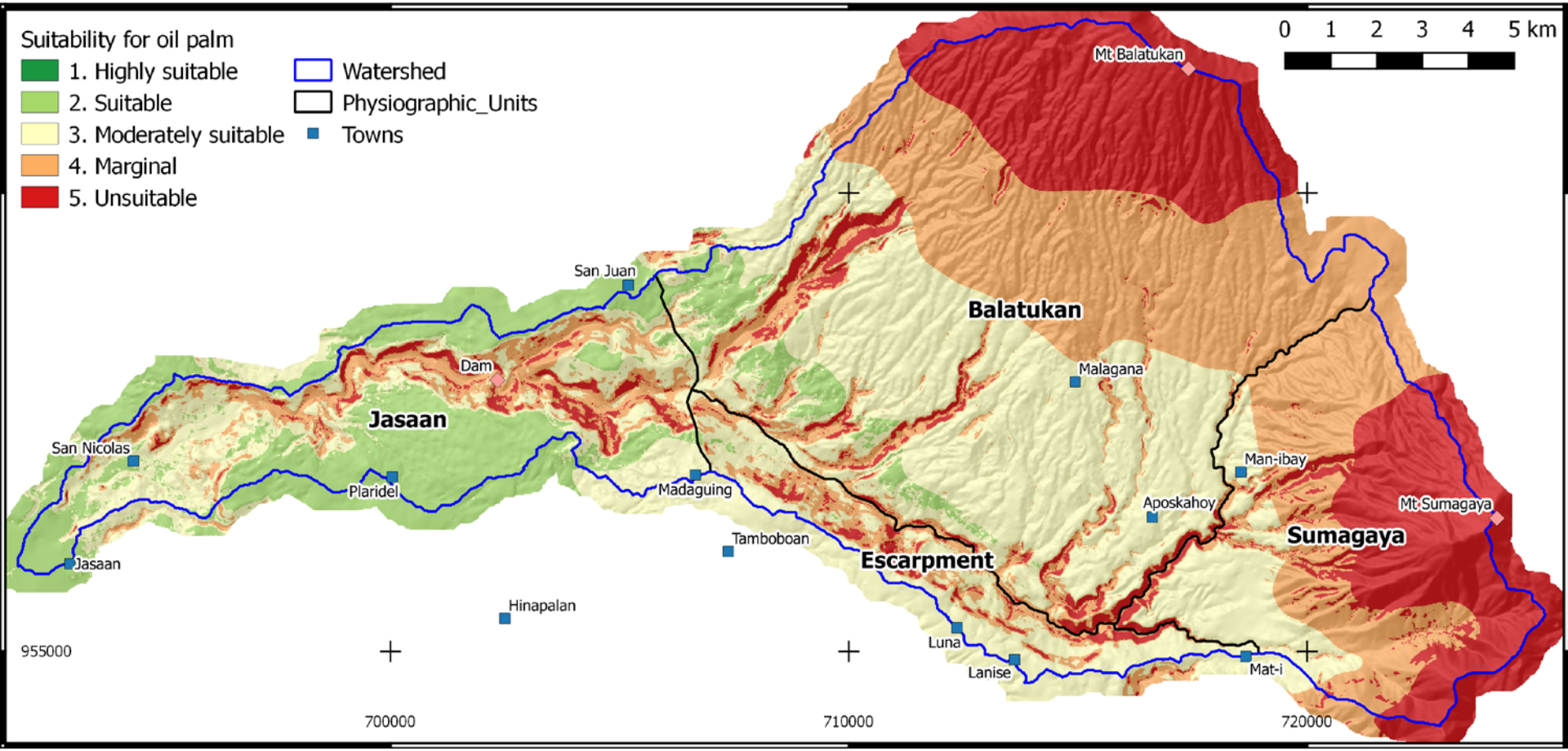
Cabulig River Catchment, Northern Mindanao

Suitability for lowland, rainfed rice



Cabulig River Catchment, Northern Mindanao

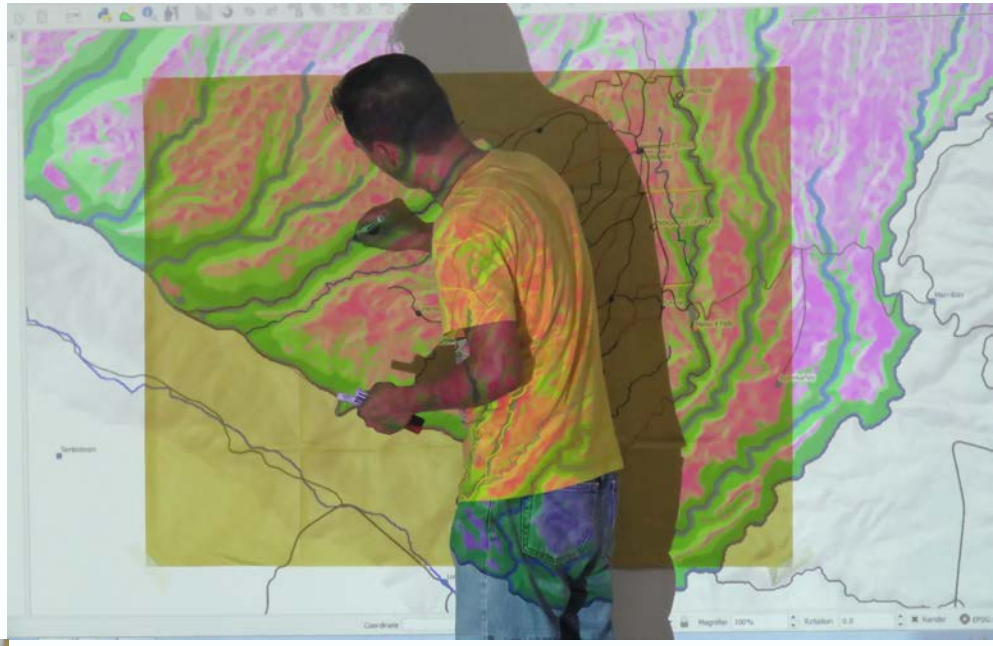
Suitability for oil palm



Working with villagers and advisors

Using land resource information to achieve change

- Participatory land use planning uses land resource information
  - To empower communities to make land use change that are:
    - technically feasible and
    - match community aspirations



- Land resource information enables extension staff to provide location specific soil management advice
  - Based on mapped soil and land properties

Thank you

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Survey organisation and local field teams

A partnership to improve survey efficiency

Survey organisation

- Reconnaissance survey
  - Develop landscape model
- Design statistically-based sampling
- Design simplified site description sheets
- Train local field teams

- MIR analysis of samples from **all** sites
  - Calibration using standard laboratory analysis of samples from a **small** subset of sites
- Produce maps of soil properties using spatial prediction

Local field teams

- Provide local knowledge
  - Geography, land use, social/cultural expectations
- Liaise with local officials, land owners and other stakeholders

- Majority of field work
  - Locate sample sites using GPS
  - Simplified soil profile descriptions
  - Sample **all** layers at **all** sites
- Sample preparation

- On-going interpretation of outputs after completion to assist land use planning & agricultural extension